Profitable Genomic Innovation Challenges: A Canadian Canola Case Study

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Abstract:

As an innovation makes its journey from idea to commercialized product, it faces a series of decision points that determine whether to proceed or discontinue. While many of these decisions address features of the actual innovation itself, such as, prototype design and cost of production, some are external to the innovation. Taken in combination, all of these have the ability to determine whether the innovation is commercialized or falls into the valley of death. Using a static model, this paper models research and development and commercialization costs for genetically modified canola to test for variable sensitivities. Using internal rates of return (IRR) and net present value (NPV), the paper estimates the distribution of research benefits to: three multination enterprises; the rest of the industry; Canadian producers; Canada; and the rest of the world. Additionally, we examine how regulatory costs, regulatory timing, intellectual property rights costs, upfront research and development (R&D) subsidy and evenly distributed R&D subsidy affect the distribution of NPV and IRR to canola research.

Key Words: GM crops; intellectual property rights; investment decisions; net present value, rates of return; regulation; threshold

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1. Introduction

The ultimate question asked of any change in technology is 'qui bono?' or who benefits? Past waves of technological change in the agri-food sector have delivered a relatively straightforward distribution of benefits and costs (see Alston et al. 2000). Agricultural biotechnology has potentially rearranged the historical distribution of impacts. Whereas many of the innovations in the past were yield enhancing traits developed by public researchers and provided at low or no cost to producers, most of the agricultural biotechnology developments in canola, corn, cotton and soybeans have occurred in the private sector, protected by enhanced private intellectual property rights (IPRs) and commercialized through increasingly proprietary systems.

While the ability to protect the intellectual property (IP) that is generated while developing new plant varieties is now possible, it is unclear whether stronger IRPs have impacted the distribution of technology benefits. Large, rapid infusions of private capital into canola breeding and development depressed marginal rates of return and shifted the focus of much of the research away from broad yield enhancing research into narrower niche areas, such as herbicide tolerance and novel oil attributes. Also factored into this is the length of time it takes for development firms to receive approval for unconfined release of genetically modified (GM) plant varieties. The length of time and the cost of regulating GM crops has increased over the past 20 years. To that end, this paper models research, development and commercialization costs for GM canola to test for variable sensitivities. This paper builds upon the previous internal rates of return (IRR) research as it models the impacts of the external variables of IPRs and regulatory delays. Data is available for both public and private GM canola commercialization, which allows us to identify how internal and external variables play crucial roles in the innovation cycle. We demonstrate which of the external variables have the potential to most adversely affect genomic innovations.

This paper is structured to address five points. Section 2 provides the background to the issue and reviews the relevant literature to the topic. Section 3 provides the methodology applied within this paper. Section 4 offers an analysis and implications of the resulting data. Section 5 provides an assessment of the market following a series of shocks. Concluding thoughts are captured in Section 6.

2. Background

The funding of canola research in Canada has undergone many changes since its inception in the mid-1950s, when Agriculture Canada began a program to improve rapeseed. Over time research has shifted from a modest public research program to a large research industry dominated by private sector participation. Prior to 1973 all commercialized varieties were developed by the public sector, while in the 1990-98 period 86% of the varieties were private. By 2013, there were no publicly developed varieties undergoing field trials in Canada.

Beginning in the mid-1980s, a number of private research programs identified that canola would be an ideal plant to make tolerant to broad-spectrum herbicides. One of the challenges of evaluating the impact of new technologies is separating the specific research for herbicide tolerant varieties from the significant amount of ongoing research on canola. Between 1985 and 1998, public and private research programs world-wide invested more than C$1.1 billion, of

which approximately C$200 million was for the research, development and regulatory approval for herbicide tolerant varieties. Most of the gene isolation work was done during the 1980s separately from the transformation programs. The introduction of private research into the canola industry after 1985 caused a significant change in the seeds business. Previously public breeders undertook all of the development and released on average about one new variety every year. Since 1985 more than 200 new varieties have been released, with more than 30 new varieties in each of the past few years (Brewin and Malla 2012).

There have been a limited number of studies that have undertaken evaluations of the returns to research in the canola sector. An evaluation of public investment in canola research and development (R&D) was first published by Nagy and Furtan (1978). For the period 1960–1974 they calculated the IRR from improved yield research to be 101%. Ulrich et al. (1984) updated the estimates of IRR in canola research for the period 1951-1982 and calculated the IRR from research into improved yields to be 51%. Ulrich et al. (1987) incorporated trade effects and found the estimated Canadian IRR from higher yielding varieties to be 50%. Brewin and Malla (2012) estimate the producer benefits of growing herbicide tolerant canola. Gray and Malla (2001) estimated the total benefits and the distribution benefits of the switch from rapeseed to canola varieties. The Canola Council of Canada (2001) and Phillips (2003) estimated the producer benefits associated with the adoption of transgenic and genetically modified, herbicide tolerant (GMHT) canola varieties respectively. Malla et al. (2004) estimated the average and marginal IRR and net present value (NPV) to canola research investment between 1960 and 1999. Gusta et al. (2011) estimated the producer benefits of GMHT canola in Western Canada.

Since 1985 a number of developments have occurred, with significant potential to change the scale and distribution of returns. There has been a revaluation of the relative value of canola. Health studies in the mid 1980s were just beginning to hint at the substantial health benefits of consuming the mono-unsaturated fats in canola rather than polyunsaturated fats found in coconut and animal-based oils. As the evidence became clearer, consumer interest in canola rose. A significant change came in 1985 when the US granted GRAS (generally regarded as safe) status to canola oil. As adoption rose, the price of canola oil rose from a perpetual discount to soybean oil during the 1980s to approximate parity in the 1990s; meal still sells at a discount.

At the same time, the results of this private research effort were protected through strengthened IPRs.[1] As a result, it is no longer clear that the traditional distribution of benefits continues today. It now is important to disaggregate the returns to the production chain into shares held by farmers versus shares captured by either the input suppliers (e.g. research companies) or the processors.

When economic theory and the literature of returns to research are juxtaposed with the rise of private investment (often for biotechnology-based effort) in the canola sector, Phillips and Khachatourians (2001) estimated gains for research to yield an IRR between 20-95%. This figure may actually be larger for specific biotechnology-based developments because of the reduced cost of the research and the increased array of attributes that can be bred into the seed, which adds new value to consumers.

There have been advances in the estimation of returns to research that use econometrics to examine the effect of R&D investment on agricultural productivity (e.g. Thirtle and Bottomley 1988; Pardey and Craig 1989; Leiby and Adams 1991; Huffman and Evenson 1989, 1992, 2001; Chavas and Cox 1992; Alston and Carter 1994; Evenson 1996). These studies imposed an

[1] In 1987, Canada revised its Patent Act, moving from 17 years of protection from date of award, to 20 years of protection from date of filing.

assumed shape and length of adoption lag to calculate the returns. Some of the more recent econometric studies have instead statistically estimated the shape and length of adoption lag and generally have found lower rates of return (e.g. Akgungor et al. 1996; Makki et al. 1996). Alston et al. (1998) also explicitly dealt with the concept of knowledge depreciation, which is not common in the agricultural R&D literature. These new approaches have relevance for estimating the IRR for canola research.

Given the dramatic changes that have recently occurred in the canola industry, there is a need to reexamine the returns to research in the sector. In particular, the entrance of private industry, the change in property rights, the regulatory process and the changed role of the public institutions have influenced the benefits created.

Since the commercialization of GM crops began in 1995, a number of scholars have investigated the impact of the regulatory system on the agri-food sector. Present regulatory systems were designed to adjust for the commercialization of the first generation of GM crops. This regulatory approach is slowing considerably as the regulatory system is faced with commercializing products that are second and third generation. Jaffe (2005) reports that in spite of no new traits being regulated, the USDA consultation process has more than doubled. The average number of months to get regulatory approval in the US between 1994-99 was 5.9 months and between 2000-04, it took 13.6 months. A 2011 report released by EuropaBio that examines regulatory approval times between Brazil, Canada, the European Union and the United States documents that the average time to approve a GM crop in the US had risen to 25 months (EuropaBio, 2013).

Two studies examine the complex issue of crop regulation costs. The first is a study done by Pray et al. (2005) that examines the cost of biosafety regulations for the approval of Bt cotton in India. This process involved officials with Monsanto and their Indian seed partner company, Mahyco, working with officials from three different committees in the Indian regulatory system. Pray et al. identify two cost categories, pre-approval and post-approval. The pre-approval costs included costs for feeding studies for a wide variety of animals, poultry and fish, pollen flow, impacts on soil and socio-economic. The cost for this category is estimated to be US$1.8M. The post-approval costs are for three studies on socio-economic issues, pest management and chemical resistance. These costs are estimated to be US$200,000. A second study is by Kalaitzandonakes et al. (2007) and examines the cost of regulatory approval for insect resistant (IR) corn and herbicide tolerant (HT) corn in the ten key markets. These key markets are defined as the major producing and importing countries and are listed as: Argentina, Australia, Canada, China, the European Union (EU), Japan, Korea, the Philippines, Taiwan and the US. The cost categories that are examined cover studies in the range of animal toxicity, non-target organism, protein assessment, phenotypic and stewardship. The cost for approval of IR corn is estimated in the range of US$7-15.4M, while the estimated cost for HT corn is US$6.2-14.5M.

An industry report prepared by Phillips McDougall (2011) identifies that the average number of months it takes for a GM event to receive regulatory approval in 2011 was 65 months, up from 49 months in the 2008-2012 period. The total cost of receiving variety approval in key markets was estimated to be US$136M. The concern within the seed development industry is that the commercialization of new traits will only be done by large multinational seed developers.

The cost of obtaining regulatory approval for innovative GM crops is an important concern, but clearly, the time it takes to receive regulatory approval is the greater of the two. Most economists conclude that the time it takes to complete regulatory oversight is more

important than the actual out-of-pocket direct cash costs. Smyth and Phillips (2001) estimated that if Monsanto and AgrEvo had waited to commercialize their HT canola until they gained regulatory acceptance in Japan, they would have incurred a two-year delay and a major opportunity cost. This ex-post analysis calculated that, by adopting an identity preserved production and marketing regime to channel the asynchronously approved varieties to the accepting North American market, the companies accelerated adoption by two years, which was estimated to have generated a NPV in 1995$ of more than C$100 million. Pray et al. (2005) also discovered that the two-year delay (pause) in the approval of Bt cotton in India led to aggregate losses to farmers alone of more than US$100 million.

Bayer et al. (2010) undertook a sensitivity analysis in their regulatory study to evaluate the effects of increasing regulatory costs and altering the time required for regulatory approval and, hence, adoption of the technologies by farmers. They found the effects on total net benefits of increasing the direct cash costs of regulatory compliance in each case were small, even with four-fold increases. They estimated less than a US$1 million change in NPV in most cases, with the impacts varying from a 1% decrease for rice and papaya traits to a 7% decrease in the case of mosaic virus resistant (MVR) tomato. These losses were small compared to the opportunity costs that were incurred when commercialization was delayed from one to three years in the regulatory system. A one-year delay in adoption resulted in a 12% decrease in the projected NPV for Bt rice and up to a 36% decrease for MVR tomato while a 3-year regulatory delay was estimated to cause a 34% drop in the NPV of Bt rice compared to the baseline and a 93% decline for MVR tomato.

There is some supporting evidence that these costs may actually be incurred, as the Phillips McDougall study discussed above reports that firms in 2011 faced a regulatory process that was on average 21 months longer than before 2002. This undoubtedly generates significant opportunity costs to developers and users.

As noted above, the time for regulatory approvals has increased in the US. This is also the case for the European Union, where it takes an average of 45 months for the EU to render a decision (EuropaBio 2011). It is highly probable that this substantial lag time played a deciding factor in the 2012 announcement by BASF to relocate all of their corporation's research regarding plant biotechnology to the US (BASF, 2012). This results in a loss of 140 jobs in Europe, with 123 research jobs relocating in North Carolina. Other jobs will also be eliminated. BASF has deep roots in Europe and this move is seen as a huge blow to the biotech industry in Europe. Europe has resisted approving GM crops for 15 years now and it would appear that the true cost of this lack of regulatory action is apparent.

The tendency in industry is to focus on the issue of the greatest concern. So far no one has compared and contrasted the impact of regulatory costs and approval times with other potential impediments to commercial success. Other possible impacts could in the first instance simply be the absolute cost and difficulties raising adequate cash flows to sustain the research and gestational activities. Alternatively, one can imagine that the ability to protect and exploit the IPRs embedded in the seed and related technologies could be critical. Many farmers have strong views about their 'farmers' privilege' to save and reuse seed which is embedded in the UPOV agreements and written into national laws for plant breeders rights. Many farmers have tested to see how that privilege fares with seeds embodying patented traits or technologies. Some estimates put the dilution at above 10% in the canola sector in Canada, even though the biotechnology industry was investing heavily in private enforcement, investigations and litigation. While the Monsanto v. Schmeiser (2004) decision in Canada appears to foreclose

those privileges, it remains technically possible to reuse seed. Under some conditions one might imagine seed producers exercising their 'farmers' privileges' in defiance of the law. This risk, perhaps not high in Canada, is not inconsiderable in other markets with less-developed legal systems. With the introduction of hybrid technology into canola, virtually all required seed is purchased annually.

This paper is one attempt to compare and contrast across the three challenges to private commercialization of seed innovations: research costs; regulatory compliance costs and processes; and incomplete intellectual property protection.

3. Methodology

By its very nature, investment requires an upfront commitment of resources with the benefits flowing in future time periods. This dynamic nature of investment precludes the simple comparison of benefits and costs. This section contains a brief description of the conceptual framework used to estimate the returns to canola research and simulate the effects of alternate scenarios on industry decisions.

The process of creating new crop varieties can be described in four phases, as discussed by Alston et al. (1998). During the first phase, or the research phase, research resources are spent to develop a crop variety that has commercially desirable characteristics. This production process depends on the stocks of human capital, knowledge and germplasm as inputs into the creation of a new variety. The attribution of the cost of creating these important stocks is difficult. As a result, the creation of these stocks is often considered to be sunk costs by the technology developer, independent of the particular research program. The whole study of research spillovers would be important if these costs were to be attributed. At the end of the research phase a new variety is created.

There are many years between the research expenditure to develop a new variety and the variety reaching the first adopters. Research itself takes a number of years to produce any tangible product. Even after a variety with potential has been created it must be tested both internally and by external regulatory agencies before it can be licensed for sale. This period of waiting is referred to as the ‘gestation lag of research’, and is defined as the number of years between making the investment and the uptake and use of a new technology or product. In practice, the gestation lag is difficult to estimate, because the expenditure to create a new variety is often spread over many years. For instance, a new variety released in year T may have involved research and development expenditures in years T-2 to T-8. To get around this problem of multiple gestation lags most studies have estimated a single gestation lag, which represents the lag between the weighted mean time of expenditure and the commercialization of a licensed variety.

The third relevant period for estimating the returns to research is the adoption phase. During this phase the new variety is adapted, adopted and then supplanted by other varieties. The typical pattern is low adoption in the first year(s) of introduction, growing to peak adoption later; ultimately every variety is replaced by other newer varieties. In terms of economic impact the variety has its largest annual impact in the year when the adoption rate reaches its peak but the size and shape of the shoulders is important for the overall returns to an innovation.

The final stage is the depreciation phase. Research often creates a new process or new germplasm. These innovations provide a very important base onto which subsequent research is built. Thus, innovations in the form of new varieties contribute to the stock of knowledge or germplasm, which continue to play a role long after the particular innovation has been

supplanted by newer innovations. For instance, the first double-zero rapeseed varieties (ultimately named canola) are no longer used but some of the germplasm from these varieties continues on in many of those grown today. Although durable, the contribution to the stock of germplasm is not permanent and depreciates over time. One of the common reasons cited for depreciation is that pests in the environment eventually adapt themselves to attack a particular germplasm and new genetics is required.

These four phases of crop variety development, and the long lags between investment and output, have made the estimation of the returns to research difficult and the subject of considerable discussion.

The NPV or IRR analysis offers a simple yet comprehensive way to incorporate the four stages into a single metric and thereby to examine the decision-making of firms and policy makers. The Alston et al. (1998) framework helps to identify the benefits and costs in each period. The NPV then allows one to calculate the overall effect of the entire process. The NPV is the sum of the benefits net of costs over the life of the innovation (n periods), discounted to a reference period using the cost of capital (r). The conventional presentation of the calculation is shown in equation 1.

$$NPV = \sum \frac{(Benefits_i - Costs_i)}{(1+r)^n} \qquad \text{Equation 1}$$

Conversely, one can set the NPV to zero and solve for the internal rate of return (r in equation 1). Both calculations add value to our discussion.

In markets where the anticipated market share is insufficient to provide the innovative firm with the necessary IRR, then the project, product or technology fails to cross what has been coined 'the valley of death'. The valley of death can be triggered in two ways. In some instances small innovative firms may simply run out of investment funding and have to halt further R&D and commercialization due to lack of capital. In the canola sector, more often the leading innovative firms have substantial capital resources from which to draw, but still have to make hard choices. It is seldom clear whether the decision to suspend further activity into a specific research project encompasses a simple analysis of potential returns and, if so, what specific variables drive the expectations about the IRR. In addition to the normal gestational costs, emerging social issues such as market acceptance or the ability to trade the final product free of trade barriers in foreign markets may also play a contributing role in decision making and valuation of the market prospects.

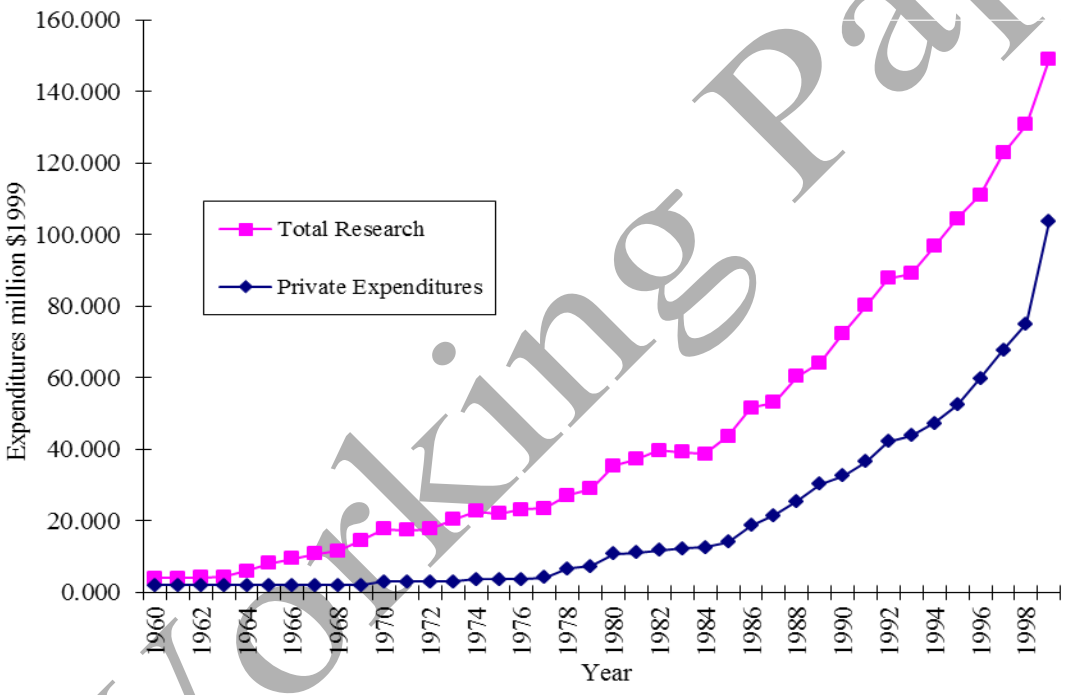
4. The baseline

Phillips (2003) undertook a comprehensive review of a multi-year research program in canola that yielded a significant flow of innovative products. This offers a unique dataset for examining thresholds for genomic innovation. Ten GM canola research programs began about 1985, each costing approximately C$1.5 million per year for an estimated seven years of research. This phase was followed by three years of gestational investments to satisfying the food, feed and environmental safety requirements in Canada and the US and to comply with the varietal registration requirements under the Canada Seeds Act. Returns to the technology began in 1995, with initial commercialization in Canada. Farmer adoption was modest in the first two years as the biotechnology developers and seed trade implemented an identity preserved production and marketing system (Smyth and Phillips 2001) while they negotiated for market access in Japan

(the EU market was also targeted but eventually abandoned). Full unconstrained commercialization began in 1997. By 2002 adoption of herbicide tolerant varieties (developed using both transgenics and mutagenesis) captured more than 90% of the market. A number of novel oil varieties were also tested but failed to gain significant market share.

Costs and benefits for this major industrial investment program were calculated beginning in 1980 and spanning 2002. Industry, supported by producer check-off groups and government investment of an estimated C$450 million in this research space (Figure 1). The resulting seed innovations (mostly herbicide tolerance) generated savings for producers by reducing the number of herbicide applications, by lowering dockage and by raising overall yields (after a brief period of yield drag as the baseline germplasm embodying these traits were dated). By 2002 producers were gaining C$100 million annually (Smyth and Phillips 2001). As acreage grew and the technologies were improved, producer gains were $350 million annually by 2007 (Gusta et al. 2011).

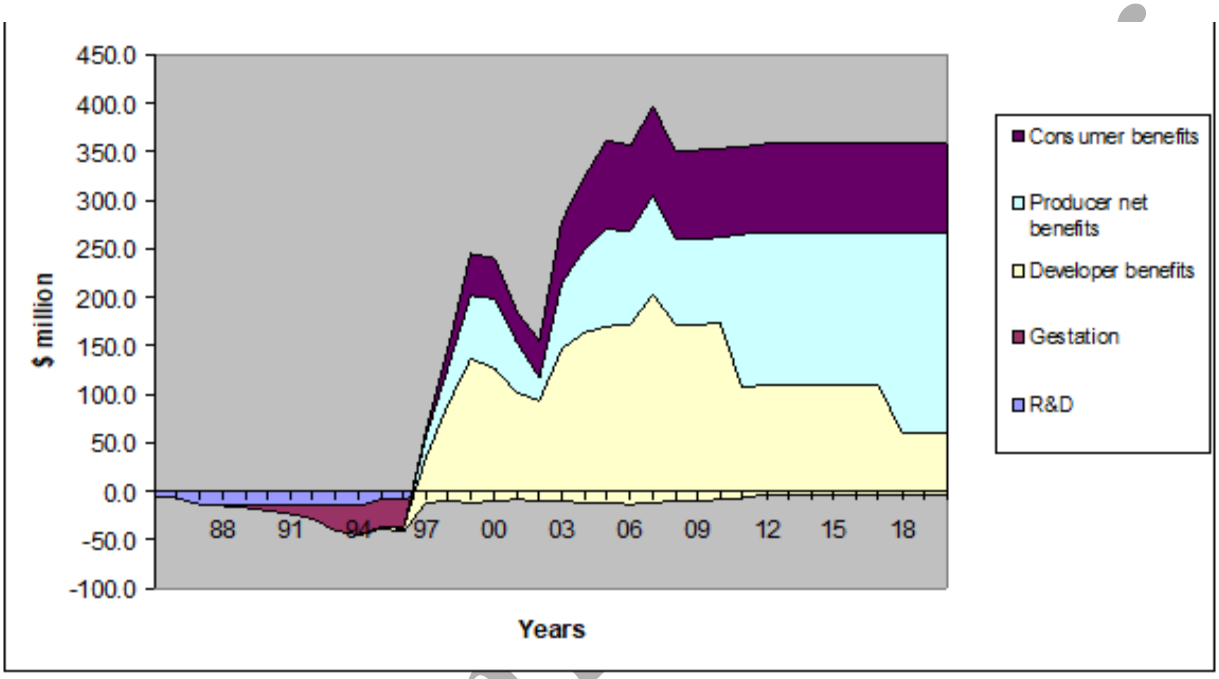
Figure 1: Canola Research Expenditures



The global biotechnology companies were both the major investors in technology R&D and the major beneficiaries of the returns. As Moschini and Lapan (1997) note, it is important to calculate and include innovators' monopolistic or oligopolistic profits in the total calculation of the returns on the technology. In their study of Roundup Ready soybeans, Moschini et al. (2000) estimate that innovators captured between 37% and 50% of the gross benefits generated. The net operating return for canola innovators is widely pegged at about C$15/acre. Given adoption rates and adjusting for the ongoing technology maintenance costs, the industry was estimated to be generating approximately C$225 million annually in 2009-2010. Technology providers are benefitting as investments in canola R&D average C$80 million per year.

This study extrapolated those estimates, adjusting for the fact that many of the core proprietary traits will come off the patent in the next few years, which will lead to a shift in producer surplus from the biotechnology developers to the producers. Visually, the story is represented in Figure 2. Results from an applied study by Gusta et al. (2011) pegged the producer and developer benefit from GM canola between 2005 and 2007 in the range of C$343 million to C$422 million annually, which suggests our analysis may be on the conservative side.

Figure 2: Costs and benefits from GMHT canola



Putting these estimates together, it is possible to determine the NPV of the innovators' investments. Discounting net benefits (using the corporate paper rate for Canada) shows that the industry began to show annual profits in 1997 and in 2000 for the first year the NPV of GMHT canola for the innovators turned modestly positive. The implied rate of return on this investment for the entire industry is therefore approximately 20%. The return could be even higher, as some of the research undertaken in Canada has been subsidized by the federal and provincial governments, through below-cost provision of infrastructure and by grants through Agriculture and Agri-Food Canada's Matching Investment Initiative.

Meanwhile, consumers in Canada and abroad shared the benefits of lower prices due to the higher yields in the sector. While the per capita benefits were marginal, the aggregate benefits were calculated to be in the range of C$100 million.

5. Impact of Changing Market Factors

Using the 35-year baseline case database discussed above, we introduced five shocks to simulate and assess the market impacts of various possibilities: (i) $50 million R&D subsidy spread evenly over the development program; (ii) $50 million R&D subsidy paid by front end loading on the first third of R&D; (iii) double the cost of obtaining regulatory approval; (iv) delay approval by two-years; and (v) weaken IP protection leading to a 50% dilution of IPR revenues. Following these market impacts, we compare the scenario results to the baseline, providing some

insights into which adjustments would facilitate further genomic innovations and which would hinder.

Based on the four phases of varietal development, we estimate that the total cost of the research phase for a single successful trait was C$150 million, with 10 years (1985-1995) of development costs followed by a three-year gestational period, with an estimated cost of C$10 million per trait. The cost of seed development and multiplication are additionally included at this point. Over the 35-year period, total development and gestation costs would exceed C$300 million. The model sets adoption to begin in 1995 with an estimated C$3 billion in benefits for the innovators accumulating over the first 25 years of adoption. Producers are projected to gain C$2.7 billion in benefits over the 25-year period, while consumers gain C$1.7 billion in benefits. Knowledge stock phase benefits have not been priced. The baseline NPV for the entire global economy, using a 10% discount rate, was only C$45 million; nevertheless, the biotechnology developers are major winners, as are Canadian producers who adopt the trait and global consumers. Owners of competing technologies supplanted by the new varieties loose, as do producers who are unable or unwilling to adopt the new technology. The IRR for the developers is estimated to be approximately 20%.

With the baselines established, we were able to apply the market shocks, providing estimates of the deviations. Table 1 illustrates the impacts. A C$50 million R&D subsidy (equal to one-third of the estimated out-of-pocket private costs of developing new traits) spread evenly over the duration of the research program adds a net C$27 million to the developers, compared to front-loading the same subsidy, which adds C$36 million for the multinational developers.

Shocking the regulatory system show that time is more valuable than money. Doubling the cost of the regulatory process lowers the NPV of private developers return by C$37 million, while adding a two-year delay to regulatory approval is nearly twice as costly, reducing returns by C$65 million. This delay also has a substantial impact on producers, reducing their value by nearly C$50 million.

By far, the impact with the greatest effect is a change in IP policy that results in a loss of C$150 million for the technology developers, much of which is shifted to farmers (C$125 million).

Table 1: NPV at 10% rate (1985-2020) (C$M)

	Three MNEs	Rest of industry	Canadian producers	Canada	Rest of the world	World
Baseline NPV (1985-2020)	$233	-$400	$208	$26	$19	$45
Deviations from baseline						
R&D subsidy ($50M evenly)	$27	$2.6		$29		$29
R&D subsidy ($50M upfront)	$36	$3.8		$40		$40
Regulatory change (2x cost)	-$37			-$56		-$56
Regulatory change (2 year delay)	-$65	$77	-$48	-$37	-$3.9	-$41
Change IPR system (50% dilution)	-$150	-$2.6	$125	-$28		-$28

When we apply the same five market impacts and calculate the IRR, we can see the potential effect on commercial returns (Table 2). Front-loading the R&D subsidy has the largest impact, not only for the developers, but also to Canada and at a global scale. Front-loaded subsides more than double the commercial benefit, at marginal costs for government. The speed of the regulatory system is as, or more, important than the cost for firms but vice-versa for government (potential mismatch of interests). Regulatory burden is the one policy that has the potential to absolutely destroy value without necessarily any offsetting benefits to other actors. Intellectual property rights changes are more than a zero sum—they have the potential to change incentives for private investment and redistribute rents between innovators and users.

Table 2: Internal rate of return (1985-2020)

	Three developers	Canada	World
Baseline	20.0%	11.1%	11.8%
Deviations from baseline			
R&D subsidy ($50M evenly)	2.8%	1.5%	1.6%
R&D subsidy ($50M upfront)	7.0%	2.0%	3.0%
Regulatory change (2x cost)	-2.0%	-2.0%	-2.0%
Regulatory change (2 year delay)	-3.1%	-1.6%	-1.6%
Change IPR system (50% dilution)	-4.3%	0.1%	0.1%

The relative importance of the market impacts is likely to be different for industry and government. In the case of industry, in decreasing order, would be the timing of subsidies, changes to IP policy and delays in the regulatory system. Conversely, for government the order would be regulatory costs, the timing of subsidies and delays in regulatory approvals.

6. Conclusions

Based on this analysis of genomic research as it pertains to the canola sector, the following two observations can be made.

First, government support for funding innovative R&D is crucial to the success of innovation. Varieties of programs of this nature exist and clearly contribute economic value if offered at the right time in the innovation process. Based on our study, the more capital that is available and the earlier that it is in the innovation process, the more favorable it is for innovations to make it through the valley of death.

Second, while arguments can be made about whether having producers or industry fund some of the regulatory costs for approving new crop varieties given the substantial benefits from commercial production, the economic benefits of innovative technologies being commercialized in a cost-efficient and timely manner should not be overlooked by governments. There is a correlating responsibility to governments that fund innovative R&D and that is to adequately fund the corresponding regulatory system. For the innovation process to function effectively, simply providing funding for innovative R&D without also supporting the regulatory process seems counter-productive. While the firms commercializing the technologies will not likely be Canadian firms, the producer and consumer benefits of getting the products into the market far exceed the cost of employing additional bureaucrats to ensure the capacity of the regulatory system is maximized.

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