BEST PRACTICES FOR CANADIAN AGRICULTURAL INNOVATION: LESSONS FROM THEORY AND PRACTICE

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LESSONS FROM THEORY AND PRACTICE

Historically, agricultural innovation has been a very important source of economic growth in Canada. Innovation in genetics, products, practices, processes, and institutions have allowed the sector to increase both the quantity and quality of products available to consumers, while freeing up labour, land and other resources for use elsewhere in the economy.

Despite this strong record of innovation, there is growing consensus of a critical need to improve policies in support of agricultural innovation in Canada. Slowing rates of productivity growth, underinvestment in research, and poor records of value added commercialization suggest that government innovation policies have become less effective over time. At the same time, the growing global demand for basic food, bioproducts, and functional nutrients, suggests increased opportunities for innovation. In an increasingly globalized economic environment, remaining competitive is not only financially rewarding, it is essential to the survival of this vital sector.

This paper provides an overview of current theory regarding the importance of innovation to the agricultural sector's competitiveness, describes key factors that influence the rate of innovation and adaptation in the sector, and finally, examines best practices in support of innovation and adaptation and their rationales from three perspectives:

i) Applying economic theory and public policy to identify key sources of market failure in agricultural innovation.
ii) The role of comparative advantage and trade opportunities in exploiting economies of scale in innovation.
iii) Canadian and international experiences as a source of "best practices" in innovation systems.

A synthesis of ideas derived from these three perspectives is used to identify best practices, in the form of government programs or other interventions that can be used to enhance agricultural innovation in Canada today and to identify significant gaps in the range of interventions currently offered in Canada.

What is innovation?

"*An **innovation** is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations*." P 46. OECD, (2005). Innovation can occur within firms, within markets and networks, and within institutions.

For innovation to occur, the notion of doing something different must be conceptualized and acted upon. It is useful to divide agricultural innovation into stages where new products and processes are conceived (e.g. science, applied research, prospecting), and stages where new products and processes are put into use (e.g. commercialization, adaptation, diffusion). This somewhat artificial dichotomy is evident in the often used "Research and Development" and "Research and Commercialization" descriptors of innovation processes.

The Role of the National Innovation System

The capacity to innovate goes well beyond the discovery of new knowledge and the ability of entrepreneurs to take an idea to market.

"National innovative capacity depends on the strength of a nation's common innovation infrastructure (cross-cutting factors which contribute broadly to innovativeness throughout the economy), the environment for innovation in a nation's industrial clusters, and the strength of linkages between these two." Abstract - *Furman et al. (2002)*

This broad view of innovation is reflected in the Science &Technology (S&T) Strategy of the Government of Canada (2007), which recognizes the need to create infrastructure and the economic environment to commercialize ideas, and importantly, to cultivate the linkages between public research and industry. This being said, the creation of an effective national innovation system is extremely difficult because markets alone often fail to provide appropriate incentives for the production, sharing and utilization of knowledge.

In the description of innovation it is important to consider that agricultural innovation differs from innovation in other sectors in several respects including:

1) Primary agriculture is made up of many small firms, which are generally too small to undertake a great deal of research internally. These firms do have a great deal of tacit or implicit knowledge, making both horizontal and vertical information sharing important for innovation.
2) Many types of agricultural research are sequential in nature, meaning that new products, particularly genetics, build upon the breakthroughs of the past.
3) Many types of agricultural innovation such as new varieties and new food products are not patentable. This makes standard patent based measures of innovation less applicable in agriculture.
4) Producer and industry organizations have been active in the governance and funding of research. These "quasi-public" - "quasi-private" organizations are an important alternative to the private-public dichotomy that occurs in other industries.

Why is Innovation Important?

Innovation is important because it is integral to economic growth. Productivity growth involves producing more output (as measured in quantity and quality) with the same quantity of resources, which necessarily involves innovation. Productivity growth in turn drives economic growth, increasing incomes and general well being.

The linkages between innovation and economic growth are clearly illustrated in agricultural innovation, where a wide range of new technologies, new genetics and new production practices have significantly increased agricultural output, while dramatically reducing the labour requirement for the sector. These innovations have driven down costs of production and food prices, while freeing up labour and other resources to be employed elsewhere in the economy. A century ago, agriculture employed one in four people in Canada, and food made up about one third of consumer expenditures. Thanks to

innovation, consumers have a far greater range of food products to choose from and despite eating many meals away from home, now spend less that 10% of their total budget on food.

Innovation and productivity improvements are also integral to international competiveness, as they continue to stimulate economic activity around the globe. As is evident in the long-term decline in grain prices, this innovation and productivity improvement continues to drive down global agricultural prices over time. If innovation were to cease in Canadian agriculture, the sector would become increasingly uncompetitive over time. Conversely, if innovation in Canadian agriculture were to occur faster than elsewhere, this would increase Canada's competitive position and would allow the sector to become more productive and profitable over time.

In addition to market benefits, innovation in agricultural systems has a strong track record of addressing many non-market issues that influence the well being of Canadians including environmental problems, food safety, and the functional nutritional content of food. Thus, to the extent that it improves the social welfare of Canadians, policy makers have an interest in increasing the rate of innovation in Canadian agriculture, especially in cases where there is little incentive for the private sector to do so.

The Role of Markets, Market Failure and Policy in Innovation

In a market economy, government policy is often directed toward those activities where markets fail to provide the appropriate incentives for optimal resource allocation. As such, identifying market failures is a logical starting point to discuss best practices for innovation policy. For the sake of brevity, only six of the most important market failures for agricultural innovation in Canada are described below.

1) Unprotected Knowledge as a Public Good

In the absence of enforceable property rights, many forms of knowledge and products of innovation are non-excludable, meaning that one cannot affordably prevent the public from using them. Non-excludability makes it impossible for private firms to sell innovations and therefore these "public goods" tend to be provided by the public sector or through some other policies and institutions.

While advances in genomics and hybrids, combined with the legal protection of intellectual property rights (IPRs), have made more products of research excludable, many types of research are still non-excludable and remain as public goods, requiring government investment. This includes many forms of agronomic and processing knowledge, where imitation makes protection difficult. The public good aspect also remains an important market failure in many forms of crop and livestock genetics, where farmers can freely multiply and distribute genetic progeny.

2) Protected Knowledge as a Toll Good

Once created, knowledge is "non-rival" and can be used over and over again without depletion. This characteristic of knowledge means that once it is protected (and is no longer a public good), it becomes a "toll good" and there are large economies of size in the creation and use of it.

This is an important source of market failure, as knowledge industries tend to become very concentrated and are able to set prices for output above the marginal cost of producing that output, which limits the adoption and societal welfare gains from innovation. While some research industry concentration is beneficial because it allows firms to capture economies of size, empirical studies show that very concentrated industries tend to be less innovative.

The toll good market failure described here also exists in many of the cost components in product development processes including testing, regulatory compliance, labeling, packaging, and logistics. The resulting *economies of size,* means that firms in large markets will have a significant cost advantage over firms in smaller markets. In Canada, where there is a small domestic market, firms may find innovation and commercialization more difficult than in larger markets like the US. While "free trade" between nations does alleviate this to some extent, there are still numerous differences in many agricultural standards and regulations across nations that restrict trade.

3) Private Incentives for Health

A third important market failure for agricultural innovation is the existence of public and private health insurance, which reduces individuals' incentives to pursue a healthy diet. While individuals do have some concern for their health, the fact that over 90 percent of "out of pocket" costs associated with illness are borne by others through health and disability insurance, reduces the private (individual) incentives to purchase healthier foods, functional foods and neutraceuticals. These reduced incentives limit consumer demand for healthy food, which in turn reduces the private incentives for research and adaptation in "health" foods. Despite the importance of health care costs, governments have been very slow to recognize health-related market failures in the development and sale of health products but are becoming increasingly aware of the potential cost savings associated with promoting healthy lifestyles. One positive example is government funded tobacco reduction programs, which have contributed to the reduction in smoking among certain demographic groups.

4) Asymmetric Information for New Technologies and New Products

A fourth market failure relates to asymmetric information associated with new technologies. The seller of a new product has the incentive to over-report the benefits of that new product. Without another source of reliable information to verify the benefits, potential buyers will be reluctant to purchase the innovation. Unbiased information about the efficacy of a new product is a public good that accelerates innovation, while enhancing the degree of competition among innovative products.

5) Asymmetric Information Regarding the Safety of Foods

In the absence of third party information, consumers face a great deal of uncertainty regarding the safety of food. Governments have responded to this market failure by implementing food inspection, quality standards and process regulations. While these policies can address asymmetric information issues, food safety regulations are often particularly costly to innovating firms, who are obliged to *show* that they have satisfied regulatory requirements (in addition to just satisfying the requirements) as part of a registration process. As a result, these policies create a very significant entry barrier for new products, which impedes the speed and scope of innovation.

6) A Lack of Markets for Environmental Externalities

The inability to value environmental impacts in the marketplace is becoming an important source of market failure for agricultural innovation. In the absence of regulation or trading systems for pollutants, private firms have little incentive to develop products and processes that are less harmful to, or actually improve the environment. This lack of accounting for environmental damage has reduced the incentive to develop and commercialize green technologies in agriculture. Only after the long term negative economic impacts of certain practices becomes apparent, have we seen a movement towards some "green" policies and technologies.

Comparative Advantage and Economies of Scale

Market forces play a critical role in innovation. The number of market failures that are inherent in innovation creates a real challenge for the design of innovation policy. Domestic policies, often designed to deal with imperfect market forces, will shape the national innovation system in individual countries. While the innovation system will be important for success, one has to be mindful that comparative advantage, economies of size, and international trade flows will also play important roles.

The non-rival nature of knowledge creates very significant economies of size in the innovation process. Firms must incur considerable fixed costs for every product developed including, research, development, product testing, regulatory approval, product packaging, product-promotion, and supply chain development. The greater the quantity of product sold the more these costs can be spread across output and the lower the average cost will be. Thus, firms in large markets have an advantage over those firms with access to small markets. This result was verified in an important study of national innovation systems in seventeen OECD countries where Furhman et al. (2002) found that domestic population and GDP have a strong positive effect on the rate of innovation.

In a fully globalized economy, economic borders would not exist and production and innovation would occur in a manner consistent with the principles of comparative advantage. Effective innovation practices would be rewarded and production would occur in those jurisdictions where the quality-adjusted-cost-of-production was lowest.

However, many studies have found that despite NAFTA, WTO and other free trade agreements, borders are "thick" meaning that products do not freely move across borders, even in cases where tariffs are small or non-existent. The fact that other countries have different standards and regulations means that firms must spend considerable resources to comply with foreign regulations. In some cases, such as with BSE and COOL (Country Of Origin Labeling), even compliance with international standards does not guarantee equal access. The result is that production does not occur in locations where comparative advantage would suggest it should. Moreover, given the economies of size in innovation, fractured markets can limit scale and retard innovation.

The thick border is a particular problem for Canada, which does 80 percent of its trade with the United States. Thick borders mean that Canadian innovators often only have access to the relatively small Canadian domestic market (Furtan and van Melle, 2004). This is an acute problem for the food processing industry, the health food industry, and the livestock industry in Canada. In this relationship, US based firms have a distinct advantage because they are better able to capture economies of size. Freer access to the US market would give Canadian innovators a much larger market, allowing them to be more competitive globally.

Examples of Success in Innovation In Canada

Wheat, Canola and Pulse Crop Innovation

While continuous genetic improvement has been critical to agricultural productivity growth in western Canada, there are three examples of successful innovation in wheat,

Canola and pulses that had transformational impacts on the sector. It is particularly striking that each of these transformational innovations involved different institutions.

In 1886, the government passed the Experimental Farm Act with the aim of developing the western wheat economy. In less than twenty years this large public investment bore fruit when Charles Sanders developed the Marquis wheat variety. This fast maturing, high quality hard spring wheat variety dominated the Northern Great Plains for thirty years allowing the development of the western Canadian wheat economy. The variety was so successful and prevalent that, even today, every hard red spring wheat variety grown in western Canada can trace some of its ancestry back to this variety. While publically funded wheat breeders continue to produce valuable new varieties to the present day, the persistent very high rates of return to wheat research suggest a chronic underfunding.

Canola is also a remarkable success story. Public research and breeding that began in the 1960's created double low rapeseed in Canada, which was trademarked as "Canola". During this period, the Rapeseed Association of Canada was an important catalyst for development. In the 1980's, the development of transgenic processes and later hybrids attracted significant private investment in Canola research. These companies, working with public institutions and the Canola Council, have developed a 10 billion dollar crop with significant value-added processing in western Canada. Recently, this innovative industry has developed and commercialized high oleic Canola, which reduces trans fats in cooking. In value and volume terms, this may be the largest functional food in the world.

The pulse crop sector in Saskatchewan is another example of success in crop development. In the past two decades, the area of pulse crop planted has expanded from a small base to about 4 million acres per year. This recent success is worth noting because much of the research that has driven this innovation process has come from a compulsory value-of-sale levy, which Saskatchewan producers voted for in 1984. The 1% levy currently provides significant producer directed funds for research, which are often matched by provincial and federal government contributions.

In addition to this success in specific crops, Western Canada has also been at the center in the development and adoption of direct seeding technologies. These technologies have not only reduced soil erosion and sequestered large quantities of CO_2 from the atmosphere, they have been profitable for farmers and have resulted in the creation of a significant manufacturing industry that ships this technology throughout world.

In each of these developments, there has been significant involvement of the public and private sectors as well as industry organizations. Public scientists have played an important role in research, while public variety trials and demonstration plots play an important role in accelerating the adoption. In the case of grain varieties, the adoption curve is very short and farmers make seed purchase decisions based on information from trusted sources. Industry organizations with strong representation from farmers have also been actively involved in the innovation process. For example, the soil conservation and

commodity associations helped direct research, and with public support were involved in extension and technology demonstration activities. The annual meetings and newsletters produced by these organizations provide a very good source of information for growers, further accelerating the adoption process. These organizations also play important roles in strategic planning by creating a sense of direction for these industries.

Livestock
Beef Dairy and Hogs
In several parts of the Canadian livestock industry there has been a strong tradition of keeping track of pedigree, and using record of performance of offspring to enhance genetic selection. By developing strong horizontal linkages among livestock breeders, these systems are a very effective, low cost, mechanism for finding the very best genetics for breeding. They have resulted in rapid productivity improvement over time as well as a Canadian export industry for genetics. Annual livestock shows and sales, such as the Toronto Royal and the Western Canadian Agribition, have provided an important showcase for new genetics. Initially promoted and designed by the public sector, these horizontal linkages are now industry driven and controlled.

Extension
While laboratory and genetic based research tends to have large economies of scale, localized agronomic research may be required to address local production problems. These research activities also have a natural extension component, as farmers can observe whether the practices are suitable for their local conditions. This relationship was evident in the adoption of the zero tillage on the Canadian prairies. Davey and Furtan, (2006) found that the rate of zero tillage adoption was statistically higher in Crop Districts that contained AAFC research stations and associated extension activities.

The private incentive for investment in regional agronomic research is often very limited as farmers can easily mimic the best farming practices without paying royalties. This leaves the role of agronomic research to industry organizations, the government sector or some combination of the two. In the case of the Canola Council of Canada, farmer involvement in the agronomic research program meant that recommendations were quickly adopted by the industry, thus highlighting the importance of industry involvement in this type of research. In the case of zero tillage research, it was very much a three-way partnership between the producer (driven by soil conservation associations), local AAFC agronomists, and tillage machine manufacturers who were interested in the development of the technology.

Examples of Success in Innovation Around the World
Funding Crop Research in Australia
The Australian Grain Research Development Corporation (GRDC) is an interesting model of success for crop research. The GRDC emerged from pre-existing forms of levy-funded research institutions called Rural Industry Research Funds, and is a statutory corporation created by the Australian federal government that has the goal of bringing about improvements in production, sustainability and profitability in that country's grains industry (GRDC Website, 2008). In contrast to many crop research systems, the GRDC

takes a "demand pull" approach to setting its research priorities, relying on market signals to direct research. This strategy involves the establishment and maintenance of strong linkages across producer and other business groups, which is accomplished by the creation of a Board and advisory panels that are composed of producers, downstream industry groups, scientists, and executive managers (GRDC Website, 2008).

Funding for the GRDC is based on a compulsory 1% check-off on grain producers that is matched by the Australian Government up to a total of 0.5% of the gross value of grain production (GVP). As a result, the total check-off collected is dependent on a variety of factors including weather, the effects of disease and pest outbreaks, the price of grains, and any market driven changes to the crop mix. In total, the check-off is collected on 25 different cereal, oilseed and pulse crops and is usually well over $100 million annually (GRDC Website, 2008), which is much higher than those check-offs collected on Canadian grains and oilseeds.

EU Food Systems

As agriculture becomes increasingly global in scale, innovation pertaining to food distribution has played an integral role in increasing the efficiency and reliability of agricultural systems. The EU is an example where trade liberalization has had a positive impact in this regard. The EU has adopted a "free trade" zone among member states and has implemented the harmonization of many agricultural and food standards (e.g. organic agriculture), which have facilitated the efficient movement of products between countries within its borders. The benefits resulting from this freer trade include enhancing food security across the EU at a reduced cost, an improvement in agricultural productivity leading to rural development, greater diversity and availability of food products, an ability to focus on improving nutritional and dietary requirements of a growing middle class, and a reduced need for agricultural subsidies. These changes in EU food systems are also likely to stimulate further innovation, as research is directed at providing further refinement of food distribution processes.

In addition to innovation related to trade, the EU is also undertaking initiatives to improve the dissemination of knowledge throughout its agricultural systems. Knowledge is generated at all levels of the supply chain and the EU is attempting to move away from the linear model of technology transfer (from researchers to producers), towards an integrated model with many linkages that emphasizes the multidirectional flow of information within a broader network. Numerous research initiatives are being carried out with the goal of enhancing this process. Two examples are; 1) the In-Sight Project, which aims at building a framework and knowledge base for a European policy on innovation in agriculture and rural areas (In-Sight Website, 2008), and 2) RAPIDO (Rural Areas, People, and Innovative Development), which was created to analyze current best practices pertaining to the expansion of innovation in agriculture, forestry, the food sector and rural areas, as well as to investigate methods of knowledge transfer to different target groups (RAPIDO Website, 2008).

Japanese Health Foods

In Japan, growing public awareness and an aging population has been the impetus for improved dietary practices and the prevention of life-style related diseases. The first national project on functional foods was commissioned in 1984 by the Ministry of Education, Science and Culture. In 1991, the Japanese Ministry of Health and Welfare (MHW) established the world's first policy of legally permitting the commercialization of some functional foods. This policy for "foods for specified health issues" (FOSHU) is based on the approval of a health claim presentation for each FOSHU product (Arai, 2001).

The first FOSHU product was a variety of hypoallergenic rice approved in 1993. Since that time, there have been over 500 products that are FOSHU approved by the MHW. These products are intended to go beyond nutrition and provide disease reduction and promote health. In 2003, it was estimated that the total size of the Japanese FOSHU market was $6.17 billion, with each Japanese person spending $134 per person on functional food. Japan is currently the only country in the world with a legal definition of what functional foods are (ATS, 2006).

Brazilian Ethanol Policy

In terms of best practices, Brazil has been a leader in developing a globally competitive sugar cane based ethanol industry. This has been accomplished through a variety of innovative policy initiatives that have allowed the industry to exploit its comparative cost advantage in ethanol production and to create a domestic demand to support this advantage. The industry initially relied heavily on direct market interventions including quotas, price setting, and direct control of ethanol distribution by the government owned oil company (Petrobas), but later moved towards more progressive policies like tax exemptions for purchases of ethanol powered cars as well as financial incentives for the construction of ethanol plants. The use of targeted research prizes to overcome specific technological hurdles and to encourage innovation has been an important aspect of reducing government intervention.

Today, government intervention in ethanol markets in Brazil is limited to blending requirements and minor tax exemptions, thus allowing current biofuels policy to focus more directly on enhancing export markets and promoting the development of new cellulosic technologies through research and development investments. The ability of the Brazilian ethanol industry to capitalize on its inherent competitive advantages through its innovative policy approach provides lessons to emerging industries elsewhere.

China's Biotechnology Sector

Although still undergoing a rapid industrialization process, China's biotechnology sector has become a world leader in innovation. Its' Ministry of Science and Technology has articulated a very comprehensive policy for development that includes a technical accumulation of knowledge phase, an industry and development phase, and a sustained development phase. The initial phase of the policy has focused heavily on directing

financial resources and attracting top researchers into the area of biotechnology, with the objective of stimulating innovation. As of 2006, China had approximately 2500 enterprises with over 50,000 employees involved in biotechnology (Li et al, 2006).

China's massive investments into biotechnology research and development are now starting to pay dividends with the emergence of a burgeoning bioproducts industry. For example, one textile research and development company has developed the technology to utilize soybeans, milk, and bamboo in the production of clothing (Checkmate Public Affairs Website, 2005a). A corn industry park located in north-eastern China is developing ways to use corn instead of petroleum in the process of making resins, fibres and other refined chemicals (Checkmate Public Affairs Website, 2005b). A plant for the production of polylactic acid (PLA) used in the production of bioplastics is scheduled to open in the near future. Numerous other products are in the research and development phases including biofertilizers, biopesticides, biogas, cellulosic ethanol, pharmaceutical and health products, the development of fast-growing high output crops, and products aimed at combating bioterrorism. China's rapid progression in biotechnology is a great example of how much can be accomplished in a relatively short time period through innovation.

Danish Pork Sector

The Danish Pork Sector is an example of how organizational innovation can contribute to reduced transaction costs, increased efficiency, improved product quality, and overall increased competiveness (Hobbs, 2001). Success of the sector can be partially attributed to the development of producer co-operatives with a small number of individuals serving as board members in more than one co-operative along the supply chain, which has effectively improved the co-ordination of activities along the supply chain (Karantininis, 2003). Increased vertical and horizontal co-ordination allowed the sector to adjust quickly to changing market conditions and to facilitate the flow of information in both directions along the pork supply chain. The Danish model is an excellent example of an industry remaining competitive despite inherent cost disadvantages (Hobbs, 2001).

Further innovation in the Danish Pork Sector is evident in the sectors ability to organize its sector-wide research agenda with limited resources. The National Committee for Pig Production represents a large component of the sector and allocates research resources based on a prioritized ranking system that assesses the efficacy and value of individual projects to the sector as a whole. Although relatively straightforward, this sector-wide co-ordination of research resources is an effective approach to maximizing research efficiency and could have application in various aspects of Canada's agricultural sector (Euken, 2006).

Entrepreneurship

Innovation and entrepreneurship are gaining attention at the post-secondary education level. There is wide acceptance that future prosperity and national economic growth is dependent on these activities. The Global Entrepreneurship Monitor (GEM) project initiated by Babson College and the London Business School has determined that among

countries with similar economic structures, the correlation between entrepreneurship and economic growth exceeds 0.7 and is highly statistical significant (Reynolds et al., 1999).

The GEM project also reported that providing individuals with quality entrepreneurship education was one of the top priorities for increasing the level of entrepreneurial activity. Andrew Nikiforuk (1996) reported that a much larger percentage of graduates of the entrepreneurship programs at the University of Calgary and Swinburne University of Technology in Australia started businesses (37% and 87% respectively) in comparison to graduates of management programs with no entrepreneurial focus (14% was normal). These results indicate that education and training in entrepreneurship are seen as the keys to creating a culture of enterprise, recognizing entrepreneurship as a career option and developing the pre-requisite skills to succeed as an entrepreneur.

Best Practices for Agricultural Innovation

The list of best practices outlined below is intended provide a short list of the most important practices for agricultural innovation. These best practices are based on market failures and the experience of success outlined above, as well as the experience and other readings.

There are many large volumes and books written on the topics of agricultural innovation, and therefore the list should not be considered as comprehensive. The list can be a good starting point for the development comprehensive national agricultural innovation system.

International Access

BP1: Continue to be proactive in negotiating reduced barriers to international trade.

R: Given the fixed costs associated with innovation, access to global markets is essential for a Canadian agricultural innovation strategy. While progress has been made on traditional tariff barriers, the government of Canada needs to continue to be proactive in reducing non-tariff barriers to trade. Industry associations, working with governments can be important in developing international industry standards.

BP2: Harmonize food and pesticide regulation with the United States, and push for more harmonization internationally.

R: Given the fixed costs involved in new product development, the size of the market is a very important determinant of innovation. Given the predominance of Canada/US trade, unfettered access to this large market is very important. Cooperating with large US regulatory agencies would bring many additional resources to bear on decisions vital to human and environmental health.

Horizontal and Vertical Linkages

BP3: Support industry organizations.

R: Industry organizations play a very important role in agricultural innovation. The atomistic structure of the industry (particularly primary producers) requires horizontal and vertical linkages to coordinate and fund industry level initiatives. Without some government support, the tendency for parts of the industry to free ride will result in underinvestment in these critical activities.

BP4: Support government and university outreach and engagement with the agricultural industry.

R: This activity increases the human capital in industry, while enhancing the vertical and horizontal linkages in the sector. Two way flows of information are essential for the innovation process.

BP5: Coordinate and sponsor regular agricultural outlook and foresight analysis.

R: These forums bring industry together to develop shared visions and to identify future innovation opportunities. Market outlook can improve short run decision making. Many past innovation successes have come from a common industry desire to create something missing from the market place, a common recognition of an economic opportunity, and the willingness to cooperate to pursue the opportunity. Programs like Advancing Canadian Agriculture and Agri-Food Saskatchewan (ACAAFS) have provided funding in this capacity and should be maintained or enhanced.

BP6: Support food and agricultural trade shows.

R: Trade shows are critical to the marketing and adoption of many innovative products. These shows enhance the vertical and horizontal linkages in the industry, particularly when held in conjunction with other industry forums. Again, programs like ACAAFS provide funding for initiatives like this.

Building Intelligence

BP7: Coordinate, sponsor and undertake reconnaissance to identify firms and regions that are leaders in specific agricultural technologies, and encourage Direct Foreign Investment (DFI) and immigration of highly qualified personnel.

R: The international spillover of knowledge is very important for innovation. At any point in time, the agriculture industry needs to know where the global frontiers in knowledge and innovation are. These flows of knowledge can be enhanced with *reconnaissance*, with FDI where multinational firms transfer technology across international borders, and through immigration of highly qualified personnel.

BP8: Develop and implement deliberate human resource strategies designed to recruit and educate scientists, social scientists, and entrepreneurs in fields related to agriculture and food.

R: Education, human capital, and social capital have been identified as key ingredients in successful innovation systems. The training and recruitment of scientists are important for research. Successful adaptation of knowledge for commercialization, is a knowledge intensive process requiring individuals with knowledge of economics and other social sciences to develop policies and to maintain the stock of social capital that catalyzes innovation. Entrepreneurship differs from standard business skills and plays an important role by focusing innovation efforts.

Investing in Science

BP9: Continue to invest public resources in basic science/biotechnology/genomics.

R: This is proven component of national innovation systems. Private companies have little incentive to invest in these activities but as complements to private research activities, they cause a "crowding in" of applied research. These activities also train high quality personnel for industry, which increases the ability to innovate.

BP10: Use more prizes or financial awards for applied agricultural research where research inputs are unknown and targets for outcomes can be described.

R: This practice has been very successful in Brazilian ethanol and other industries. Funding is based on measurable outcomes rather than extensive proposal processes. Industry associations can play an important role in identifying technology needs and setting the target thresholds for prizes.

BP11: Spend resources on analysis and coordination to develop Canadian systems of IP protection to maximize national benefits from innovation. This involves the creation of private incentives for research, without creating unnecessary obstacles and freedom to operate issues for other firms and the public sector.

R: The management of intellectual property rights is very important for innovation. While restrictive property rights increase incentives for private investment, research spillovers can be an important driver of industry innovation. The sequential nature of most agricultural innovations makes this tradeoff especially important. A lack of knowledge sharing among researchers slows the innovation process particularly when it involves sequential innovation processes.

Access to Infrastructure

BP12: The government, working with shippers and the rail industry, should develop the infrastructure and regulatory system to ensure low cost inland access to marine containers.

R: In a globalized economy, low cost access to high quality transportation is a prerequisite for innovation. The grain economy was developed and continues to be reliant on low cost bulk shipment of commodities. Containerized shipment is becoming vitally

import for the quality control and traceability in supply chains. The large volume of empty marine containers returning to Asia creates a significant opportunity for the shipment of grain and high valued products. At present, there is a lack of infrastructure for inland container loading ports, a lack of an Asian partner, and the existence of pricing disincentives employed by the railways.

BP13: The government, working with industry should develop and maintain high-speed internet access for rural areas.

R: In a globalized economy, affordable access to high speed internet is essential for agri-food marketing, procurement, and general communication.

Crop Specific Innovation

BP14: Continue to provide public funding for basic and agronomic research.

R: These important forms of research are pubic goods by nature and will be underfunded by the private sector. Environmental challenges create the need for agronomic research, while transgenics has created a greater potential for genetic modification. The related fields of structural genomics, plant physiology, metabolomics, transcriptomics, glycomics and proteomics offer great potential for increasing productivity in agriculture. Given the investments taking place internationally, Canada must invest to remain competitive.

BP15: Implement compulsory producer controlled research levies supported by government incentives.

R: The persistent high rates of return to applied research suggests a chronic underfunding of applied crop research activities. Industry levies matched by government levies are an efficient source of funding. The commercialization and adoption of new crop varieties works very well with new genetics and is quickly put into use by farmers.

BP16: Continue the existing practices of providing public funding for variety testing and record of performance systems.

The atomistic nature of primary agriculture makes horizontal and vertical communication costly, yet essential for industry commercialization and the use of new technologies. Public funding maintains the third party integrity of these systems.

Food innovation

BP17: Government should proactively fund research to support health claims, product testing, and registration.

The development, testing and adoption of new food products are knowledge intensive processes involving public goods. This is especially true for health related products, where benefits primarily accrue to taxpayers. Government can play an important role as an impartial third party in providing and disseminating information.

BP18: Government should proactively fund public new product comparisons.

The food sector can learn a great deal from varietal testing and record of performance systems employed in the grain and livestock sectors. These programs put third parties in charge of scientific analysis and comparison of new products. These public expenditures reduce the need for product promotion and focus the buyers on outcomes. The result is an industry where scarce resources are put into product research rather than marketing, yet the adoption of new products is very rapid.

BP19: The government should create a policy to assure adequate financial resources (loans programs, equity, etc.) to pay for food innovation and commercialization.

R: Harath et al. (2007) found that financial barriers had a large unequivocal impact on Canadian functional food and nutraceutical firm performance. As they point out, this result is not surprising given that these firms are typically medium size enterprises with limited access to credit. The Agri-Opportunities Program is an example of the kind of programs that is required.

Environment

BP20: The government should implement a policy to create monetary incentives for carbon sequestration and GHG mitigation in agriculture.

R: There are many agricultural innovations that can sequester carbon and mitigate GHG emissions. Without any monetary incentives, the innovation will be limited to those processes and activities that would take place anyway. Additional incentives would spur agricultural innovation while addressing important environmental objectives.

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