Who benefits from intellectual property rights for agricultural innovation?

The Case of Ogura Oilseed Rape in France

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CropLife INTERNATIONAL

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About Steward Redqueen

Company profile
Steward Redqueen is a strategy consultancy firm that aims to make business work for society. It is represented in Amsterdam, Barcelona and New York and executes projects around the world. As specialists since 2000, Steward Redqueen focuses on integrating sustainability, quantifying impact and facilitating change for (multinational) corporations, (development) financial institutions and public sector organisations.

Socio-economic impact assessments (SEIA)
In the long run, business cannot succeed in societies that fail or fail to share the fruits of economic growth. The private sector therefore must include societal interests in its decision making and look for shared benefits. The better stakeholders understand how the private sector contributes to economic development, the more they will support its strategic goals. Steward Redqueen quantifies direct and indirect socio-economic impact in a particular country or region and analyse the myriad of ways through which firms are connected to the economy.

The Authors
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Track record
Steward Redqueen has completed more than 100 socio-economic impact studies and evaluations for multinational mining companies, development finance institutions, multinational food & beverage firms, agricultural companies, banks and recreational organisations, in Asia, Africa, North & South America and Europe.

About Crop Life International

CropLife International (CLI) is a global federation representing the plant science industry. On the industry's behalf, CLI address international developments in crop protection and agricultural biotechnology.

CLI promotes approaches that enhance sustainable agriculture in the interests of farmers, consumers and the environment. CLI aims to provide transparent information to its stakeholders and welcomes open dialogue with parties interested in the future of food and farming.

CLI is committed to supporting the safe and responsible use of the industry's products in order to provide a secure, varied, healthy and affordable diet for consumers.

The activities are financed by its member associations and research and development-driven member companies.

About EuropaBio

EuropaBio is the European Association of BioIndustries, and was created in 1996. Our members are involved in research, development, testing, manufacturing and commercialisation of biotech products and processes in human and animal healthcare, diagnostics, bioinformatics, chemicals, crop protection, agriculture, food and environmental products and services. EuropaBio also counts a number of National Biotech Associations in its membership who in turn represent more than 1800 biotech SMEs. The member companies active in agricultural biotechnology are BASF, Bayer, Dow Agro-Sciences, Keygene, KWS, Limagrain, Monsanto, Pioneer Dupont, Syngenta.

Executive summary

This study examines the case of Ogura oilseed rape technology in France. Ogura is a patented hybridisation technology developed by the French public research institute INRA that is used to make Oilseed Rape (OSR) hybrids with higher yields. The first hybrid seeds based on the Ogura innovation were introduced in 2000 and resulted in rapid adoption by farmers over the last decade. This technology is available on the market through non-exclusive licenses to several seed companies for which INRA receives royalty income.

Agricultural innovations are necessary to increase farmer productivity and global food supply. But research & development (R&D) require substantial investments and costs. Without the opportunity to recoup investments, limited resources are allocated to agricultural innovations. Over the last decades, Intellectual Property Rights (IPR) provided market protection to innovators and increased the incentive for R&D investments by enabling innovators to recoup investments, to generate income for shareholders and to fund new R&D. This legal environment stimulated R&D investments and the introduction of innovations, which have spurred agricultural productivity and food supply significantly.

However, IPR in agriculture are increasingly being questioned in society because some argue that it allows developers to extract too much profit at the cost of consumer. There is thus a trade-off between the need for R&D investments to produce new innovations (future benefits) and the distribution of the benefits from existing innovations to users and society (present benefits). Against this background EuropaBio and Crop Life International commissioned Steward Redqueen to develop an economic framework to analyse the socio-economic effects and the economic logic of IPR in agriculture.

Research in this area has so far focused on the partitioning of benefits once an innovation is available in the market and only qualitatively described the importance of the innovation incentive. The analysis in this report is an effort to include both perspectives and the trade-off between current and future benefits. A framework is developed that compares IPR regimes based on *the probability of innovations happening (the incentive)* and *the consumer benefits once an innovation is available in the market*. This framework has been applied to the development and adoption of Oilseed rape hybrids developed by using the Ogura technology (‘Ogura hybrids) in France and compares the actual situation (non-exclusive use of IPR) with exclusive use of IPR and a situation without IPR.

The results of this economic study show that:

- Even under favourable market conditions (increasing crop prices), it took INRA and seed companies approximately 15 years to recover their R&D investments;
- The Ogura hybrids have been adopted by 83% of farmers and will have delivered a projected € 1.0 billion economic benefit over the patent life;
- About 50% of this total economic benefit accrues to farmers and 25% further downstream towards processors and end consumers of livestock products.
- Most likely all downstream benefits will trickle down to the consumer over time

The report also examines the influence of the strength of IPR through economic modelling of what would have happened had Ogura hybrids been commercialised *either* without competition through exclusive use of patents *or* under full competition without an IPR system. These results show that the decision for an IPR regime involves a trade-off between current and future benefits:

- Whether or not certain processes and products are protected by IPR, pricing power of seed producers is constrained by the presence of alternatives and the heterogeneity of farmer preferences;
- In the case of Ogura, it can be heuristically argued that deviating from the non-exclusive use of patents would have reduced societal benefit:
  - In the absence of IPR the total societal surplus would have increased slightly by € 16 million (+10%), but it would have been rather unlikely that Ogura would have been developed – at least by a private sector company – because of the inability to recoup the investment as the innovator surplus would have vanished;
  - Exclusive use of patents would result in lower societal benefits of € 46 million (-39%) in exchange for a somewhat higher probability of innovations happening because innovator benefits would increase by € 11 million (+31%);
  - In other words, a small increase of (hypothetical) societal surplus would have eliminated the incentive to innovate whereas a modest increase of the incentive would have come at considerable societal cost.
- Even in the case of exclusive use of patents, farmers (and parties further downstream) would still receive at least 60% of the total economic benefits.

Finally, the report indicates some other socio-economic effects of Ogura:
- Using the same resources, Ogura led to 320,000 tons extra OSR production in France without additional resource use. This translates into a reduction of 66 kg carbon per ton OSR;
- In 2012, € 123 million extra farm benefits resulted into almost 1,200 jobs.

General Lessons

1. Intellectual Property Rights are essential to enable innovation by providing innovators the ability to recoup investments and fund new R&D.

2. Stronger IPRs increase the probability of innovations happening.

3. Most of the social welfare coming from patented innovations accrues to farmers and further downstream towards processors and end consumers, which, in the case of Ogura, is about four times higher than what accrues to the technology developer and seed companies combined.

4. The market power of an agricultural technology is primarily determined by the ability to increase performance (in this case yields) and not by the strength of its IPR.

5. Even when IPR are used exclusively, the pricing power of a seed producer is constrained by the presence of alternatives and the heterogeneity of farmer preferences.

6. The absence of IPR would have a considerable cost for society since the key innovation incentive would be eliminated and thus the chance of new innovations happening and their economic benefits would be significantly reduced.

Key Figures of the Ogura case

€ 1.0 billion	societal benefits during the Ogura patented life
75%	of societal benefits accrue to farmers and consumers
15 years	to obtain break-even for technology provider INRA and seed producers
320,000 tons	annual extra Oilseed Rape production by using Ogura hybrids without extra use of resources
€ 123 million	extra farm income from the use of Ogura hybrids in 2012
83%	adoption level of Ogura hybrids by farmers in 2012

1. Introduction

1.1 IPR in general

Many advances in society are made through innovation, the act of developing a new idea that can be applied to the resolution of a technical or market problem via an improved process or product. Innovation is the task of converting inventions into marketable products or technologies and making them available to a user.

Protection of intellectual property aims to encourage developers to innovate. IPR encompass any new creation which is given the legal status of property and grants developers a certain degree of protection from market forces, thereby enabling them to appropriate a part of the economic benefits resulting from adoption of the innovation. IPR are 'rights given to persons over the creations of their minds' and can be divided into the areas 'industrial property' (including trademarks and patents) and 'copyright'.[1] The importance of these rights was first recognized in the Paris Convention for the Protection of Industrial Property (1883) and the Berne Convention for the Protection of Literary and Artistic Works (1886).[2]

According to a joint study of the European Patent Office (EPO) and the Office for Harmonization in the Internal Market (OHIM), IPR-intensive industries contributed 26% of employment and 39% of GDP in the EU during 2008-2010. These shares are somewhat higher in the EU than in the US where IPR-intensive industries contribute 19% to employment and represent 35% of GDP. The World Intellectual Property Organization (WIPO) has identified several reasons to promote and protect IPR: innovations in technology and culture generate progress for and well-being of humanity; IPR protection creates a financial incentive to invest in innovation as it secures a return on investment for a considerable term; and IP intensive industries fuel economic growth and create jobs.[3] However, critics have argued that strong IPR can impede competition and prevent progress because IPR would lead to excessive power for inventors (allowing them to charge prices far higher than under full competition) and thus limiting the adoption and diffusion of new technologies and production methods. Moreover, 'patent trolls' may distort the market and 'patent thickets', a web of overlapping patent rights, make it difficult to market a new technology. An optimal IPR system should balance the incentive to innovate and the costs of these inefficiencies.[4]

1.2 IPR licensing

Technology licensing has been and will continue to be an essential mechanism to enable a return on investment and the sharing of benefits between research institutions and companies, as well as between companies. Once a patent is filed, an institution or company may commercialise the innovation itself, or market the innovation to potential licensees, or a combination of both. This allows the inventor to create a revenue stream and recover funds that were used in the product's development phase.

Based on the exclusive rights conferred by a patent, licensing is a permission granted by the patent owner to another to use the patented invention on agreed terms and conditions, including payment of a certain fee, while the patent owner continues to retain ownership of the patent. Here, the patent owner has the opportunity to transfer its rights to the licensee(s) through exclusive or non-exclusive licensing.

Licensing not only creates an income source for the patent owner, but also establishes the legal framework for making the innovative technology available to a wider group of researchers within institutions or companies, who may, in turn, further contribute to the development of the technology concerned.

1.3 IPR and innovation in agriculture

Farmers face the challenge of producing larger quantities of food while preserving and protecting natural resources. New technologies over the past century have enabled farmers to meet the needs of a growing population. This agricultural innovation process often requires significant research and development (R&D) investments that may or may not produce technologies that can be commercialised.

IPR has been used in agriculture to stimulate R&D investments by providing market protection in order to recoup investments. Part of the ensuing higher profits are reinvested into research and development (R&D) to produce the next round of new products that benefit farmers, consumers and the environment.

Five well known examples of IPR protected innovations are introduced here:

1. In *mechanisation,* the first patent was granted in 1886. Tractors are one of the great labour-saving innovations of the 20th century.[5]
2. The first patent for *synthetic fertiliser* was granted in 1911. Synthetic fertiliser supplies nutrients essential for the growth of plants. Fertiliser use can increase crop yields up to 30 to 50%.[6]
3. In the *crop protection* area, the first fungicide patent was granted in 1934. Such products protect crops against diseases, insects and weeds. By reducing pest pressures, crop protection products cut global crop losses in half each year.[7]
4. A revolutionary *drip irrigation* method that provides water directly to the roots of a plant through a tube system was patented in 1963. Used on more than 6 million hectares around the globe,[8] drip irrigation increases yields potentially by up to 50%.[9]
5. Since 1992, when the first *plant biotechnology* patent was granted, genetically modified (GM) seeds have been developed that enable:
    - Higher farmer income due to lower expenditure on inputs and higher output per hectare;
    - More efficient use of inputs (water, energy, etc.);
    - Nutritional benefits of vitamin-enhanced varieties and lower “bad” fat oil profiles.[10]

1.4 The need for IPR to enable agricultural innovation

The adoption of innovative crops is considered to have been the most rapidly adopted agricultural innovation since the invention of the plough.[11] It has transformed farming and plays an important role in driving long term productivity and sustainability in agriculture. GM crops are planted and replanted on more than 1.5 billion hectares cumulatively since 1996 and on 13% of global arable land in 2013; biotech crops have added € 75 billion to global farm incomes.[12]

The plant science industry is one of the world’s most R&D-intensive industries. It ranks in the top four global industries in terms of percentage of revenues invested into R&D. For example, the industry’s top 10 companies annually invest about € 1.69 billion – or 7.5% of sales revenue – into new product development.[13,14]

The cost of discovery, development and authorisation of a new plant biotech trait is estimated at over € 100 million.[15] Whereas historically most agricultural research was funded from public sources, the private sector has become the dominant player since the first biotechnology patent was granted in 1992. Currently the private sector is responsible for most of the global crop R&D expenditure[16]. The ability to protect IPR has increased the ability of technology developers to recoup their investments and to generate a profit. This in turn has spurred private sector investments in additional agricultural innovation.

The optimal IPR use depends on the technology and the market environment. Within agriculture, IPR essentially consists of patents, plant variety rights (PVR) and trade secrets. Trade secrets seem less suitable for protecting products sold on the open market due to the possibility of replication through reverse engineering.[17] PVRs only protect new varieties, which meet certain conditions, as a whole, in specific territories and during a defined time span. They do not protect specific plant characteristics ("traits"). The patent system, on the other hand, protects specific innovative technologies and traits in exchange for the full public disclosure of the invention, which brings new scientific information into the public domain. This disclosure is important as it induces further improvements of prior innovations and additional innovations.

However, the need for patent protection of agricultural innovations is increasingly being questioned by civil society. Pressure is increasing to limit the scope of patent protection for agricultural innovations or to exclude patentability of these innovations altogether. An important driver of this resistance is the fact that once a new technology exists (ex-post) a patent causes developers to set prices higher than under free competition.[18] This is seen by many as allowing developers to extract (too much) profit at the expense of the consumer. But the innovation would likely not have existed without an incentive for the upfront (ex-ante) investment of the developer. In other words; a trade-off exists between the ex-ante and ex-post interest of society.[19]

A patent is a social contract between society and innovators. Society accepts short term exclusive rights, in order to enable long-term social welfare through innovation. But it is clear that this social contract breaks when either society denies profits to risk-taking innovators or developers benefit too much from the protection granted to them.

1.5 Research objective

The objective of this research is to develop an economical model for the socio-economic framework to analyse the trade-off between:

a. The need for IPR to encourage R&D investments to generate new seed technologies driving future benefits for society;
b. The influence of IPR on the partitioning of economic benefits stemming from new seed technologies over seed companies and farmers driving current benefits for society;

The framework is applied to the case of Ogura hybrid rapeseed technology in France.

2. Framework

The framework mentioned in the research objective essentially ties together the ex-ante and ex-post perspectives on patents: the developer needs a guarantee that he can appropriate a sufficient part of the potential future benefits of a new technology as an incentive to invest in R&D. Society has a dual objective: on the one hand, it wants to maximize the probability of innovations happening, which means incentivising innovators. On the other hand, it wants to maximise the consumer benefits coming from the new technology once it is commercially available.

Agricultural research so far has focused mainly on the partitioning of benefits once an innovation is commercially available; it only qualitatively describes the importance of the innovation incentive. This analysis pioneers an approach to describe both perspectives and the trade-off between current and future benefits.

The framework in Exhibit 1 shows the trade-off between these two perspectives. Stronger IPR increase the incentive to innovate (and thus the probability of innovations happening) but tends to decrease the share of the benefits for consumers whereas the opposite is true for weak IPR.[20] From a value chain perspective it is important to note that consumer benefits initially consist of farmer income but some of these benefits may leak away to the end consumer (i.e. on and post farm benefits). The producer benefit (i.e. total benefit minus farmer benefit) is shared between technology developer, seed producer and seed distributor.

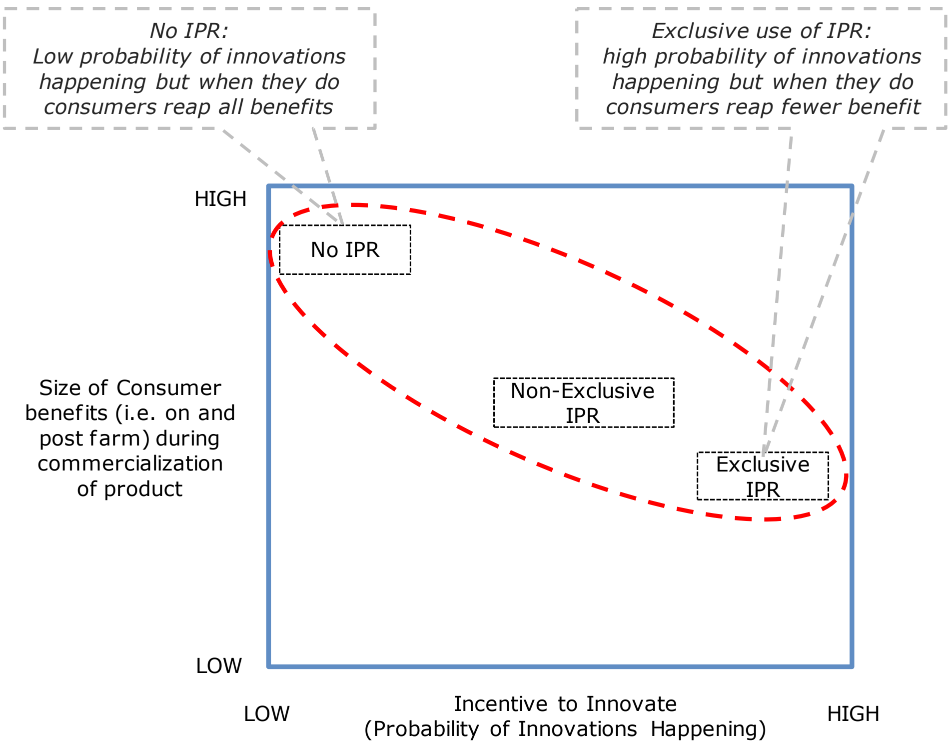

Exhibit 1: *Trade-off between consumer benefits and agricultural innovation incentives under different IPR regimes. Note that the location of the IPR regimes are highly indicative since they depend on local legislation.*

The three IPR regimes are indicatively shown in Exhibit 1: No IPR, Non-Exclusive use of IPR and Exclusive use of IPR. Table 1 describes the effects of these regimes in more detail on consumer benefits (ex-post) and the incentive to innovate (ex-ante). As mentioned in Section 1.3, the optimal IPR regime depends on the innovation and the market circumstances.

IPR regime	Effects on (ex-post) consumer benefits	Effects on (ex-ante) incentive to innovate
No IPR	• Free technology allows for free competition and maximises consumer benefits vs other IPR regimes	• No market protection for innovator eliminates incentive for private R&D investments
Non-Exclusive use of IPR	• Competition on the market as seed producers can access technology through license fee • Lower consumer benefits vs no IPR due to license fee	• IPR provide higher incentive vs no IPR • Non-exclusive use of IPR lowers incentive vs exclusive use of IPR
Exclusive use of IPR	• Exclusive use of IPR provides most market power for innovator which lowers consumer benefits of current technology	• Most market power through exclusive use of IPR maximises incentive vs other IPR regimes

Table 1: *Effects of IPR regimes on (ex-post) consumer benefits and (ex-ante) incentive to innovate*

This report analyses the adoption of the hybrid Ogura rapeseed technology in France along the lines of the framework. The Ogura technology is an example of a non-exclusive IPR case as INRA grants non-exclusive licenses on its patented technology to seed producers. In addition to the observed partitioning of economic benefits the report also describes what would have happened under no IPR and exclusive use of IPR.

3. Background Ogura and Oilseed Rape (OSR) in France

3.1 Ogura hybrid technology can improve crop yield by 6-10%

The hybrid Oilseed Rape (OSR) introduced in the French market is based on the OGU-INRA technique, developed by the French National Institute for Agricultural Research (INRA). INRA is a public research institute with a € 882 million budget in 2012, ranking among the top 1% most-cited research bodies worldwide. In 2013, INRA had almost 500 plant variety certificates filed and owned 289 patents.[21]

The hybridisation of OSR is an example of a process innovation, as it is essentially a new production method. It enables combining traits of parents of two different varieties, which means that the offspring can show better performance than the sum of both. With these techniques seed companies can speed up genetic progress, ensure a better regularity of production and improve agronomic performances, like yields and characteristics of the product.[22] Hybrid seeds are considered one of the main contributing factors to the dramatic rise in agricultural output during the last half of the 20th century and are today the norm in many crops. However, the offspring seeds of hybrid crops will not consistently have the desired characteristics and farmers therefore repurchase seeds every growing season. This provides an effective protection for the seed producer.

INRA's development of the Male Cytoplasmic Sterility technology (CMS, also known as OGU-INRA) was a breakthrough in the hybridisation process of OSR. This led to the marketing of the first seed variety of hybrid OSR in 1994. As this first generation hybrid seed (based on 1991 patents) were associated with high Glucosinolate (GSL) values which can have negative side effects on human and animal health, further research was desirable. In 2000, the second generation hybrid seed (based on 1991 and 1996 patents), which could be considered the second generation of improved hybrids, reached the market with low GSL. A third generation of hybrid incorporating improved fertility restorer with better agronomics characters (based on 1991, 1996 and 2000 patents) were launched in 2008.[23]

This study focuses on the use in France of second generation Ogura hybrids, which on average improve yields by 6-10% according to academic research.[24] Exhibit 2 shows that after slow adoption until 2006, the uptake of the technology in France went fast and culminated in an 83% market share in 2012. It will be shown later that this uptake pattern was driven by the increase of earnings per hectare, which depends on yield increase, the market prices for the crop and the cost of the hybrid seed. For the 2nd generation hybrids, the 1991 patents represent the crucial breakthrough, but the 1996 patents made the innovation commercially viable and provided the ability to recoup the R&D investments (see Section 4.1).

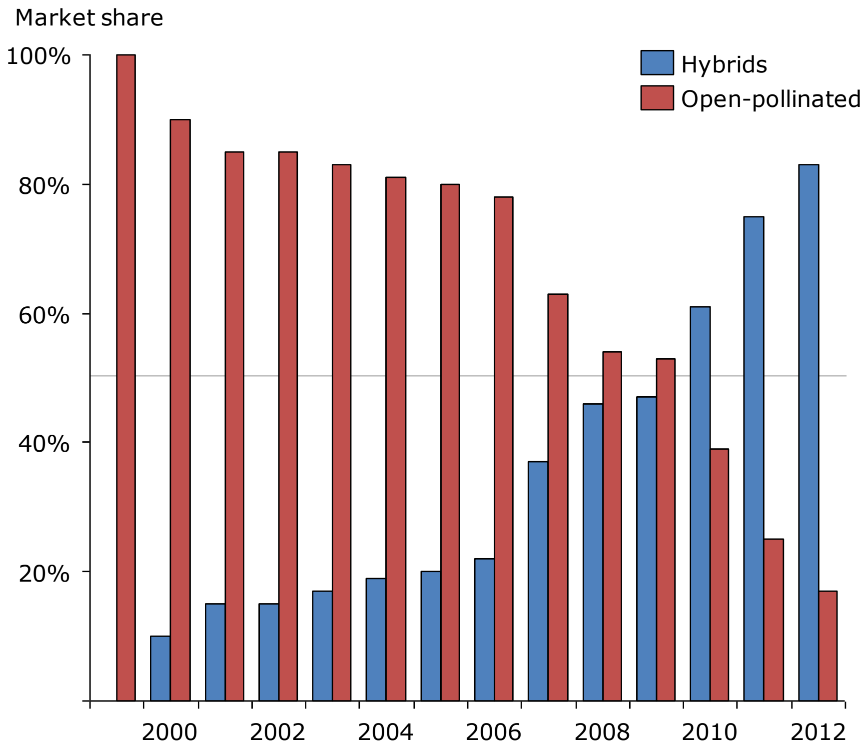

Exhibit 2: *Observed market share of Ogura in France from 2000-2012*[25]

3.2 INRA grants non-exclusive licenses on patented technology to seed producers

Broadly, five stages can be distinguished in the R&D of an agricultural innovation: discovery, proof of concept, early development, advanced development, and pre-launch. In the hybridisation process of OSR, INRA was responsible for the discovery and partly for proof of concept. INRA built a pool of all patents needed to develop Ogura hybrid varieties[26] through the acquisition of required patents it did not hold itself. In this way, INRA served as one-stop-shop for a bundling of Ogura technology. The patents were made available by INRA through non-exclusive licenses, which maximises the Freedom to Operate (FTO) for seed companies. Exhibit 3 provides an overview of R&D phases with estimations of the cost involved.

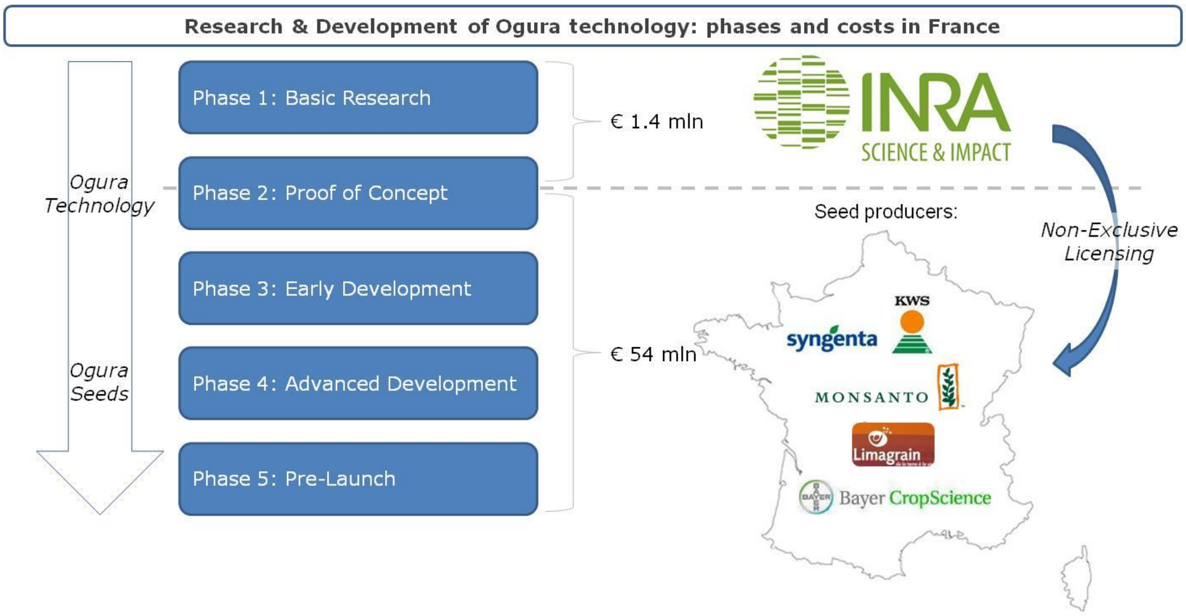

Exhibit 3: *R&D phases and their estimated costs for Ogura Hybrid technology in France*[27]

By obtaining a non-exclusive license, seed companies can use the technology to further develop different Ogura Hybrids. As shown in Exhibit 3 this seed development requires substantial investments from the proof of concept to the pre-launch phase. To increase the likelihood that companies would indeed make these investments, the patent licence agreement is structured as a royalty on the actual revenues rather than as an upfront license fee. Effectively, the royalty was 5% of the seed revenue generated until 2011 and 1% thereafter until 2016. Without going into detail on the many consortia and co-operations that have taken place, one can say that in Europe about five or six large companies have taken all the necessary steps to introduce commercial seeds. Up until 2011 this has produced € 50 million of global income for INRA, which lowers its dependency on government subsidy. Of these, € 14 million have been generated in France and relate to 23 varieties that have been introduced in this market since 2000.

3.3 France is among the largest producers of Oilseed Rape

Over the last decades, demand for Oilseed Rape has increased rapidly. The most common uses of OSR are oil for food and biodiesel and animal feed (as a by-product). Although, use of OSR for food purposes decreased slightly in Europe, the demand for it as a biofuel has increased exponentially. In Europe, OSR is the most important raw material used in biodiesel. Together, the countries of the European Union are the largest OSR producer worldwide, followed by Canada, China and India respectively. Within the European Union, France is largest producer, accounting for about 9% of global production and 26% of European production.[28] Within France, OSR production is concentrated in the Centre and North.

In France, the OSR price increased since 2000 from € 185 per tonne and peaked in 2012 with € 479 per tonne, which made its cultivation more attractive for French farmers. Moreover, this price increase has made the switching to the higher yielding hybrids more attractive. Exhibit 4 shows that, consistent with the greater adoption of hybrid seeds, the average yield trends upward, although year-to-year variation is significant. Based on the previously mentioned 6-10% yield increase of hybrid seeds and the market share shown in Exhibit 2, we estimate that roughly half of the higher yields per hectare come from the adoption of hybrid seed. Similarly, the land used for OSR production increased with more than 30% (see Exhibit 4). Because 2.1 kg of seed per hectare is needed, the market size for OSR seed was about 3.3 million kg in 2012.[29]

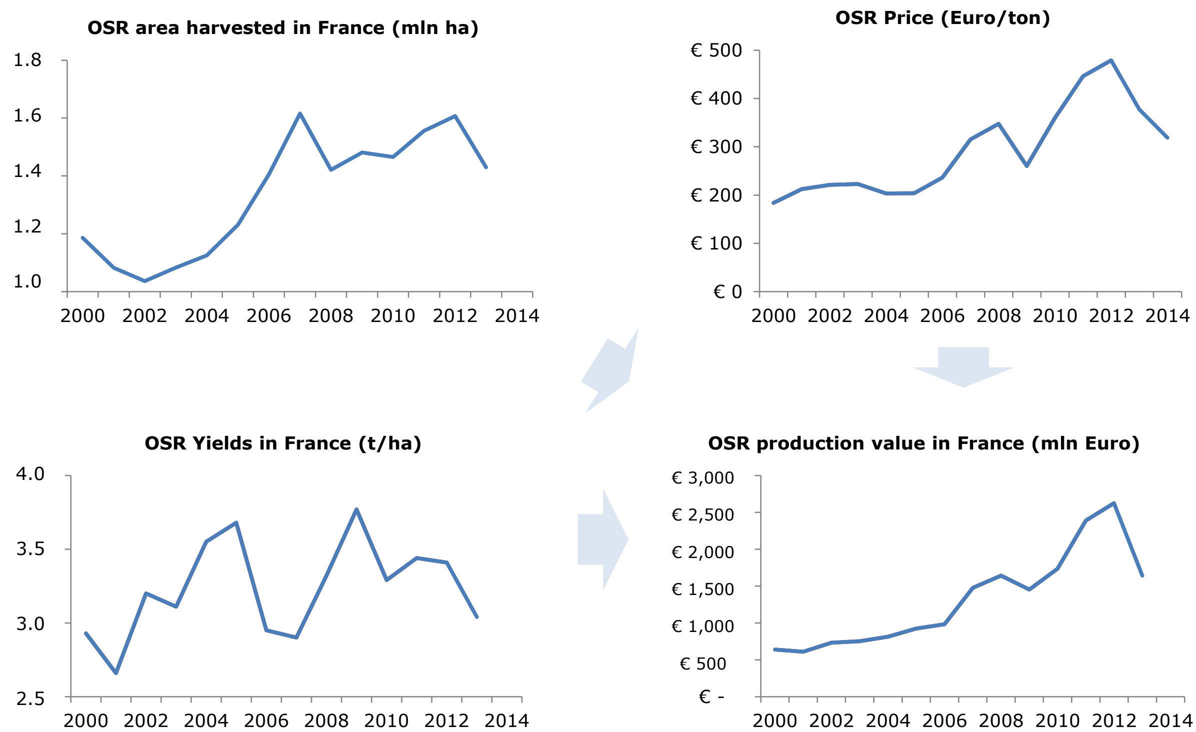

Exhibit 4: *Oilseed Rape (OSR) production info in France*[30]

4. Economic logic of IPR: economic benefits and benefits division of Ogura

Ogura technology provided € 1.0 billion of total economic benefit in France, while the licensing of patents provided the innovator INRA the opportunity to recoup investments. Section 4.1 gives more insight in the break-even points for INRA and the seed producers. Section 4.2 describes the partitioning of total economic benefits over the various actors.

4.1 Break-even point is about 15 year for seed companies and longer for INRA

INRA licensed the Ogura technology to seed companies during the final research phase. Exhibit 5 shows the license income of INRA globally. INRA's initial research on Ogura began in the 1980s, and came to its break-even point in 2006. This break-even point has been made possible by the patent(s) on the technology. Here, the 1991 patents represent the breakthrough of the Ogura technology. However, the innovation would not have been commercially viable in combination with the 1996 patents. Exhibit 5 illustrates the long lead times for this innovation: two decades to break even followed by a short period during which profits are made.

Most of INRA Ogura income was generated up until 2011 when its key 1991 patents, which carried a royalty of 4%, expired. The other patents, for which it receives a 1% royalty, will expire in 2016.[31] Although one may conclude that the research institute has profited handsomely from the Ogura technology, one has to remember that in principle these profits have to cover the R&D cost of technologies that did not reach the market as well as fund the future R&D project pipeline. An industry survey in 2011 indicated most units that are tested during the discovery phase of the R&D process will never be introduced in the market place.[32] And, even under favourable market conditions (increasing crop prices), it took INRA still 15-20 years to recover their R&D investments.

Essentially, the economic outcome for INRA means that for every success (e.g. Ogura), 12 equally costly R&D projects could fail. According to INRA's financials about 80-90%[33] of its total license income comes from Ogura, which underscores that the technology's success is more of an exception than the rule. Of course, INRA is largely public funded and one may argue that it would not stop research in absence of IPR. However, INRA's use of patents lowers its dependency on government subsidy. Furthermore, most agricultural research is nowadays done by private institutions which need revenues to fund new R&D. When a private company cannot recoup its R&D investments it will most likely not invest. An top of that, it would expect a sufficient ROI that is competitive with other investment opportunities.[34] Therefore, the R&D investments and agricultural innovations would decrease significantly without IPRs.

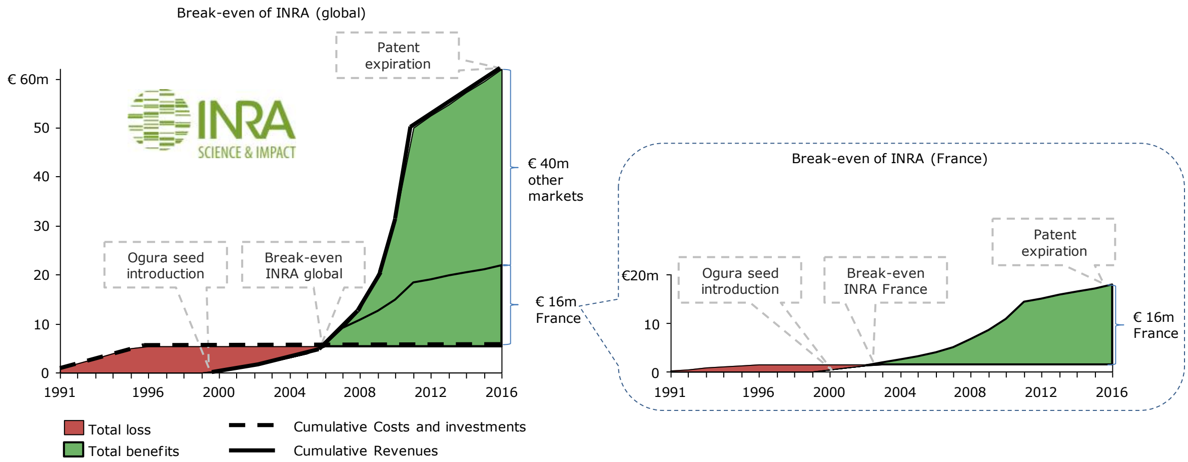

Exhibit 5: *Break-even point of Ogura for INRA, global and in France. An estimated 30% of Ogura's license income is originating from the French market (€ million, nominal)*

Seed companies signed the first licence agreements for Ogura technology in the mid-1990s. In order to make the early stage technology commercially viable, seed companies together spent approximately € 54 million to introduce commercial Ogura varieties in France in 2000.[35] It took until 2010, ten years after market introduction, to recoup these investments as shown in Exhibit 6. This would have been longer under less favourable development of OSR crop prices. For instance, the break-even point would roughly be 3-4 years later (i.e. 2013-2014) when OSR prices would not have increased after 2005.[36]

Some of the ensuing profits are reinvested into research and development (R&D) to produce the next round of new products.

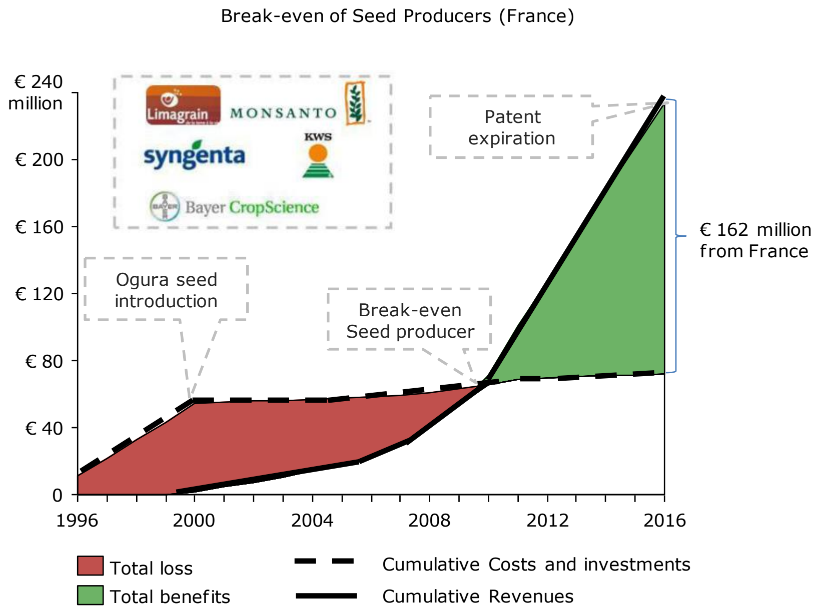

Exhibit 6: *Break-even point of Ogura for seed producers in France (€ million, nominal)*

Farmers that switch to Ogura hybrids do not need to change their operations. Thus as long as the yield increase and prevailing crop prices compensate for the higher seed costs, farmers turn a profit from the first year (see also Exhibit 8). In 2012, the extra costs for Ogura hybrids represented only 1% of farmer revenues while providing an extra 6-10% extra revenues. The adoption of Ogura hybrids is furthermore reversible; farmers can switch back to open-pollinated seeds ('lignées'), or adopt newer and better seeds for that matter, at any point in time.[37]

4.2 Projected economic benefit Ogura over patent life is € 1.0 billion

As shown in Exhibit 2, Ogura hybrids had captured 83% of the OSR seed market in France in 2012. The estimated total benefit created by Ogura over the full patent life is estimated to be € 1.03 billion as shown in Exhibit 8 and over time in Exhibit 8. Most of this benefit, about € 0.77 billion or 75%, goes to the farmers and downstream processors and consumers. Exhibit 7 presents the land use for OSR farming in 2012 and indicates that a large share of the on-farm benefits lands in the central and northern part of France.

From 2000 to 2014, farmers have spent a premium of € 235 million on Ogura hybrids relative to open-pollinated seed. Of this € 54 million (23%) accrued to seed distributors, 165 million (70%) to seed producers and € 16 million (7%) as royalty income to technology provider INRA. When assuming that the adoption of Ogura increases yield with 8%, the associated increase of farmer revenue is € 865 million. Therefore, total farmer benefits up until 2012 are € 631 million (i.e. € 865 - € 235 million).

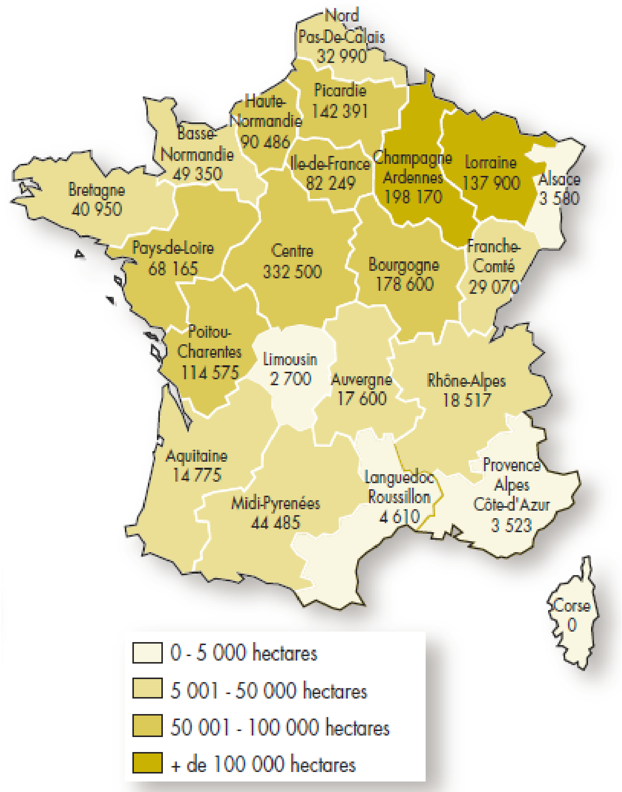

Exhibit 7: *Land use in hectare for Oilseed Rape farming in France, 2012 (Prolea 2013)*

Exhibit 3 summarises the R&D investment of INRA and seed producers, respectively € 1.4 million and € 54 million. By subtracting the investment costs from the extra revenues one arrives at € 110 million net benefit for seed producers (€ 164 million - € 54 million) and € 15 million for INRA (€ 16 million - € 1.4 million). The total realised economic benefit from inception to 2014 sums up to € 818 million. Assuming that the adoption rate remain at their 2012 level we project another € 210 million economic benefit until 2016, when the patent expires. Exhibit 5 summarises the partitioning of € 1,028 million economic benefit over the patent life. About 75% of the total economic benefit is captured by farmers, although it may well be that a part of this 'leaks' away to end consumers because of the lower crop prices due to larger production (see also Section 4.3). Other research on agricultural innovation suggests that once yield-increasing technologies (such as Ogura) is adopted more widely, most benefits in the long run will be gained by the end-consumer.[38]

One could also speak about the societal break-even point. In other words, at which point in time do the cumulative benefits of all parties involved in the chain match exactly their total costs. In the Ogura case, this point occurred around 2004 and is basically a weighted average of INRA, seed producer and farmer break-even.

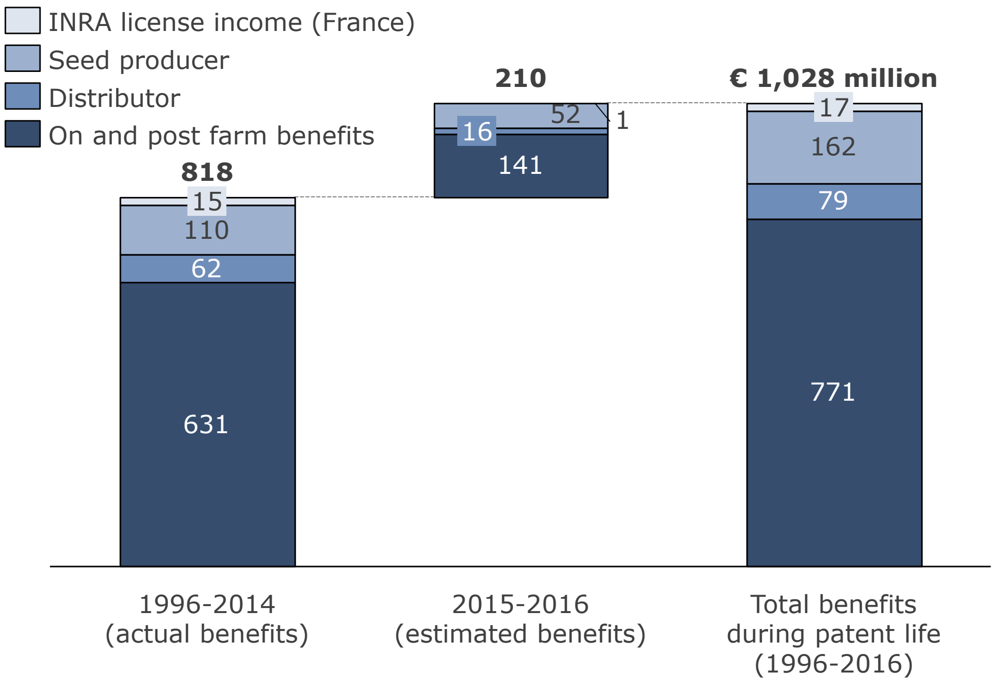

Exhibit 8: *Ogura economic benefits in supply chain during patent life, € million nominal (for estimated benefits for 2015-2016 constant 2014 crop prices have been assumed)*

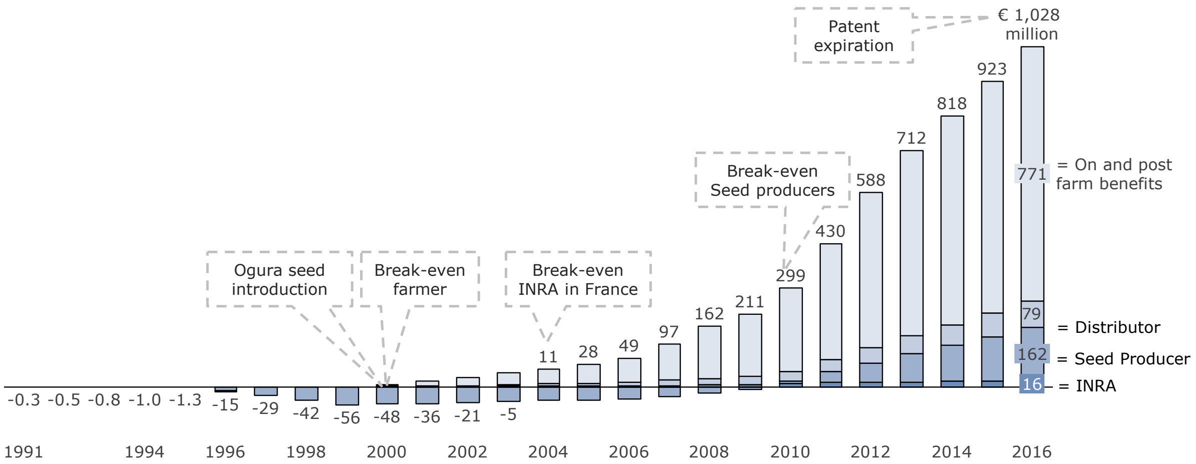

Exhibit 9: *Total benefits of Ogura for INRA, seed companies, distributors and farmers (i.e. on and post farm benefits) in France, 1991-2016 (€ million, nominal)*

To summarise this Ogura case: the technology provider (patent holder) and seed companies take considerable investment risk which took about 15 year to recoup. In return they receive about 25% of the total economic benefits. On the other hand, farmers receive 75% of the benefits while facing a limited financial risk. For INRA, the recovery of investment has been made possible through granting licenses on its patented technology to several seed companies.

4.3 Breakdown of on- and post-farm benefits

This section elaborates on the division of the *actual* on and post-farm benefits (€ 631 m 2000-2014, see Exhibit 8-9) up to the consumer. First, the estimated split between on and post-farm is shown and subsequently we indicate to what extent the post-farm benefits are likely to trickle down to the consumer.

Exhibit 10 summarises the value chain of rapeseed. Rapeseed is mainly used for crushing to produce rape oil for food and fuel purposes. During this process, an important by-product is produced: protein-rich rape meal which in Europe is an alternative for imported soy meals. Every 2.4 ton rapeseed produces 1.4 ton meal and 1 ton oil.[39] Rape oil prices are typically five times higher than its meals.[40]

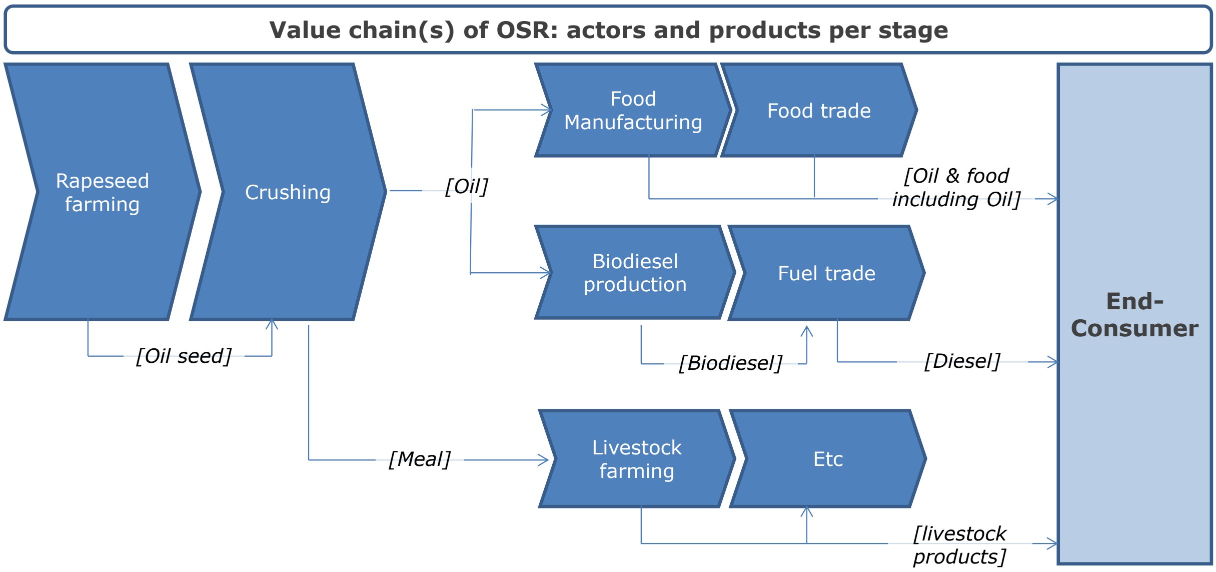

Exhibit 10: *The value chain of rapeseed*[41]

Over the full patent life, Ogura supports an increased production of some three million tons of rapeseed in France. According to FEDIOL, all extra rape oil in EU since 2003 is used for biodiesel production (see Exhibit 19 in Appendix III.3). Therefore, we assume that the extra rapeseed is crushed into oil used for biodiesel production, while its by-product rape meal is supplied to livestock as feed to substitute imported soy meals.

Typically, a change in supply in agro-commodity markets is met with a significant price response (USDA, 2014). However, rapeseed is clearly a fuel crop, especially in Europe where in 2012 two-third of its oil was used for biodiesel.[42] Therefore, price effects of Ogura-related extra production will have a smaller price effect in comparison with non-fuel crops, as its price is pre-dominantly set by the fuel price and biofuel quota.

In the early years after introduction, there was no price change related to Ogura because adoption was still limited and pre-dominantly in France. After 2007, adoption in and outside France rose sharply and as consequence extra rapeseed supplies related to an estimated price decrease of € 6 per ton after 2011 (see Appendix III.4).

These price effects translate into a shift of € 203 m from on to post-farm. These originate from both adopting and non-adopting farmers as prices affect all farmers. During 2000-

2014, it is estimated that € 489 m benefits remain on farm for hybrid farmers, while other farmers who did not adopt hybrid seeds lost € 62 m (see Exhibit 11).

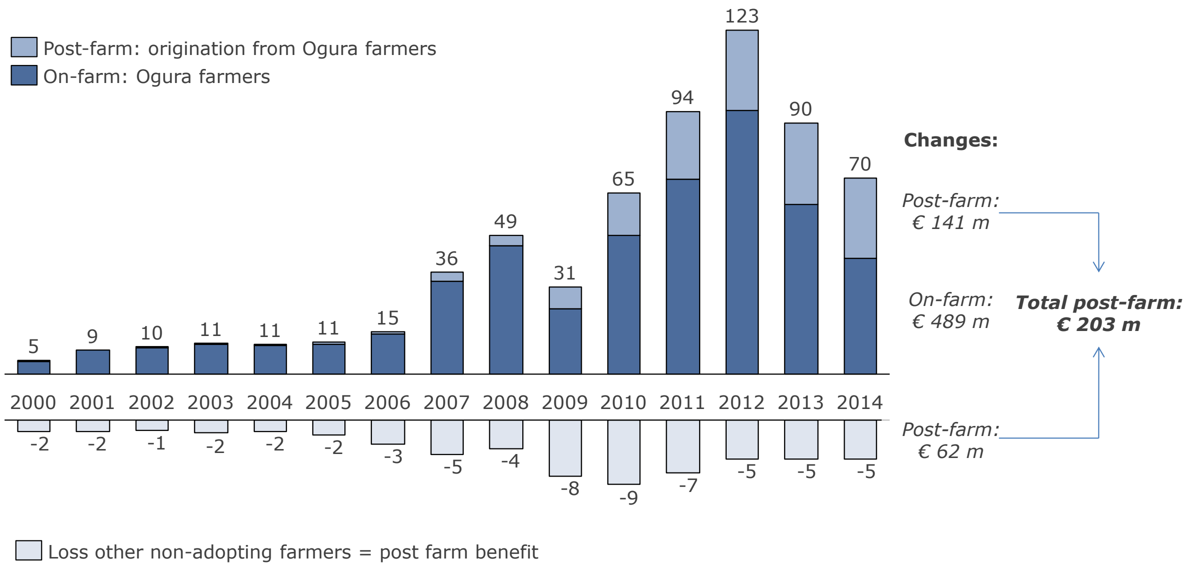

Exhibit 11: *Shift from on to post-farm benefits per year during 2000-2014 (€m)*

Exhibit 12 summarises the farmer benefits that relate to the extra yield and the shift in benefits from adopting and non-adopting farmers to post-farm. Here, we take the € 631 m (2000-2014, see also Exhibit 8) as starting point, which are the estimated farm benefits based on historical data. Subsequently, the price decrease results in € 141 m loss for hybrid (Ogura) farmers and € 62 m for other farmers using open-pollinated varieties, shifting € 203 m to post-farm (1/3 share of total).

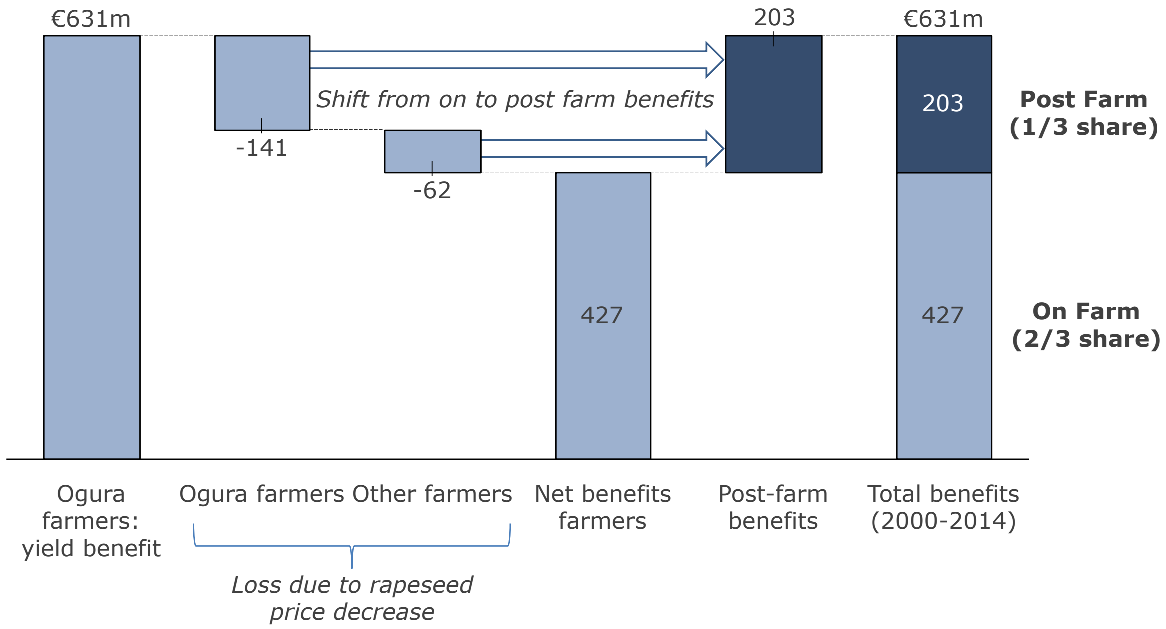

Exhibit 12: *On-farm benefits related to yield increase and benefit shift to post-farm related to price during 2000-2014 (€m)*

Knowing the estimated size of post-farm benefits, the question remains to which extent these trickle down to the consumer and for which products. There are no expected price changes for rape oil and biodiesel due to the nature of this chain. Oil demand for fuel use is highly elastic and therefore prices will hardly change when more rape oil is produced. However, more rape oil production provides also more rape meal to the market which demand is much more inelastic (i.e. significant price response). Therefore, rape meal prices will decrease and so will rapeseed prices as a consequence. This means that the post-farm benefits almost completely trickle down through the chain of livestock products and its producers and consumers.

The EC food price monitoring reports indicate that (processed) crop and feed prices typically travel down to the consumer with delay.[43] Also the analysis from CEREOPA and LEI-Wageningen University indicate that a change in protein-rich feed cost will most likely result in a change in consumer prices for milk and meat.[44]

Building on this research, it is expected that most of the € 203 m post-farm benefits will trickle down to the consumer in the short-term. However, feed costs are just a small portion of the consumer prices of livestock products, which will therefore have just a minor price effect per product.[45] In other words, the € 203 m is spread among many consumers.

5. Effects of IPR strength

In this section we consider how the distribution of economic benefits would have changed had Ogura been commercialised *either* without competition through exclusive use of patents *or* under full competition without an IPR system. In terms of Exhibit 1, we aim to analyse the difference between the exclusive (i.e. a stricter IPR regime), no IPR and non-exclusive use of IPR (i.e. actual situation of Ogura, where INRA grants non-exclusive licenses). For reasons of simplicity we focus on the interface between seed companies and farmers and hence distinguish two groups:

- Producer: INRA, seed companies and distributors
- Consumers: farmers, downstream industry and end-consumers

Because we cannot rely on observed data we must resort to modelling, which is described in the Appendix III. Essentially, using observed data, we derive a demand curve for Ogura technology, which describes at what seed price how many farmers decide to switch. That in return allows us to analyse how a rational producer would maximise its revenues.

The results presented hereafter of this single case study cannot be generalised as the optimal IPR use in agriculture depends on the technology itself as well as on local market dynamics.

5.1 Exclusive use for Ogura would lower uptake from 80% to 60%

Exclusive use of the innovation will grant more market power for the producer. But this greater market power does not mean unconstrained pricing power. If the producer prices the seed too high, adoption will be small and revenues will suffer whereas when it prices the seed to low, adoption will be high but margins will suffer. It turns out, as shown in Exhibit 13, that the optimal price for the producer will be € 11/kg higher than under non-exclusive patents, i.e. a € 24/kg premium on open-pollinated seed versus the actual € 13/kg premium.

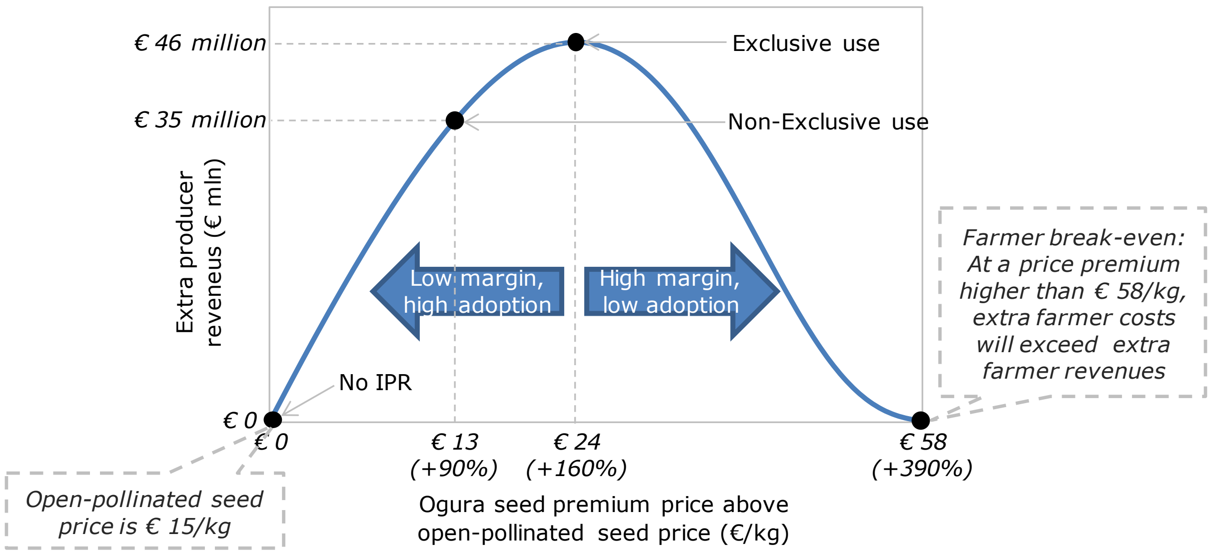

Exhibit 13: *Optimal Ogura seed pricing for maximum producer revenues*

Based on historical adoption data and using 2012 crop prices, the model shows that the percentage of farmers that adopt Ogura at this higher price decrease from 80%[46] to 60%; the higher seed price lowers the earnings per hectare such that 20% of the farmers deem them insufficient to switch. Relative to the actual premium of € 13/kg, producer revenues will go up 31% from € 35 million to € 46 million in 2012.

Although Exhibit 13 illustrates the increased market power coming from more IPR protection, it also shows that the pricing power of the producer is not unlimited. Whereas it is often assumed that patent holders are de-facto monopolists, the reality is that their market power is constrained by the presence of alternatives and the heterogeneity of individual farmer preferences.

In other words, it is the quality of the product in comparison with market alternatives and the heterogeneity of farmer appreciation of the technology that determine producer revenues and not just the strength of its IPR.

5.2 Exclusive use increases innovators' incentive and lowers current welfare

The 20% lower Ogura uptake causes the total economic benefits for society, or social welfare, to decrease by € 46 million (or 29%), in 2012. The consumer benefits will decrease by € 57 million (or 46%) whereas the producer benefit will increase with € 11 million (or 31%). A detailed explanation of these results is presented in Appendix III.3.

The larger producer benefit for the innovator acts as a larger incentive for the private sector to invest in R&D than under non-exclusive use of patents and thus increases the probability of innovations happening. This is particularly relevant as the private sector has overtaken the role from the public sector as largest investor in ag innovation. For example, since 2000 the private sector accounts for 80% of total R&D Oilseed Rape R&D.

Other research, summarised in Appendix III.4, has shown similar results for producer-consumer benefits once an innovation is made available to the market.

5.3 Non-Exclusive use seems appropriately balancing present and future benefits

The results presented in Section 5.2 enable a more in-depth exploration of the trade-off outlined in the research objective in Section 1.4. Exhibit 14 shows the consumer benefits (which accrue to farmers, processors and end-consumers) once the innovation is commercially available versus the producer benefit, which is used as proxy for the incentive to innovate. This seems a reasonable proxy as the variables that drive the ex-post producer benefits move in the same direction as the ex-ante incentive. In other words, when a producer would have perfect foresight of market conditions (e.g. crop prices, farmer willingness to adopt), its expected returns would largely influence its incentive.

Going to the left in Exhibit 14 from the actual case of non-exclusive licensing to the no IPR case shows that consumer benefit would increase with € 51 million (+41%), however at the cost of € 35 million producer profit and thus the elimination of the innovation incentive. The total social (i.e. consumer and producer) benefit would increase modestly with € 16 million (+10%). Going to the right to the exclusive patent case decreases consumer benefit with € 57 million (-46%) while it somewhat increases the producer benefit by € 11 million (+31%). The total social benefit would decrease by € 46 million (-29%).

The absence of IPR would lead to a modest increase of social consumer benefit at the very considerable cost of eliminating the innovation incentive and thus the probability of improved products becoming available in the future. Exclusive use of patents on the other hand would, in this case, modestly increase the innovation incentive at a substantial social cost.

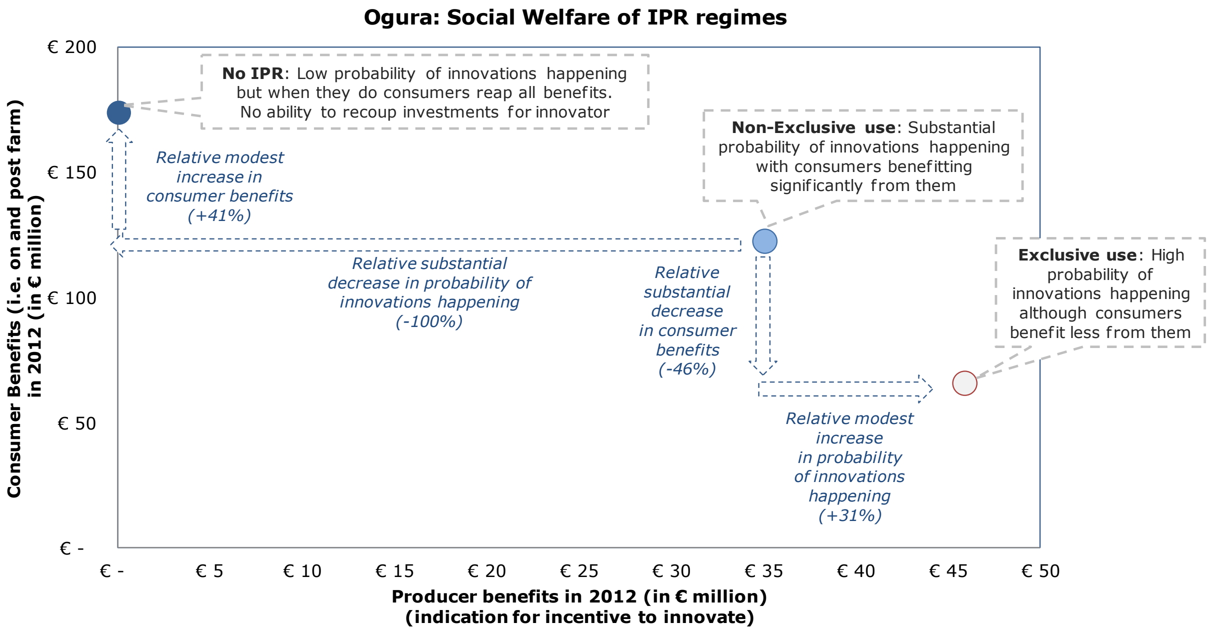

Exhibit 14: *Social welfare of Ogura under different IPR regimes in 2012. The consumer and producer benefits for these regimes are respectively: No IPR (€ 174 million, € 0), Non-Exclusive use (€ 123 m, € 35 m) and Exclusive use of patents (€ 66 m, € 46 m)*

In other words, the absence of IPR would increase the probability of missing innovation substantially, while exclusive use provide some increase to innovation incentive with a relative considerable cost for the consumer. Thus it seems that the non-exclusive use of patents has struck an appropriate balance between the current and future benefits. It is important to note that one cannot generalise based on the results of a single case study and the validity of the applied heuristic logic depends on many factors, prime among which the dependence of the incentive to innovate on the expected profits[47] and expectations about market prices for the crop. Therefore, the optimal IPR use in agriculture depends on the technology itself as well as on market circumstances.

6. Other socio-economic effects of Ogura

Section 4 highlighted the Ogura benefits for the farmers, seed companies and technology provider. However, the effects are not limited to economic costs and benefits. This section summarises the effects on resource efficiency and the employment effects of extra farm income.

6.1 Ogura reduces carbon footprint with 66 kg per ton of Oilseed Rape

According to other research on OSR production, water and energy use during drying and storage depend on the size of production, while other energy, fertilizer and pesticides use depend on the hectares of land used. As presented in Section 3, Ogura leads to 8% higher yields on average for OSR production. Therefore, producing an extra 330,000 tons OSR implies higher resource efficiency (see Table 1).

	Diesel	Fertilizer	Pesticide
Savings per tonne OSR	1.8 l	7 kg	0.07 kg
Total savings in 2012 (related to an extra 320,000 tonnes OSR)	7.9 million l	28 million kg	0.3 million kg

Table 2: *Estimated resource efficiency for OSR production related to Ogura in 2012*

When combined, the savings during the OSR production translate into a 66 kg carbon reduction per tonne[48] and almost 300,000 tonne CO_2-emissions in total, which is almost as much as the annual emissions of 150,000 cars.[49] With the 2008-2013 average market price of € 10 for a tonne of CO_2 emission this is equivalent to € 3 million. The broader environmental effects of Ogura are currently under examination by INRA.[50]

6.2 Annual € 123 million extra farm benefits results into almost 1,200 jobs

From 2000 - 2014, farmers earned € 631 million extra income due to higher yields from hybrid Oilseed Rape. The re-spending of the extra incomes on goods and services (i.e. induced economic effects) supports jobs elsewhere in the economy. The majority of these supported jobs can be found in the various service sectors, as indicated in Exhibit 15. Especially since 2010, the number of job supported by these induced effects increased significantly to almost 1,200 jobs in 2012 and are associated with € 123 million extra farm benefits in 2012 (see Table 6 in Appendix II.3).

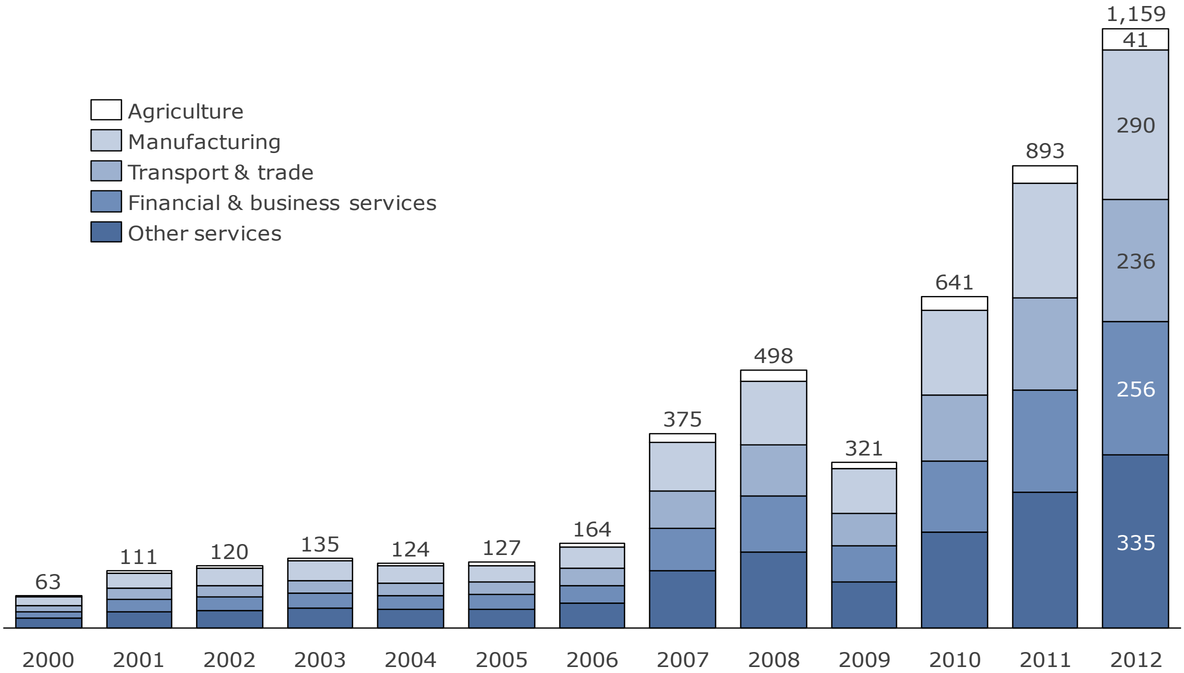

Exhibit 15: *Jobs related to re-spent of extra farm income (induced effects) 2000-2012*[51]

7. Recommendations

This report shows the trade-off between current and future benefits of IPR for ag innovation. In order to further validate the findings presented we recommend to:

- Apply the framework for other crops and markets in order to verify whether the conclusions on the effect of IPR strength on social welfare can be generalised;
- Investigate in greater depth the dependence of the innovation incentive on IPR regimes. In this report we have used the ex-post producer benefits as a proxy for the incentive to invest in (the next round of) innovation. By analysing trends of IPR strength and ag innovation using larger data sets this can be substantiated more.

Appendix I: Framework

I.1 Literature review social welfare of IPR use for ag innovation

The use of IPR for agricultural innovation and its effects on social welfare is discussed in several research papers. Many papers discuss the ex-post benefits and surplus division once the technology is in place, but also underline the importance of the ex-ante incentive for innovation.

Within the economic literature, IPRs are defined as economic institutions designed to address existing market failures that disincentivise R&D investment.[52] IPRs are meant to promote R&D investment and introduction of successful innovations by rewarding innovators with (temporary) market power on these products. In this way, innovators are better able to recoup their R&D investment.

An optimal IPR regime is a balance between innovation incentives and societal benefits. Therefore, IPR regimes must both encourage incentives for innovators and minimise the economic losses related to the market power of innovators (i.e. consumers losses as a result from high prices that exceed the market equilibrium, and the associated deadweight losses).[53]

IPRs are pull mechanisms that encourage the incentive to innovate through more stable, larger or efficient markets by increasing the expected innovator benefits.[54] For policy makers, pull mechanisms such as IPRs are attractive instruments because they do not request any ex-ante funding commitments, in contrast with push mechanisms such as research grants, tax reductions, etc. On the other hand, IPR regimes do require investments in effective enforcement and legislation.[55]

In short, the social welfare of agricultural innovation depends on the incentive to innovate (ex-ante) and the size of benefits during commercialisation (ex-post). The maximum welfare is obtained when maximising:

The number of successful innovations incentivised

x

The size of (consumer) benefits during product commercialisation

I.2 Definition 'size of benefits during commercialisation'

In this study we define the 'size of benefits' as the total net benefit created by Ogura in the entire value chain, consisting of the following actors: technology provider, seed company, distributor and farmer. Although in this research we allocate all benefits at the end of the chain to the farmer, in reality part of these benefits will leak away to downstream actors because wide adoption of Ogura will increase yields and thus lower OSR market prices. In general, yield-increasing technologies have a decreasing effect on crop prices[56], and would lead to benefits of downstream industry (food, feed, energy production) and end-consumers. This effect is quantified in a Bt soy study, where the total benefit remains the same, but the farmer share is divided with industry and end-consumers.[57]

Farmer benefits are divided into hurdle profit and surplus. Surplus is what farmers ex-ante perceive as benefit, while the total benefit is the actual total income created by the new technology (see also Appendix II and III). While the innovator and seed company surplus is closely related to their gross margin, the consumer surplus is the difference between what consumers pay and their ex-ante willingness to pay.[58] For example, while a farmer would increase earnings at a seed price premium of € 20 per kg, he may only switch when the premium is € 10. This means that at a price premium of € 10 his economic surplus (perceived benefit) is zero, although the adoption will increase his profits. In this report we have looked at the total benefit, i.e. the sum of hurdle profit and surplus.

The strength of an IPR regime affects the level of competition and the size of the benefits.[59] A strict IPR regime will lower competition, increase prices, lower uptake and therefore decrease the size of the benefits. The size of benefits under patent use can also vary depending on its effects on the Freedom to Operate (FTO).[60] The number of patents needed to commercialise a product and the number of patent holders have a large effect on the FTO as these factors increase the hurdle for a technology provider or seed producer to develop technologies and products in terms of access and costs.

I.3 Definition 'incentive to innovate'

The economic incentive for an innovator depends on the size of the expected benefits and the difficulties and risks to obtain these benefits. Protection through IPR gives the innovator more market power, which enables him to recoup investments and earn profits for shareholders and new innovations. Stronger IPR give innovators the ability to gain a larger benefit of their new technologies, which encourages R&D investment.[61] These incentives explain to a large extent the behaviour of the private sector according to the neo-classical economic theory, but not or to a limited extent public sector behaviour regarding R&D investments.

Appendix II: Economic benefits and benefits division of Ogura

II.1 Revenues, costs and benefits of technology provider INRA

Revenues

The INRA Ogura license revenues are estimated based on:

- Royalties of 1991 patents (4% royalty over licensee revenues, i.e. seed companies) and 1996 patents (1% royalty)
- Market share information of the French seed association (UFS) and seed price information of AMIS Global database of Phillips McDougall

The revenues originating from the French market are summarised in Table 3. Until 2011, France represented almost 30% of global revenues.

Year	Cumulative royalty rate	Total Ogura license revenues in France (in € million)
2000	5%	€ 0.3
2001	5%	€ 0.5
2002	5%	€ 0.5
2003	5%	€ 0.6
2004	5%	€ 0.6
2005	5%	€ 0.7
2006	5%	€ 0.7
2007	5%	€ 1.2
2008	5%	€ 1.7
2009	5%	€ 1.8
2010	5%	€ 2.3
2011	5%	€ 3.5
2012	1%	€ 0.7
2013 (est)	1%	€ 0.7
2014 (est)	1%	€ 0.7
2015 (est)	1%	€ 0.7
2016 (est)	1%	€ 0.7
Total		**€ 17.8**

Table 3: *INRA Ogura license revenues and royalty rate in France*

Costs

An estimate of INRA's Ogura investments are derived from the R&D breakdown of hybrid seeds listed in Table 4 and INRA-transfert documents and interviews, the license management body of INRA. According to INRA-transfert, Ogura was licensed halfway the proof of concept phase. Therefore, 100% of the 'discovery' costs and 50% of the 'proof of concept' phase are allocated to INRA. Together, the total INRA research investments sum up to € 5 million. As the scope of the study is France, we have used OSR production in France as share of total European production to allocate costs to the French market (€ 1.4 million based on 26% European OSR share).

R&D phases hybrid seed	Investments (€ million)		
	Minimum	Maximum	Middle
Discovery: Basic research, idea identification	€ 1	€ 4	€ 3
Phase I: Proof of Concept	€ 4	€ 7	€ 6
Phase II: Early development	€ 7	€ 11	€ 9
Phase III: Advance development	€ 11	€ 22	€ 17
Phase IV: Pre-launch	€ 0.7 per variety		

Table 4*: R&D phases of hybrid seed*[62]

II.2 Revenues, costs and benefits of seed companies

Revenues

The seed company benefits represent the extra revenues of selling Ogura hybrids in France. These extra benefits are equal to the Ogura price premium multiplied with the quantity Ogura hybrids sold *minus* the Ogura royalty payments (see Appendix II.2). It is assumed that the production costs of Ogura and open-pollinated seeds are similar. The French seed market data is based on UFS and AMIS global information. The seed company benefits are presented in Table 5 and the Ogura market share since introduction in Exhibit 2.

Year	Extra seed company Ogura revenues (€ million)	Royalty Costs (€ million)	Seed company net benefits (€ million)
2000	€ 1.9	€ 0.3	€ 1.5
2001	€ 2.7	€ 0.5	€ 2.3
2002	€ 2.8	€ 0.5	€ 2.4
2003	€ 3.2	€ 0.6	€ 2.7
2004	€ 3.5	€ 0.6	€ 2.9
2005	€ 3.7	€ 0.7	€ 3.1
2006	€ 4.1	€ 0.7	€ 3.4
2007	€ 7.6	€ 1.2	€ 6.4
2008	€ 10.8	€ 1.7	€ 9.1
2009	€ 13.4	€ 1.8	€ 11.6
2010	€ 17.0	€ 2.3	€ 14.7
2011	€ 29.9	€ 3.5	€ 26.4
2012	€ 26.6	€ 0.7	€ 25.9
2013 (est)	€ 26.6	€ 0.7	€ 25.9
2014 (est)	€ 26.6	€ 0.7	€ 25.9
2015 (est)	€ 26.6	€ 0.7	€ 25.9
2016 (est)	€ 26.6	€ 0.7	€ 25.9
Total	**€ 233.9**	**€ 17.8**	**€ 216.0**

Table 5: *Seed company net benefits of Ogura in France 2000-2016*

Costs

The upfront Ogura development costs of the seed company can be separated into European and country specific investments. Phase I (50% for seed company), Phase II and Phase III as listed in Table 3 are European investments, while Phase IV are country specific investments. According to Monsanto UK, an estimated number of five seed companies have taken full development costs at the European level. Furthermore, 'AMIS Global' reports that 23 Ogura varieties have been introduced in the French market since 2000. Therefore, the development costs for France can be estimated as follows:

- Ogura development costs in Europe (Phase I - III): 5 firms x € 29 = € 144 million
- Ogura development costs in France (Phase I - III), allocated based on French OSR production in Europe: 26% x € 144 million = € 37 million
- Phase IV: € 0.7 million x 23 varieties = € 17 million
- Total development costs in France (phase I - IV): € 17 million + € 37 million = € 54 million

II.3 Revenues and benefits of farmers

The farmer benefits in the study represent the extra benefits of farmers that have adopted Ogura. In other words, the extra yield multiplied with the OSR price *minus* the extra seed costs. The production data, Ogura market share and seed costs information are based on Eurostat, Prolea, UFS and AMIS Global seed market data and presented in Table 6.[63]

Year	Extra revenues Ogura farmers (€ million)	Extra seed costs (€ million)	Net farmer benefits (€ million)
2000	€ 7	€ 2	€ 5
2001	€ 12	€ 4	€ 9
2002	€ 13	€ 4	€ 10
2003	€ 15	€ 4	€ 11
2004	€ 15	€ 5	€ 11
2005	€ 16	€ 5	€ 11
2006	€ 21	€ 5	€ 15
2007	€ 46	€ 10	€ 36
2008	€ 63	€ 14	€ 49
2009	€ 48	€ 17	€ 31
2010	€ 87	€ 22	€ 65
2011	€ 133	€ 39	€ 94
2012	€ 158	€ 35	€ 123
2013	€ 124	€ 35	€ 90
2014	€ 105	€ 35	€ 70
2015 (est)	€ 105	€ 35	€ 70
2016 (est)	€ 105	€ 35	€ 70
Total	**€ 1,075**	**€ 304**	**€ 771**

Table 6: *Farmer costs and revenues during Ogura patent life (2000-2016)*

Appendix III: Analysis of on and post benefits in OSR value chain

III.1 A demand curve for rapeseed

Exhibit 16 summarises the theory regarding fuel crop market dynamics. There is probably no other crop than rapeseed that is so intensively used for fuel production, especially in the EU (i.e. two-third of rape oil for biodiesel production). The first graph shows that OSR crop demand is the combination of fuel and food demand. Left from point (P’, Q’) there is no fuel demand, which could be the results of food shortages or low fuel prices making biofuel production less attractive.

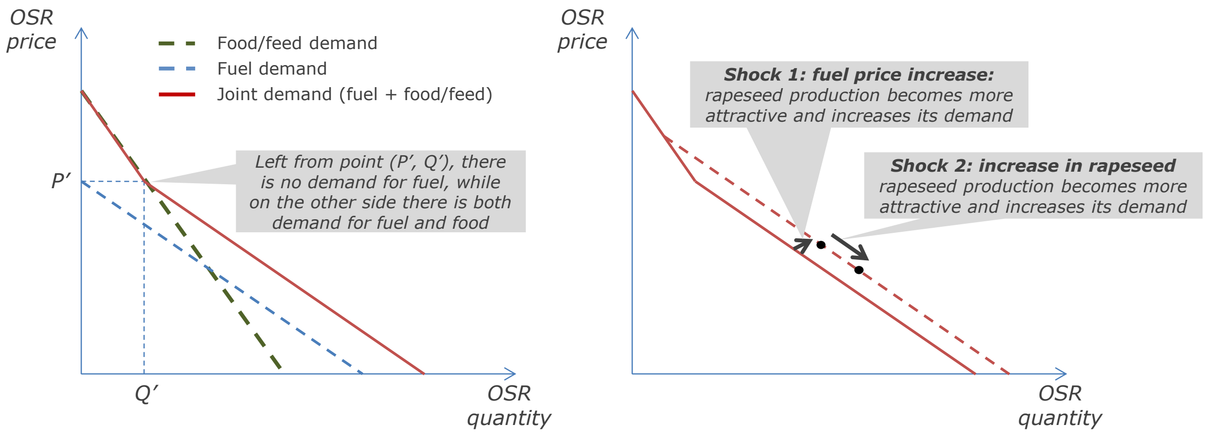

Exhibit 16: *Theory of rapeseed market dynamics*[64]

The second graph in Exhibit 16 shows two possible shocks in the rapeseed market. *Shock 1* shows the effect of an increase in the fuel price. This will increase the attractiveness of rapeseed production and therefore the demand curve shift to the right. *Shock 2* is an increase in rapeseed production (e.g. because of new technology or extra land in production), which will have a lowering effect on the crop price. The size of the price decrease depends on the slope of the demand curve.

In our research, we analyse the effects of the Ogura-related supply shock (similar to *shock 2*). Since the introduction of Ogura seeds, there has been rape demand for fuel (see Exhibit 19), so therefore we focus only on the construction of demand curve for fuel, right from point (P', Q') in Exhibit 16. Consequently, a rapeseed demand curve can indicate the effect of a supply shock on prices and consequently the shift from on- to post-farm benefits.

In principle, the rape demand for fuel is almost perfectly elastic resulting in a vertical demand curve and mainly driven by the fuel price and biofuel quota (see also Exhibit 19).[65] However, as also explained in Section 4.3, crushing of rapeseed into rape oil for fuel demand produces also the by-product rape meal with more inelastic demand. Therefore, the demand curve is the weighted average of fuel and meal demand, see Exhibit 17. The slope of the meal demand is based on the historic info of rape meal prices and its supply (see Exhibit 20).

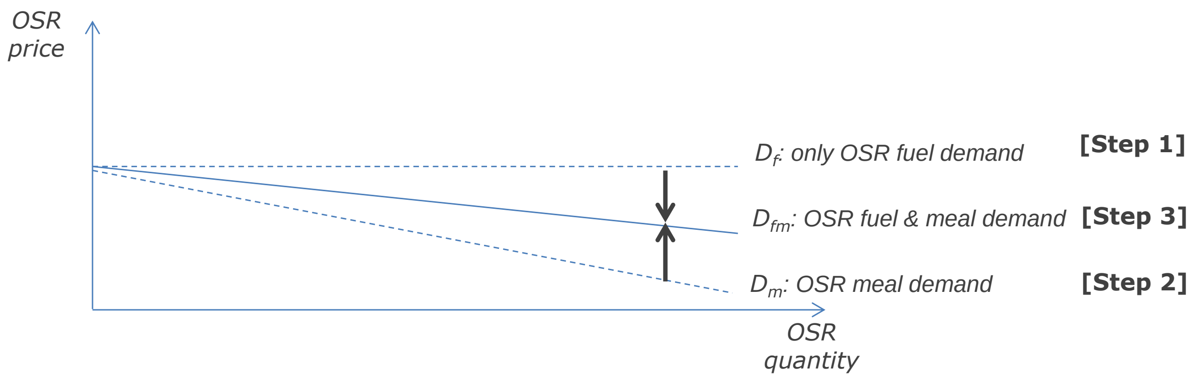

Exhibit 17: *Construction of rapeseed demand curve based on weighted average of rapeseed fuel and meal demand*

In the remaining part of this section, we explain how the demand curve was constructed for the year 2012 (see Exhibit 18) and a similar procedure is used for all the other years during 2000-2014. As a starting point, the demand curve for fuel is drafted as a vertical line (perfectly elastic) through the actual rapeseed quantity and price of 2012.
Secondly, we integrate the meal demand into the rapeseed demand curve:

- Extra EU rape meal increases the price gap between soy meal and rape meal (i.e. soy meal price premium): from 2000-2014, every extra million ton rapeseed resulted on average in € 15.6 per ton price premium. We interpret this as the lowering effect on the rape meal price because of extra rape meal production.
- A lower rape meal price decreases the benefits of the crusher.
- The lower crusher benefits are balanced out by lower rapeseed prices (see also explanation III.2)

This procedure translates an expected decrease of rape meal prices into a decrease of the rapeseed price in 2012 and thus the demand curve we set out to construct.

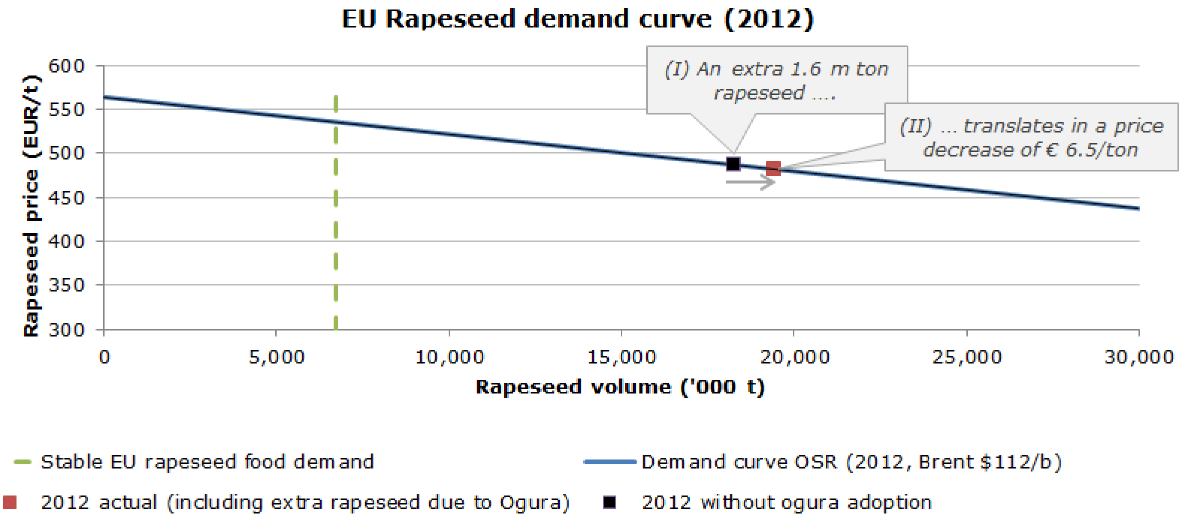

Exhibit 18: *EU rapeseed demand curve in 2012*

Using the rapeseed demand curve in 2012, we estimate that an additional 1.6m ton in the EU (i.e. supply shock related to Ogura seed adoption) translates into a price decrease of € 6.5/ton. Accordingly, we can use this price decrease in the EU to estimate the benefits that shift from on- to post-farm in France. In 2012, French rapeseed farmers produced 5.29 m tons, which is sold for € 6.5/t lower price due to Ogura. This shifts 5.29 m ton x € 6.5/t = € 34.3 m from French farmers (adopting and non-adopting) to post-farm (see also table 8).

Similarly, we estimated the EU demand curve and supply shocks for each individual year and its consequence for post-farm benefits in France. Appendix III.4 summarizes the key results using these demand curves.

Theoretically, an increase in biofuel volumes could also decrease fuel prices and consequently prices of biofuel, rape oil and rapeseed), but is unlikely due to the relatively low extra biodiesel volume related to Ogura vs the total fuel market.[66]

III.2 Balancing out price changes in the biofuel chain

According to Schmidhuber (2007),[67] prices in the biofuel chain are highly related to oil prices "*once oil prices have crossed a certain threshold making biofuels competitive*". Based on this relationship, prices in the biofuel chain seem to balance out competitive advantages vs oil after each change "*until the competitiveness of biofuels with fossil fuels equalises*". Hertel and Beckman (2011)[68] seem to underline these relationships, but also emphasise that evidence could be improved by larger historical datasets.[69] Building on this initial evidence, we assume that lower crusher profits is balanced out by lower rapeseed prices (i.e. equalizing lower rapeseed costs for the crusher with lower benefits from rape meal).

III.3 Market relations in the rapeseed value chain

Here, we summarize key relations in the OSR chain that also have been used in drafting the demand curve. The left-hand side of Exhibit 19 shows that the extra rape oil production in the EU since 2003 is completely used for fuel and is largely driven by the fuel price. The correlation between fuel price and rape oil for fuel production one year later is high (0.87). This is a strong indication that higher fuel prices significantly increase the incentive to produce rapeseed and rape oil.

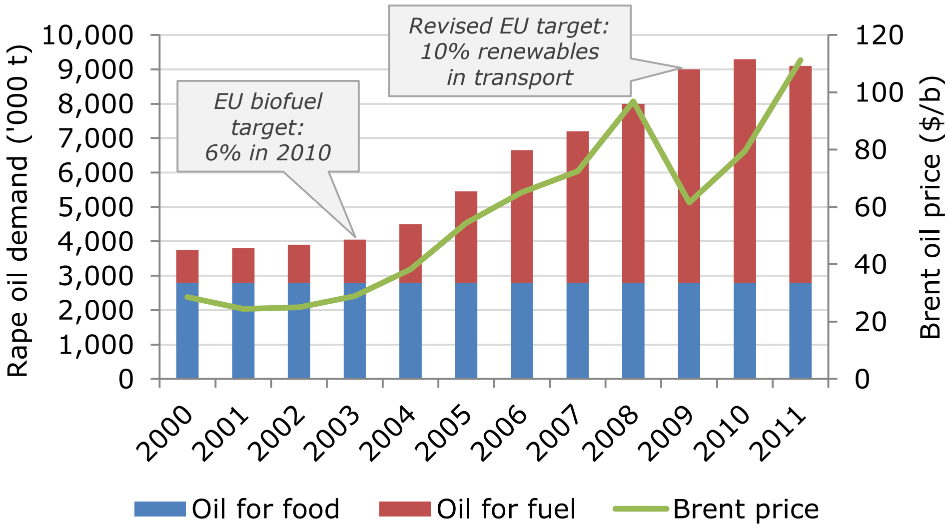

Exhibit 19: *Rape oil consumption vs Brent oil price (i.e. correlation between Brent oil price and EU rape oil production one year later is high: 0.87)*

Rapeseed is also used for producing rape meals, a by-product during the crushing process to produce oil. Rape and soy meal represent almost the full market of protein-rich feed for livestock in the EU and are partly substitutes for several feed markets.[70]

The left-hand side of Exhibit 20 shows that the price difference between soy and rape meals (i.e. soy meal premium) increased in line with the increased rape meal production in the EU. Based on the comparison between this premium and the additional EU rape meal on the market, we can derive the following relation: every extra million ton rape meal increases the premium with € 15.6 per ton (i.e. regression coefficient in Exhibit 18, see right-hand side), with a high correlation of 0.82.

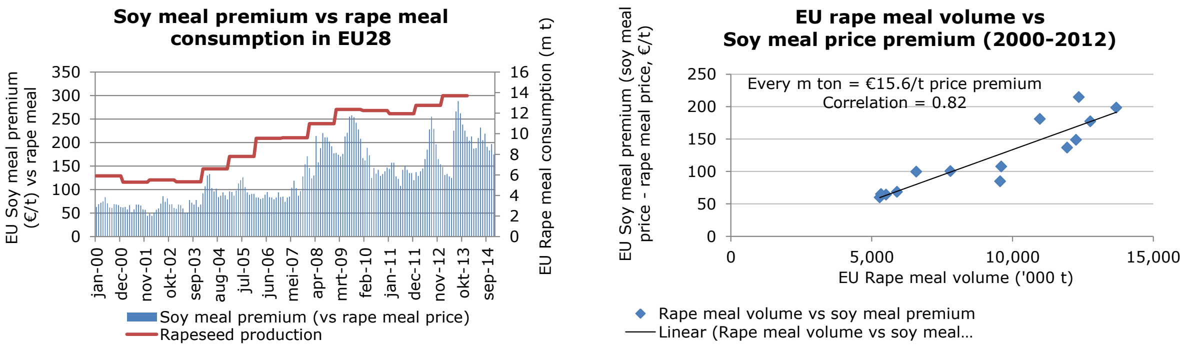

Exhibit 20: *Soy meal premium (i.e. price difference soy and rape meal) in comparison to rape meal consumption in EU 28 (left), and EU rape meal volume relation with soy meal price premium (right)*

III.4 Results estimated rapeseed price changes, on- and post-farm benefits

See below the estimated price changes due a 'supply shock' of rapeseed and its effects on and post-farm benefits.

Year	Ogura farmers yield benefit (€ million)	Price change (€/ton)	Production Ogura farmers (million tons)	Loss due to price (€ million)	HR on-farm benefit after price correction (€ million)
2000	5	0.3	0.5	0.2	5
2001	9	0.4	0.8	0.3	8
2002	10	0.3	0.8	0.3	9
2003	11	0.4	0.9	0.4	11
2004	11	0.4	1.0	0.4	10
2005	11	0.5	1.1	0.6	11
2006	15	0.9	1.2	1.0	14
2007	36	1.5	2.0	3.0	33
2008	49	1.5	2.5	3.7	46
2009	31	3.0	2.5	7.5	23
2010	65	4.6	3.3	15.1	50
2011	94	6.0	4.0	24.0	70
2012	123	6.5	4.4	28.8	94
2013	90	6.3	4.4	27.9	62
2014	70	6.5	4.4	27.9	42
Total	**631**	**n/a**	**34**	**141**	**489**

Table 7: *Effects of yield and price change on Ogura farmers in France (2000-2014)*

	Price change (€/ton)	Production other farmers (million ton)	Loss other farmers (€ million)	Total post-farm of rapeseed farmers (€ million)
2000	0.3	4.5	1.6	1.7
2001	0.4	4.2	1.5	1.8
2002	0.3	4.2	1.4	1.7
2003	0.4	4.1	1.8	2.2
2004	0.4	4.0	1.6	2.0
2005	0.5	4.0	2.1	2.6
2006	0.9	3.9	3.4	4.4
2007	1.5	3.1	4.8	7.8
2008	1.5	2.7	4.0	7.7
2009	3.0	2.6	7.9	15.4
2010	4.6	1.9	9.0	24.1
2011	6.0	1.2	7.4	31.5
2012	6.5	0.8	5.5	34.3
2013	6.3	0.8	5.3	33.2
2014	6.3	0.8	5.3	33.2
Total	**n/a**	**43**	**62**	**203**

Table 8: *Effects of yield and price change on other rapeseed farmers and total effects on rapeseed farmers in France (2000-2014)*

Appendix IV: Effects of IPR strength

IV.1 Definition producer and consumer

All actors in the value chain are grouped into two groups, 'Producer' and 'Consumers' in order to be able to compare other IPR regimes with the actual regime (i.e. non-exclusive use of patents). This also allows for better comparability with other research. The Producer includes all parties that have been involved in bringing the seed technology to the market: technology provider INRA, seed companies and distributor. The Consumers include all the parties that benefit from improved Oilseed Rape production: farmer, downstream industry and end-consumers.

IV.2 Drivers for Ogura uptake

The overview below gives a brief description of all drivers for Ogura uptake:

- Seed price: strict IPR regimes limit competition and increase prices, which lower uptake
- Crop price: a higher crop price increases earnings per hectare of farmers. Therefore, uptake of Ogura seed will have more impact on extra revenues when OSR prices are high;
- Heterogeneity of farmers: Dillen[71] demonstrated that for other ag innovations the benefit sharing is a direct reflection of the heterogeneity of farmers' technology valuation. Therefore, each farmer ex-ante perceives and values new technology differently and makes his own choice whether and when to adopt a new technology.
- Farmer economic benefit of new technology: the economic benefit describes the value for the farmer when adopting a new technology. The three main benefits are: yield increase, decrease of production costs and increase in crop value. Other benefits could be lower volatility in crop yields, lower environmental footprint, etc.

IV.3 Derivation of demand curve for Ogura seed

The essence of the economic model is the derivation of the demand curve for Ogura based on farmer economics. Each farmer makes an individual decision to adopt hybrids depending on the extra earnings per hectare. Extra earnings are driven by: changes of the crop price, yield increase of hybrids and higher seed price for hybrids. Market behaviour therefore is described as a lognormal probability distribution of switching decisions. The distribution indicates the percentage of farmers that will have switched for a particular earnings increase. Using this procedure, the demand for hybrid seed can be estimated and is converted from an exogenous into an endogenous variable, which incorporates crop price change, yield change of hybrids and seed price changes.

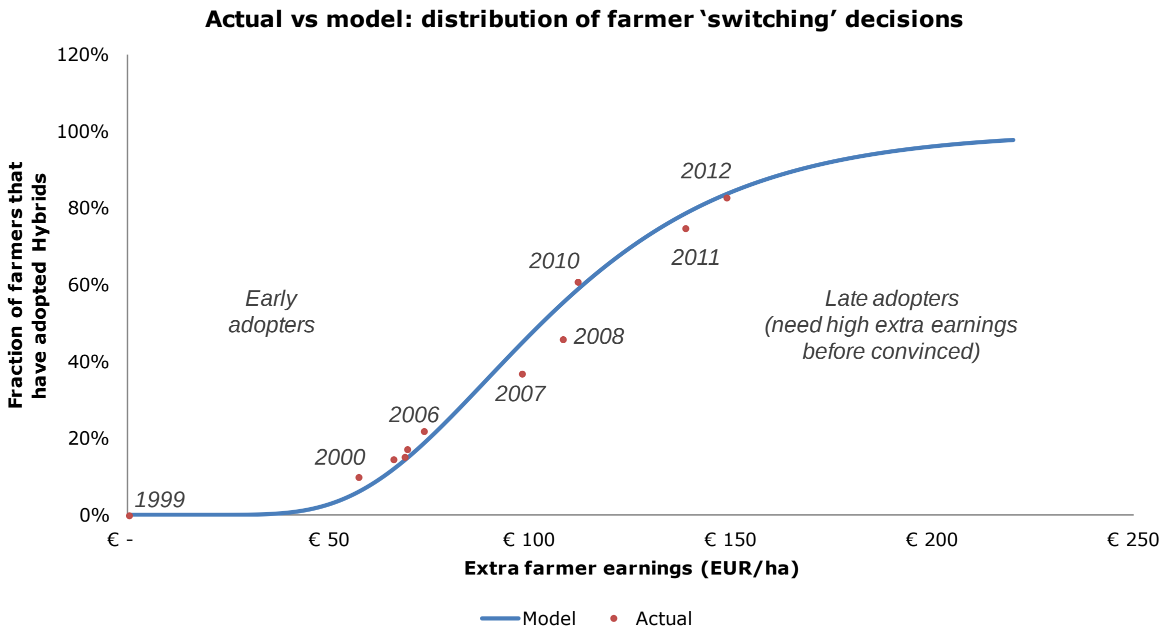

Exhibit 21: *Distribution of farmer 'switching' decisions*

The (cumulative) probability distribution in Exhibit 21 describes the switching decisions of farmers based on extra farm earnings related to Ogura. The growth in hybrid market share and farmer earnings translate into a probability distribution using a Least Squares fitting procedure. The estimated probability distribution reflects the switching decisions of each individual farmer.

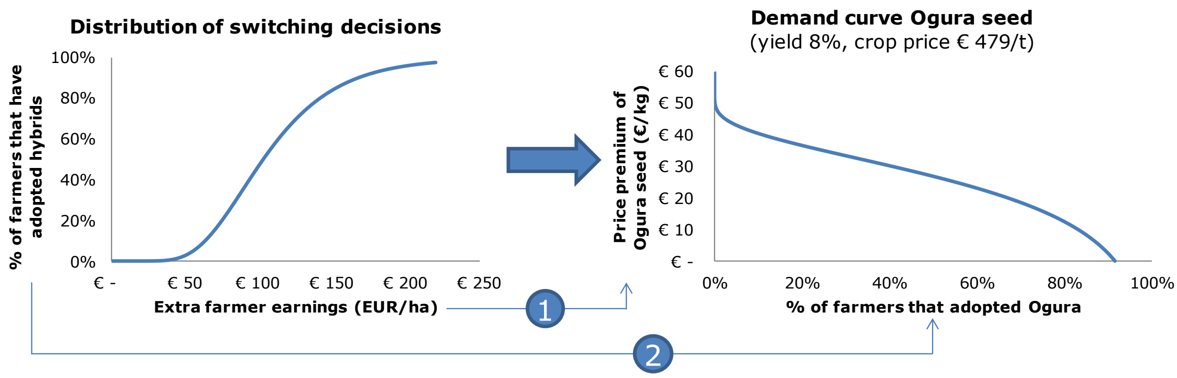

Exhibit 22: *Derivation of seed demand curve from distribution of switching decisions*

As presented in Exhibit 22, the demand curve for Ogura seed is derived from the probability distribution of market share and farmer earnings. The price for Ogura seed at which a farmer switches can be calculated for any given crop price and yield increase. By plotting these seed prices against the fraction of farmers that have adopted hybrids one obtains the demand curve which indicates the fraction of farmers that have adopted Ogura at each seed price premium.

IV.4 Breakdown of Ogura results for No IPR, Exclusive and Non-Exclusive use

Exhibit 23 shows the price equilibrium of exclusive use of patents versus the actual situation of non-exclusive use for Ogura. Under exclusive use, the producer has more freedom to set prices, but still has to consider the factors mentioned in Appendix III-2. From a producer perspective the revenue-maximising price depends on yield increase and crop price. For Ogura in 2012, the producer's optimum price premium is € 24/kg (see Exhibit 7). A lower price premium will lower margins and thereby decrease revenues (left-hand side), while a higher premium (right-hand side) would lower uptake levels to also decrease revenues. This optimum price caps the producer's surplus in 2012 at € 46 million in 2012 (see Exhibit 9).

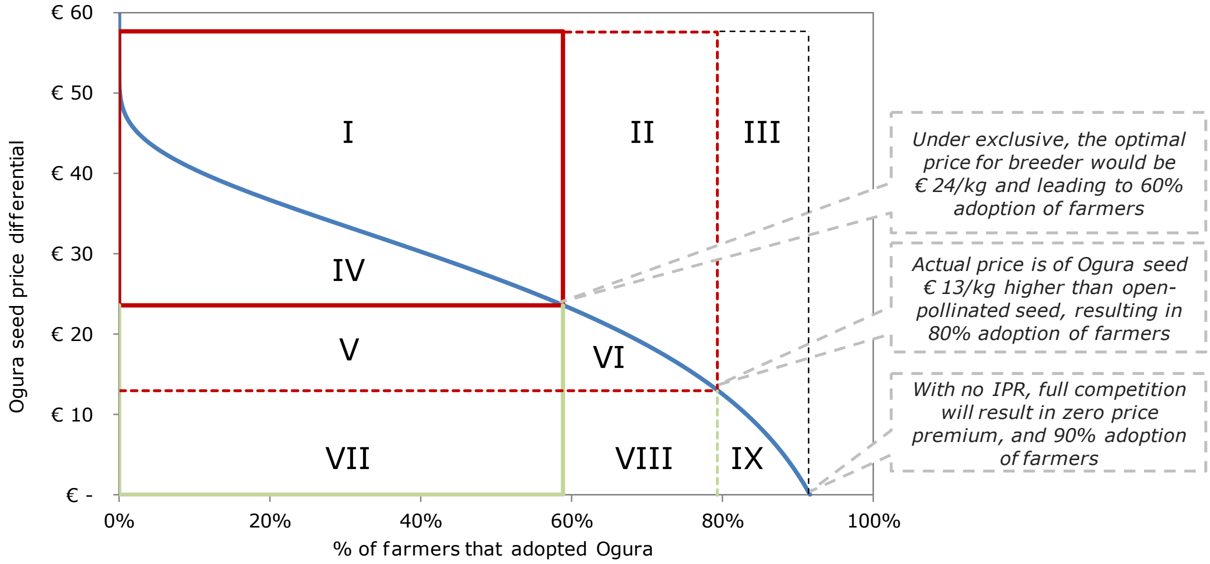

Exhibit 23: *Price equilibrium under No IPR, exclusive and non-exclusive use of patents in 2012*

The demand curve in Exhibit 23 shows that a price premium of € 24/kg corresponds with a 60% farmer uptake under exclusive use, € 13/kg premium (non-exclusive licensing) results in 80% uptake, and no premium (no IPR) in 90% uptake. Table 9 describes the outcome in terms of consumer and producer benefits as a result of the price premium and uptake. The producer surplus is described by the area between the x-axis, uptake level and the price premium. The consumer surplus represents the area below the demand curve and the price premium, while the hurdle profits is the area between the maximum price premium (€ 58/kg, break-even farmer) and the demand curve.

	No IPR	Non-exclusive use of patents	Exclusive use of patents
Consumer benefits	€ 174 million	€ 123 million	€ 66 million
Hurdle profits	I + II + III = € 94 million	I + II = € 78 million	I = € 46 million
Consumer surplus	IV + V + VI + VII + VIII + IX = € 80 million	IV + V + VI = € 45 million	IV = € 20 million
Producer benefits	-	VII + VIII = € 35 million	V + VII = € 46 million
Total benefits	**€ 174 million**	**€ 158 million**	**€ 112 million**

Table 9: *Consumer and producer benefits and related areas in demand curve (Exhibit 15) in 2012*

Exhibit 11 summarises the total benefits of Ogura during patent life under non-exclusive use (left-hand side, actual results) in comparison with exclusive use (right-hand side, model results). The producer benefit is similar to the producer surplus (i.e. gross margin of producer), while the consumer benefits can be broken down into consumer surplus and hurdle profits based on the equilibriums in Exhibit 15:

- Exclusive use: € 20 million consumer surplus, € 46 million hurdle profits (i.e. total consumer benefit of € 66 million)
- Non-exclusive use: € 45 million consumer surplus, € 78 million hurdle profits (i.e. total consumer benefit of € 123 million)

The total consumer benefit (i.e. including both hurdle profits and consumer surplus) under exclusive use is equal to 59% of total benefits (based on 2012 circumstances): € 66 million / € 112 million. This share can be compared with other studies:

- Benefits from BT cotton have been examined by several studies[72] and report a consumer benefit in the range of 51%-74%.
- Studies on herbicide resistant soybean[73] report a more divergent picture with total consumer benefit in the range 31-90%.

The consumer surplus (i.e. excluding hurdle profits) as share of total surplus is 31% under exclusive use, € 20 million / (€ 20 million + € 46 million), and can be compared among others with:

- Theoretical exercise of welfare effects under different IPR regimes (no IPR, PBR and strong patents) is executed by Perrin and Fulginiti.[74] The consumer surplus under strong patents ranges from 26-33% of total surplus.

Appendix V: Other socio-economic effects

V.1 Resource efficiency

The Ogura savings in terms of land use for OSR production are based on:[75]

- 1.6 million ha in 2012
- 3.1 t/ha open-pollinated seed yield and 3.35 t/ha Ogura seed
- 83% market share of Ogura seed in 2012

Therefore, the extra production using 1.6 million ha of land in France is:
(3.35 - 3.10 t/ha) x 1.6 million ha x 83% = 330,000 tonnes OSR.

Table 10 shows the resource efficiencies related to the extra OSR production.

OSR farm input (other than seeds)	Direct use	Total savings
Total fertilizer	293 kg/ha	31 million kg
N-fertiliser	*165 kg/ha*	*18 million kg*
P205 fertiliser	*59 kg/ha*	*6 million kg*
K20 fertiliser	*69 kg/ha*	*7 million kg*
Pesticides	2.8 kg/ha	0.3 million kg
Diesel (all activities and transport)	74 l/ha	7.9 million l
Electricity (storage, drying of OSR)	36.7 kWh/t	N/A (use per tonne)
Water	0.6 l/t OSR	N/A (use per tonne)

Table 10: *Resource efficiency per OSR farm input related to Ogura*[76]

V.2 Induced effects

The effects of re-spending farm income (i.e. induced effects) are based on:

- Extra farm income from 2000-2012 (see Table 5)
- Average spending pattern of French households on economic sectors originating from the French economic Input-Output table of GTAP 8[77]
- Average employment per 1 million revenues for each economic sector in France 2000 – 2012[78]

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