THE CANADIAN AGRI-FOOD POLICY INSTITUTE

Series II: Addressing Issues and Perspective on Policy Options

Analysis of Returns to Program Spending in the Agri-Food Sector

FEBRUARY 2011

BY SHELLEY THOMPSON

About this publication

This paper is part of the series, The Viability of Canada's Agri-food Sector. The opinions stated are those of the authors, and not necessarily those of the Canadian Agri-Food Policy Institute.

The Institute is focused on stimulating a national dialogue on agricultural issues, by addressing the policies that will enable Canada to thrive in the global agri-food marketplace.

This series is available from www.capi-icpa.ca in pdf format.

For more information, please contact:
Canadian Agri-Food Policy Institute
960 Carling Avenue, CEF
Building 49, Room 318
Ottawa, ON K1A 0C6

Telephone: 613-232-8008 or
Toll-free 1-866-534-7593
Fax: 613-232-3838

info@capi-icpa.ca
www.capi-icpa.ca

CAPI
THE CANADIAN AGRI-FOOD POLICY INSTITUTE

Canada

SUMMARY

Each year, a significant amount of taxpayer funds – an average of $6.3 billion – is spent in the agri-food sector. The majority goes to producer support – the business risk management (BRM) program area. Other areas include inspection and quality assurance programs, marketing and promotion activities, research and development programs, extension services and education. The distribution of this spending has been rather heavily weighted toward producer income support through BRM type programs, receiving over 50% of program spending. Other areas receive much less. For example, R&D receives 7% of spending.

Of particular concern is how taxpayer funds – already scarce – are allocated between program areas, particularly when this allocation is influenced by political considerations, fiscal constraints, and special interest groups. One way to judge the merits of current allocations is to assess the returns (or benefits) of program spending in relation to the taxpayer costs. Generally, program areas with higher rates of return to society should be allocated more funds, while areas with lower returns of return should be allocated fewer funds. There are two general ways of measuring whether program spending has a net social benefit. One way is through a computed "internal rate of return" (IRR), with the return on public expenditure exceeding a hurdle rate, which in many cases is the public cost of funds (long run yield on government bonds and securities). A related measurement is the benefit-cost ratio (BCR), and whether it is greater than one [1:1].

Published report and journal articles provide evidence on the returns to spending in the above areas. The published evidence (including meta-analysis) indicates that the return on public R&D spending has an IRR that is in the 40% to 60% range, which implies a BCR of at least 10:1. Within the R&D complex, evidence from the USDA indicates that publicly supported basic research has the highest return, followed by applied public research, then private research, followed by farmer education and then agricultural extension. Private research has a smaller benefit than applied public research, simply due to the spillover effects of publicly funded research. In most cases primary producers as well as consumers benefit from R&D spending directed towards commodities.

Judging from 13 separate studies, the evidence indicates that market promotion activities generate supply chain benefits with a BCR range of between 2:1 and 10:1. Producer benefits are often attributable to expanded sales volume, rather than higher prices. There are few studies on the net benefits of quality assurance and inspection programs; what published results there are suggest a BCR of at least 2.1.

All funds provided through decoupled direct payments are initially retained by producers. However, some of the benefit accrues to landlords, resulting in a BCR of less than one even though the intent was to provide income support to the farm operator. The literature indicates that government spending on direct farmer subsidies through BRM type programs is an inefficient way to transfer income. The high BCR of spending in other areas such as R&D indicates that the societal benefit is much greater than that from spending on direct income support programs. However, the distribution of benefits is across a number of segments in the food supply chain, and not just to producers.

Given the above scenario, why is agricultural R&D at only 7% of spending, while direct farm subsidies exceed 50%? A primary reason is that a long gap exists between undertaking research and reaping the benefit; moreover, research does not address farm sector income issues that require an immediate political response. The literature also suggests that producers and policy makers may not believe in returns to research data, or that producers fear that technical changes could impact them negatively while input suppliers and consumers could benefit.

This paper provides further support for a re-alignment of program spending in the food supply chain. Based on internal rates of return (IRR) and benefit cost ratios (BCR), it is evident that fewer funds should be allocated to BRM programs, while spending should be increased on program areas such as R&D and promotion.

BY SHELLEY THOMPSON, SJT SOLUTIONS

Key Findings

Public policy choices can be difficult. Allocating funds between competing needs is made more challenging because of politics and special interest groups. Limited information can increase the uncertainty surrounding the metrics used to make decisions.

The objective of this study is to provide insight into the returns to various program areas within agriculture, such as farm programs (direct payments to producers), research and development, marketing and promotion, quality assurance/inspection, and infrastructure.

Public expenditures must meet some type of hurdle rate.[1] Most experts suggest that public investments should be evaluated using the social rate of return (i.e. the cost of public funds). However, it is difficult to pinpoint exactly what the social rate of return is. Most analysts appear to view the social rate of return as lying between 5% and 10%. The market rate of return is usually higher.

The existence of spillovers can make some types of investments more attractive. These additional benefits increase the social rate of return above the private rate of return. Agriculture R&D investments have spillover effects which significantly increase their attractiveness.

Policy makers must also consider the distribution of program benefits. Not all benefits are captured by the intended beneficiary.

A review of the literature found that the internal rate of return (IRR) for agricultural R&D is high, typically between 40% and 60%. This translates into a benefit cost ratio (BCR) of 10:1 to 15:1 (assuming the hurdle rate is 4%).

Within the agricultural R&D sphere, some types of investments have higher returns than others. ERS ranks the return to research components as follows (high to low): publically supported basic or pre-technology research; applied public research; private research; farmer education; and agricultural extension.

There is no evidence that the return to agricultural R&D is falling over time.

Also, the presence of intellectual property rights (IPR) and other government interventions can impact returns and their distribution.

A survey of the literature found that the distribution of benefits of agricultural R&D to producers, consumers, and others varied significantly. Some of the distributions are shown below.

Market promotion can also produce high returns, with BCR from 2:1 to 10:1. However, because price changes at the retail level may not be reflected back to producer prices, these programs may not be very effective at increasing producer returns.

Quality assurance/inspection programs can be beneficial. One study found that the BCR of mandatory meat hygiene was 1.2:1 to 2.4:1.

Table 1. Distribution of benefits of agricultural R&D to producers.

Author	Commodity	Producers	Consumers	Others
Smith *et al*	Cotton	24%	76%	
Smith *et al*	Peanut	17%	83%	
Klein *et al*	Wheat	80%	20%	
Zentner	Wheat	62%		
Nagy	Barley	93%	7%	
Gray *et al*	Pulses	33%	33%	33%
Huot	Swine	85%		
Fox *et al*	Beef and Hogs	80%		

Investment in infrastructure increases the return to the private sector. For example, improvements in the public transportation system have allowed retailers to use Just in Time (JIT) inventory. This increases the return to retailers and can also benefit growers. A Canadian study found that a $1 increase in net public capital generated cost saving producer benefits of 0.6 cents for agriculture, 0.65 cents for food manufacturing/processing, and 0.09 cents for beverage manufacturing/processing.

So, what about farm programs (direct payments)?

Brinkman in 1999 "concluded that most of the benefits of agriculture research in Canada have gone to the narrow constituency of agricultural producers and wryly observed that 'agricultural research is Canada's most effective farm assistance program'".[2]

Alston argues that US government spending on farm subsidies is a very inefficient transfer mechanism.

In 2007, Alston showed that for every dollar in US government spending on farm subsidies:[3]

- Farmers receive 50 cents (as landowners and suppliers of inputs);[4]
- Landlords renting the land to farmers receive 25 cents[
- Domestic and foreign consumers receive 20 cents;
- Waste is 5 cents.

This is a very inefficient transfer mechanism. If spending is $20 billion per year on farm programs (opportunity cost of this is $24 billion) and if producers receive only $10 billion then the average transfer efficiency is 42% (10/24). Agricultural research on the other hand has a deadweight gain. Agricultural R&D has a BCR of 10:1 and higher. Thus, if you spend $2 billion you generate $20 billion. The amount the farmers get depends on elasticities, policies, type of technical change, etc. Assuming farmers receive 50%, then they get $10 billion and the average transfer efficiency is 420% (10/2.4). Compared with R&D, "it costs 10 – 12 times as much to achieve a given producer benefit using subsidies".[5] Table 2 provides a Canadian example.[6] Allocating $1 billion as a coupled producer payment benefits producers by $500 million. If the program is decoupled, the producers' benefit is $1 billion. Allocating $1 billion to agricultural R&D has a total benefit of $10 billion. The amount by which producers benefit ranges by commodity. For example, wheat producers would receive $8 billion (if all was $1 billion invested in wheat research); barley producers would receive $9.5 billion; pulse producers would receive $3.3 billion; and livestock producers would receive $8.5 billion. If the $1 billion were invested in market promotion, the return would be $2 billion. In the case of supply managed products, producers would retain $2 billion. In the non-supply managed commodities, if producers received 50% of the benefits (which because it depends on the price transmission elasticity, 50% is likely high), then they would benefit by $1 billion.

Figure 2 illustrates the above example. The break even analysis shows how much investment in agricultural R&D and market promotion is equivalent to a $2.1 billion direct decoupled payment.[7]

Compared with farm programs, agricultural R&D is a very good investment.

Why the underinvestment in agricultural R&D? Potential reasons include:[8]

- Producer and policy makers don't believe the returns to research. Also, producers can lose from technical change (depends on elasticities and curve shifts);
- The distribution of benefits between producer groups may be important;
- Patience is necessary. There can be a long time gap between doing the research and reaping the benefit.

Research

The public good argument is the main justification for the public support of agricultural R&D. Two other arguments are 1) there is synergy between agricultural R&D and education in agricultural sciences; and 2) it contributes to competitive markets.[9]

Table 2. Transfer Mechanism Efficiency

Type of Investment	BCR	Producer	Consumer	Other Parts of Supply Chain
Producer Payment (Coupled)	1:1	50%	20%	
Producer Payment (Decoupled)	1:1	100%		
Ag R&D	10:1			
Ag R&D Wheat		80%	20%	
Ag R&D Barley		93%	7%	
Ag R&D Pulses		33%	33%	33%
Ag R&D Livestock		85%	15%	
Promotion	2:1			
Promotion SM		100%		
Promotion Non SM		50%	50%	

The social rate is greater than the private rate because there are spillover effects (i.e. private firms can't capture all the benefits). The distribution of gains is important but with high returns, winners could theoretically compensate the losers and make everyone in society better off. Of course, whether compensation is paid is a political decision.[10]

How economists evaluate the returns to research

Comparisons between public and private investment in R&D and dissemination and long term productivity change form the basis of an economic evaluation. The process is as follows:[11]

- Investment in agricultural R&D results in new knowledge and this in turn results in new technology which is adopted by farmers over time;
- The adoption of technology increases average productivity;
- The increase in productivity lowers costs, and increases the production and/or exit of some resources (i.e., labour);
- Higher production lowers the price so some of the benefit flows to processors and consumers.

The typical time path is shown below. It takes approximately seven years before technology is developed and farmers begin to adopt it. It takes an additional eight years before technology is completely adopted. Economic analyses weigh the present value (PV) of expenditures and the PV of benefits.[12]

There are two main approaches to estimated economic returns:[13]

1) Production Function Approach: "Statistical analysis relating past expenditures on research to current changes in productivity". This is sometimes called the production function approach. In this approach, "you try to establish a statistical correlation between when, where, and what research was done and productivity gains in agriculture." The analysis is done at a highly aggregated level and covers a lot of years. Other factors that can increase productivity such as extension and education are taken into account. "If regression analysis finds positive and significant correlations between research expenditures (appropriately lagged) and productivity change, then this is taken as evidence of a causal relationship. An estimate of the rate of return to research is derived from the regression coefficients."

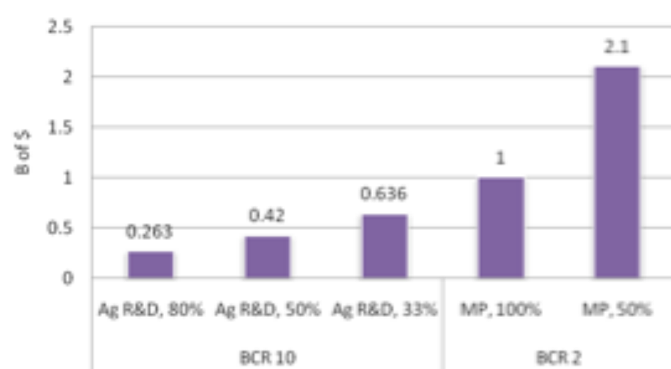

Figure 2. BreakEven $ - Direct Payment of $2.2.

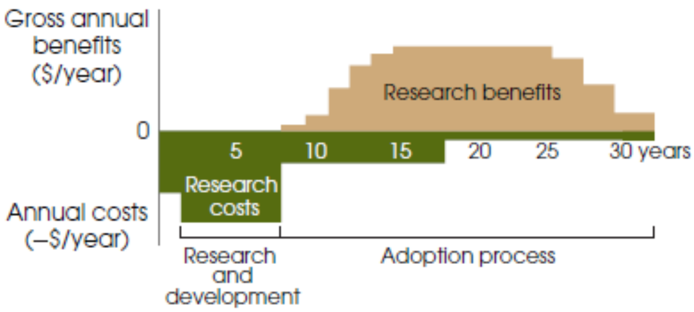

Figure 3. Flows of Research Costs and Benefits Over Time. Source: Fuglie K and P Heisey, "Economic Returns to Public Research," ERS 2007.

2) Project Evaluation/Economic Surplus Approach: In this approach you estimate the benefits and costs of a R&D project. This approach works well for successful projects but because unsuccessful projects are excluded the return is higher.
The challenges of both approaches include identifying the right lag between R&D and productivity increase; incorporating spillovers; and attribution (there are other necessary ingredients such as extension, rural infrastructure, etc.).[14]

Decision Rule

The decision rule in business is to invest if the rate of return is greater than the interest rate on borrowed funds. Modern finance added risk, changing the rule to invest if the rate of return exceeds the hurdle rate.

> **The hurdle rate is "the minimum acceptable rate of return, often abbreviated MARR, or hurdle rate is the minimum rate of return on a project a manager or company is willing to accept before starting a project, given its risk and the opportunity cost of forgoing other projects."[15]**

What is the appropriate hurdle rate for public investment, the social discount rate or risk-free market rate of interest (about 5%) or the social rate of return to assets (17.8% to 22.86%)? If the rate of return on R&D is greater than the hurdle rate then increasing investment in R&D will increase social welfare. If the budget is pre-determined, then the dollars should be allocated via the rate of return (if basic research has a higher rate of return than applied research it would be beneficial to increase basic research and decrease applied research). For the public sector, the social rate of return is hard to determine:[16]

- The past rate of return only applies to the future if the system response is the same;
- The public rate of return is more complicated because there are deadweight losses caused by raising taxes and it is difficult to observe the social discount rate (usually assume its 3% to 5%).

A low marginal rate of return can mean funding issues rather than lack of scientific opportunity. The public return doesn't generally include a risk premium because the government has a portfolio of investments.[17]

> **The internal rate of return (IRR) can be converted to a benefit cost ratio.**[18]
> **B/C = IRR/(opportunity cost of capital)**
> **(i.e. if the IRR is 40% and the long run real yield on US government securities is 4% (social rate of return), then the BCR is 10 to 1).**
>
> **The IRR is called the discounted rate of return, the marginal efficiency of capital, and the yield on an investment.[19]**

The social rate of return includes all gains to producers, consumers and processors. The social return to public expenditures should be compared to the return on US Treasury Bonds (approximately 3% to 4% per year in real terms).[20]

Importance of Spillovers

When the social rate of return exceeds the private rate of return, there is a positive externality or spillover. When there is a spillover, private firms will under-invest because they can't capture all of the benefits. There are three types of spillovers: market, knowledge, and network. [21]

The size of the spillover gap is influenced by factors such as:[22]

- Competitiveness of markets where the innovation will be commercialized;
- "lead times" and "learning curves" which can provide competitive advantage to innovating firm;
- Co-specialized assets like marketing, sales, and regulatory experience, which increase the capture of benefits by innovators;
- Benefits from coordinated research which occurs if there is a critical mass of successful projects;
- Negative spillovers from existing technology obsolescence;
- If successful commercialization requires licensing;
- IP protection to safeguard returns.

One government agency that invests in technology wants to invest in high social rate of return projects that would be under-invested in by private firms in the absence of funding. It pursues projects with a large gap between the social and private rate of return (high spillover gap). However, it doesn't want to crowd out private investment.[23]

Difficulties with spillovers include the following:

- Estimates usually don't include spill in or spill outs. It is difficult to identify depreciation costs associated with technical knowledge.[24]
- "Spillovers from research are often larger for basic or pre-technology research and smaller for research and development activities closer to the commercialization stage."[25]
- "Research with larger geographic or national spillovers should be more a Federal than State responsibility."[26]

High Level Results

Data from Huffman and Evenson and Fuglie *et al* show the following:[27]

Table 3. Studies of Rate of Return on Research.

Type	Number of Studies (1965 to 2005)	Mean Estimate
Social rate of return to public agricultural research	35	53%
Social rate of return to private agricultural research	4	45%

Based on their review, Fuglie and Heisey concluded that:[28]

- The returns to research for crop and livestock are generally high although there is some variation by commodity and time period;
- The social rate of return to private R&D is high. The private sector can't capture all of the benefit so producers and consumers also benefit;
- Agricultural R&D generates benefits over the long term. There is a time lag between R&D and productivity gain. Current research suggests that agricultural R&D undertaken today influences productivity in as little as two years and that the impact could continue for 30 year;
- There are significant spillovers across boundaries. Livestock spillovers are greater than crop spillovers because livestock production is less location specific);
- There is no clear indication that the return to agricultural R&D is declining over time.
- There has been little research on returns to non-market objectives such as food safety.

The Economic Research Service (ERS) studied the returns to research in 1996. The studies examined consistently had social rates of return of between 40% and 60%. Only one study found a 20% return for aggregate research. If extension spending is included, then the rate of return decreases to about 20% to 35%. There is little evidence that the return is falling over time. Basic science has a higher rate of return than applied science. In terms of extension, the results of estimated rate of return are variable. Huffman and Evenson found that the return to extension was 20%, which was less than for R&D. Other research by Huffman and Evenson, however, found the return to extension was 82% to 100%.[29]

ERS ranks the return to research components as follows (high to low): publically supported basic or pre-technology research; applied public research; private research; farmer education; and agricultural extension.[30]

Table 4. Summary of Social Rates of Return to Agricultural Research, Extension and Education. Source: ERS, "Economic Returns to Public Agricultural Research," in Agricultural Research and Development, 1996.

Item	Core range	Full range
	Percent/year	
All public agricultural R&D	40-60	0-100
Basic public R&D	60-90	57-110
Private R&D	30-45	26-90
Agricultural extension	1	20-110
Farmer's schooling	30-45	15-83

The overall picture of returns to research components is shown below.[31]

Some experts have argued that the estimated rates of returns are biased upwards because of:

- Wrong lag on research;
- Private sector contribution not taken into account;
- Deadweight losses from taxation not included;
- Distortions from farm programs not taken into account;
- Resource dislocation costs excluded.

ERS made the adjustments shown below and found the return fell from 60% to 35%.[32]

Table 5. Adjustments for Biases in Estimated Rates of Return. Source: "Economic Returns to Public Agricultural Research," in Agricultural Research and Development, 1996.

Adjustment	Central estimate	Range
	Number	*Percent/ year*
Unadjusted rate of return	60	55-65
Inclusion of private sector research	9	5-15
Tax collection (deadweight losses)	6	3-9
Longer research lag	10	0-20
Commodity program effects	n.a.	Negligible
Environment, health, and safety	n.a.	+/-
Structural adjustment, labor displacement	n.a.	+/-
Return after adjustment	35	

n.a. = Not available.

+/- = Effects could be positive or negative.

Alston *et al* performed a meta-analysis of rate of return studies for agricultural research and development. The studies compiled showed much variation as shown below:[33]

Table 6. Studies of Rate of Return Variation.

Rate of Return	# Estimates	Average	Mode	Mean	Minimum	Maximum
Nominal	351	69.6	52	51	-2.3	466
Real	1302	76.8	46	43.8	-100	1736
Exante	405	93.7	49	35.9	-12.3	1736
Exposte	1367	77.4	46	46	-100	5645
Average	1708	81.5	49	38	-100	5645
Marginal	686	80.5	40	50	-1	1219
Private	55	138.5	20	30	0	3539
Social	1717	79.3	40	44.3	-100	5645
BCR Reported	1683	72.4	46	44	-100	5645
BCR Derived	89	246.7	1.4	60	0.3	1720
Multi Commodity	436	80.3	58	47.1	-1	1219
All Ag	342	75.7	58	44	-1	1219
Crops & Livestock	80	106.3	45	59	17	562
Field Crops	916	74.3	40	43.6	-100	1720
Corn	170	134.5	29	47.3	-100	1720
Wheat	155	50.4	23	40	-47.5	290
Livestock	233	120.7	14	53	2.5	5645
Resources	78	37.6	7	16.5	0	457
Forestry	60	42.1	7	13.6	0	457
All Studies	1772	81.2	46	44	-1005645	

Key findings of Alston *et al* were:[34]

- * Nominal return (not adjusted for inflation) is higher than the real return (adjusted for inflation) by 25 percentage points.
- * Exposte returns (after the introduction of the innovation) higher than exante (before the introduction of the innovation) returns by 18 percentage points.
- * Social return higher than private return by 14 percentage points.
- * Imputed rate of return imputed from BCR is 163 percentage points higher than estimated rate of return.
- * Compared to rate of return for all agriculture, field crops are 25% higher, natural resources are 92% lower, tree crops are 19% higher and livestock are 12% higher.
- * No evidence that return is falling over time.
- * Average rate of return greater than marginal rate of return by 7.2%.
- * Public research has a higher return than private research by 19%.

More funding is not always a good thing.

- Analysis of canola R&D from 1970 to 1999 found a “decline in the total net return to research. The government’s Matching Investment Initiative decreases the private cost of research below the social marginal cost, and empirical results suggest that the combined effect of IPRs and government subsidies resulted in an overinvestment in research”. Authors suggest that government funds should “be focused on those sectors and technologies where IPRs do not exist.”[35]

- This research showed that when there are large government subsidies for crops, research which increases yields can reduce welfare.[36]

Distribution of Benefits

Supply management allows producers to capture benefits. Klein *et al* (1995) found that Canadian wheat producers captured about 90% of benefits because Canadian exports don't influence price. Fox *et al* found that beef and hog producers captured about 90% of benefits.[37]

Selected Studies

The following table summarizes information from selected studies on the returns to agricultural R&D.

Table 7. The following estimates of the distribution of benefits are from the selected studies.

Author	Commodity	Producers	Consumers	Others
Smith *et al*	Cotton	24%	76%	
Smith *et al*	Peanut	17%	83%	
Klein *et al*	Wheat	80%	20%	
Zentner	Wheat	62%		
Nagy	Barley	93%	7%	
Gray *et al*	Pulses	33%	33%	33%
Huot	Swine	85%		
Fox *et al*	Beef and Hogs	90%		

Table 8. Returns to agricultural R&D.

Study	Country	Commodity	Rate of Return	Benefit/Cost	Comments	Methodology
White F, S He and S Fletcher, “Research Spillovers and Returns to Wheat Research Investment,” Paper at Southern Agricultural Economics Association Annual Meeting, February 2003	US 1978 to 1995	Classes of US wheat Ex post	Hard red winter: 49.3% (private) 61% (social); Hard red spring: 43.2% (private) 102.3% (social); Soft red winter: 3% (private) 3% (social); Durum: 59% (private) 91.5% (social); White: private not calculate		Are spillovers which is why social return > private return Hard red winter benefits hard red spring and durum; hard red spring benefits soft red winter and durum; durum benefits white	Cost function
Farquharson R, J Morgan and J Brennan, “An Economic Evaluation of the Osmoregulation Gene 2004Technology to the Australian Wheat Industry,” Paper at AARES Meeting, February	Australia	Wheat Exante	IRR: NSW 10% to 22% Australia 16% to 27%	NPV: NSW $101 M Aust to $958 M Aust Australia $338 M Aus to $3.6 B Aus (4% real discount rate) B/C: NSW 22:1 to 204:1 Australia 43:1 to 390:1 Depends on adoption rate	Osmoreg gene mitigates water loss, i.e., gives improved tolerance to drought. Looks at impact of expected climate change (hotter and drier) on wheat with and without project	Assumes vertical S curve and horizontal D curve: all extra yield and production valued at same price and all benefits go to producer Results don’t include impact of spillovers IRR is low because period of R&D inputs in long and benefit period is short
Brennan J, P Martin and J Mullen, “An Assessment of the Economic, Environmental and Social Impacts of NSW’s Agricultural Wheat Breeding Program,” NSW Agriculture, May 2004	Australia Investment from 1980 to 2003 and benefits from 1993 to 2020	Wheat Ex ante	IRR: 16%	NPV: $321 M Aust B/C: 8.4 (each $ invested in wheat research returned $8.4)	Most benefits remain with producer because Australia is a price taker and processing and distribution sector in Australia is competitive	Assumes vertical S curve and horizontal D curve: all extra yield and production valued at same price and all benefits go to producer

Alston J, C Chan-Kang, M Marra, P Pardey, and T Wyatt, "A Meta-Analysis of Rates of Return to Agricultural R&D," IFPRI 2000	Meta analysis of 292 studies and 1886 rates of return from around the world		Average rate of return to research 100%, extension 85%, research & extension 48%, all studies 81%		Conventional wisdom is that typical rate of return is between 40% to 60% per year Is much variation	
Griffith G, R Farquharson, S Barwick, R Banks and W Holmes, "Estimating Returns from Past Investments into Beef Cattle Genetics RD&E in Australia," Paper at International Conference of Agricultural Economists, 2003	Australia 1970 to 2000	Beef Genetics	If make benefits more conservative, then get NPV of 921 M, BCR of 3.7:1 and IRR >19%	PV investment = $340 M PV of industry returns = $9.4 B BCR=28.1	Includes extension Other research showed 33% of benefit to beef producers and 50% to consumers	Used genetic trend data to derive benefits and used model which views technical change as % change in variable unit cost which influences supply
Parnell, P, Cumming, B, Farquharson, R and Sundstrom, B (1992), "Review of Beef Cattle Breeding Research on NSW Agriculture Research Centres," NSW Agriculture, Orange.	Australia	Beef cross breeding	IRR 13.5%	NPV of 170 M by 2020 BCR 8.5:1	exante	
Smith A and J Dorfman, "An Economic Evaluation of Cotton and Peanut Research in Southeastern United States," AAEA Annual meeting 2002	US 1963-1995	Cotton Peanuts	IRR Cotton 23.87% Peanut 53.58%		Examined distribution of benefits Cotton: producers 24% consumers 76% Peanut: producers 17% Consumers 83%	Used economic surplus approach

Plastina A and L Fulginiti, "Rates of Return to Public Agricultural Research in 48 US States," Paper presented at the International Association of Agricultural Economists Conference 2009	US 1949-91	Agricultural research	IRR: Own state average 17% Social rate of return for nation 29%		Took into account the impact of spillins which reduces returns	Production function
Nieuwoudt W and T Nieuwoudt, "The Rate of Return on R&D in the South African Sugar Industry, 1925-2001," Agrekon Vol 43, 2004	South Africa 1925-2001	Sugar Cane Research, training and extension	BCR from 1.41 to 1.59	Real IRR 17%	All research is funded by industry	Production function approach
Klein, K. K., B. Freeze and A. M. Walburger. 1996. Economic returns to yield-increasing research on wheat in western Canada. Canadian Journal of Agricultural Economics 44: 207–18.	Canada 1972 to 1991	wheat	IRR to yield increasing wheat R&D from 27% to 39%		80% of benefits to producers	Mathematical programming model
Fox, G., G. Brinkman and N. Brown-Andison, "An Economic Analysis of the Returns to the Animal Productivity Research Program of Agriculture Canada from 1968 to 1984," Intercambio Ltd. 1987	Canada	Animal Research	IRR between 25% and 124%			
Zetner 1982	Canada	Wheat	34% to 39%			
Nagy, J.G., and W.H. Furtan. "Economic Costs and Returns from Crop Development Research: The Case of Rapeseed Breeding in Canada." Can. J. Agr. Econ. 26(February 1978):1–14.	Canada 1960 to 1974	Rapeseed	IRR of 101%			

Ulrich. A., W. H. Furtan and A. Schmitz. 1986. Public and private returns from joint venture research: An example from agriculture. The Quarterly Journal of Economics 101 (1): 103–29.	Canada	Barley	IRR of 31%			
Ulrich. A. and W. H. Furtan. 1985. An investigation in the rates of return from the Canadian crop breeding program. Ottawa, ON: Agriculture Canada, Program Evaluation Division.	Canada	Canola	IRR of 51%			
Zentner, R. P. and W. L. Peterson. 1984. An economic evaluation of public wheat research and extension expenditures in Canada. Canadian Journal of Agricultural Economics 32: 327–53.	Canada 1946 to 1979	Wheat	IRR of 38%		Producers capture 62% of benefits	Production function approach
Nagy, J. G. 2002a. Economic returns to triticale breeding research at the Alberta Field Crop Development Centre. Edmonton, AB: AAFRD.	Canada	Triticale	IRR of 25%			
Nagy J, “Economic Returns to Feed Barley Yield-increasing and Disease Resistance Research at the Alberta Field Crop Development Centre,” CJAE, Vol 51, 2003	Canada	Barley 1973-2001	IRR of 27% with range from 23% to 31%		52% of benefit from yield increase and 48% from disease resistance Producers received 93% of benefit Consumer 7%	Economic surplus approach

Guzel, A., Furtan, H., Gray, R. 2005. "Returns to Research Western Grains Research Foundation Wheat and Barley Check-offs". Report for the Western Grains Research Foundation, July 2005.	Canada 1994 to 200?	Wheat	IRR for wheat of 23.8%	BCR for wheat of 4.4		Consumer surplus
Galushko V and R Gray, "Benefits from Wheat Breeding Research in Western Canada"	Canada 1977 to 2006	Wheat	IRR for wheat of 49% to 106% (ex poste)		1 professional scientist has an IRR in wheat breeding of 43% to 53% and 35% to 41% (ex ante)	
Gray R, C Nagy, V Galushko and S Weseen, "Returns to Pulse Crop Research & Development and the Management of Intellectual Property Rights," for SK Pulse Growers, 2008	Canada 1984-2008	Pulse Crops	Producers IRR: 39% in short term and 35.9% in long term Compared to 2003 study, estimated IRR have increased (doubled)	Producers BCR: 15.8 to 1 for 1984 to 2012 and 20.2 for 1984 to 2024 Investment in genetics had a higher BCR then development acceleration	Benefits to 2024 Producers, consumers and value added sector each receive about 33% of benefit	Economic surplus approach
Huot M, G Fox, and G Brinkman, "Returns to Swine Research in Canada," North Central Journal of Agricultural Economics, Vol 11, July 1989	Canada 1968-1984	Swine	IRR of 45% to 50%	BCR of 6.8 (with real discount rate of 10%) to 11.9(with real discount rate of 2%)	85% of benefit to producers Remainder to consumers	Economic surplus framework

Huffman W and R Evenson, "Contributions of Public and Private Science and Technology to US Agricultural Productivity," AJAE 1992	US 1950 to 1982	Agricultural research			Estimated elasticity for private ag research >0, thus is positive social return to private ag research (firms can't capture all benefit) Elasticities for public crop and livestock extension >0 and thus is positive social return to extension Results also suggested too little research on public pre-technology science research and too much on public applied	Production function
Malla S, R Gray and P Phillips, "Gains to Research in the Presence of Intellectual Property Rights and Research Subsidies," Review of Agricultural Economic vol 26	Canada 1970 to 1999	Canola	Average IRR > 25% at beginning but over time declined to market level		IPR and government subsidies resulted in over-investment	
Song F and S Swinton, "Returns to Integrated Pest Management Research and Outreach for Soybean Aphid," Paper for AAEA Meeting, 2008	US 2000 to 2017	IPM and outreach for soybean aphid	IRR of 140% Economic Net Benefit of $1.3 B		Exante Aphid first detected in 2000 61% of losses in do nothing scenario to consumers; 39% to producers	Economic surplus Real discount rate of 5% If use 10% rate of return to direct research is still $790 M to compensate indirect research (on IPM in general)
Falck-Zepeda B, G Traxler and R Nelson, "Surplus Distribution from the Introduction of a Biotechnology Innovation," AJAE, Vol 82, May 2000	US 1996	Bt Cotton		Increase in world surplus of $240.3 M; 59% to US farmers; 21% to Monsanto (gene developer); 9% US consumers; 6% ROW; 5% Delta and Pine Land (supplier of germplasm)	Monsanto may have lowered price as is first transgenic crop	Simulation of economic surplus

Market Promotion

Agricultural exports can be promoted without pricing changes through consumer promotion, technical assistance, and trade servicing. Consumer promotion is directed at the final consumer. It increases the final demand for the product through brand and generic advertising, public relations, and point of sale promotions. Technical training, technique transfer and organizational transfer are types of technical assistance. It increases exports by reducing costs and increasing productivity in the intermediate sectors which use the commodity as an input. Trade servicing, focusing on the market and not on individual consumers or producers, attempts to improve areas like customer relations by providing market and technical information. It consists of activities like trade missions and exhibits.[38]

"Generic advertising is generally a cooperative effort of a large group of producers (suppliers) to promote the demand for the homogeneous (similar) product" and are funded through commodity checkoff programs.[39]

How economists evaluate the return to promotion

Promotion increases consumer awareness which increases sales/profits which increases contributor profit. Thus, economists usually use consumer awareness, retail price impact or contributor profit to measure awareness. However, increasing consumer awareness might not increase sales/prices as other factors effect retail demand and farmers don't capture all the benefit.[40]

Most organizations look at the return on investment to advertizing. They look at the AME (Aggregate Measure of Effectiveness), but these are calculated and reported many different ways. The most common is the BCR (benefit cost ratio) which measures the $ increase in sales per promotional $ spent. If the BCR >1, then the promotional program is thought to be effective. These BCR's are measuring the "average" return to promotion which makes their use in funding allocations less useful. Some researchers use the marginal rate of return (% increase in sales revenue from a 1% increase in promotion expenditures) to allocate funding. These ratios don't explain whether the benefits exceed costs by enough to justify continuing the program.[41]

The reported BCR are usually in the 2:1 to 10:1 range. Some metrics are needed to make comparisons to the BCR. The opportunity cost of checkoff funds is important. In business, one compares the IRR for alternate investments. The IRR is called the discounted rate of return, the marginal efficiency of capital, and the yield on an investment. For a commodity promotion program, the IRR is "the change in the future value of the estimated returns to the promotional expenditures over time divided by a change in the present value of advertising expenditure expressed in percentage terms." The IRR "expresses the estimated marginal returns to promotional expenditures" (i.e., the % change in returns from a 1% change in promotion). For Florida orange juice promotion, the IRR was 14.4%. For growers to have done better than investing in promotion, they would have to have an alternate investment yielding more than 14.4% on average over the 33 year period of promotion. Economists use IRR in R&D analysis where the supply curve shifts, but not in promotional analysis where the demand curve shifts.[42]

The use of demand equations allows other variables (such as income) besides generic promotion to be held constant. Thus demand could decrease and generic advertising would still be effective (sharp drop in income results in lower demand and this outweighs the increase in demand from advertising).[43]

High Level Findings

According to Williams and Capps, the reported BCR are usually in the 2:1 to 10:1 range.

Generic Promotion in Australia: If the product is traded, if world and domestic products are perfect substitutes, and if a country is a price taker on world markets, then advertising won't increase the farm price. Generic domestic advertising supported by a producer levy generally only increases returns to farmers when the commodity is not traded or traded very little. In order to increase farm prices through domestic generic advertising, certain factors apply: the greater the levy rate the greater the required advertising induced increase in sales; as ratio of exports to production increases so does the required advertising induced increase in domestic sales; the more price responsive domestic and export demands are, the greater the required advertising increase in domestic sales; and the greater the ability to substitute other inputs for the commodity in production of the final product, the lower the return to domestic advertising.[44]

Cross Commodity Effects Matter: Because some dairy products are substitutes for one another, advertising that increases the demand for one product can reduce the demand for the other product.[45] Advertising one commodity can change the demand and prices for it and other related commodities. Benefits to the producers of the commodity come partly at the expense of producers of other commodities. It was found that in 1998 US beef and pork advertising was three times the optimal amount (which takes into account cross-commodity effects).[46] While cross commodity effects can be significant they are generally ignored. Results can be sensitive to health effects, especially for meat.[47]

Agricultural Policies Affect Effectiveness: The return on investment to the cotton promotion and R&D program is increased by the agricultural policy for cotton. The subsidization of foreign and domestic mills prevents the market price from increasing fully from the promotion and R&D program. This limits the offset in loan deficiency payments. Commodities with LDP and non-resource loans (such as wheat and pulses) have lower incentives to use generic promotions than commodities with subsidies for users or quotas (such as cotton, peanuts and dairy).[48]

Having Imports Contribute to Promotion: When exclusion costs are high (difficult-to-capture benefits), such as with commodities, generic promotion will be undersupplied. Exclusion costs can be reduced by national programs that access fees on imports. The government must ensure compliance and collect fees on imports. A minimum of $20 million US is needed for an effective national TV campaign.[49]

Lack of Competition Changes Decisions: The existence of a beef processing/retail sector with oligopoly power captures some of the benefit from increased consumer demand because of advertising. A simulation model of US beef found that the optimal amount of advertising for beef was lower, producer benefits were less, and packers captured most of the benefits.[50]

Technical Assistance versus Commodity Promotion: Empirical analysis suggests that the technical assistance that reduced marketing costs resulted in the largest welfare gain to US producers and that the US had over-invested in consumer promotion activities. For commodities where marketing inputs represent the bulk of the cost of the finished good (i.e. cotton and wheat), activities that reduce marketing input costs may be more effective than direct consumer promotion activities.[51]

Distribution of Benefits

The effectiveness of generic advertizing at the farm level depends on price transmission: The estimated rates of return are high, so why don't producers like mandatory checkoffs? Typically, aggregate disappearance data is used to estimate advertising and price elasticities so one can calculate "how much of a change in retail prices can be attributed to a one dollar increase in advertising, holding the quantity of the commodity produced fixed." But this assumes a 1:1 transmission of price change at retail back to the farm and that the supply of commodity is fixed. Farm level effects may differ from retail level effects because:[52]

- Nature of the checkoff – the checkoff may not be uniform across producers (could be premiums and discounts).
- Supply response – if taken into account, the advertising induced price increase is less.
- Input substitution – the final product is assumed to be produced using fixed proportions of inputs, however, as price of the advertized input increases, substitutions are made.
- Government intervention can impact price transmission.
- Presence of market power – will reduce price transmission from retail to farm.
- Industrialization of agriculture – greater vertical integration increases market power which reduces transmission.

Wohlgenant estimated price transmission elasticities and found that transmission is not perfect. Results were as follows: beef .67%; pork .69%; poultry .9%; and dairy .16%.[53]

Wohlgenant examined the distributional impacts of research versus promotion. He found that when the elasticity of substitution between farm and non-farm inputs is greater than zero and promotion or consumer research and R&D have the same impact on retail demand and farm level supply curves (i.e. parallel shifts) then "research on farm production generates greater returns to producers than research on marketing service or consumer promotion." This is because substitution of inputs is possible and the retail to farm level transmission is not perfect. Chung and Kaiser examined the case of pivotal shifts in supply and demand. With this type of shift, consumer promotion generates more benefit to producers than farm level research. However, there are no studies predicting what type of shift will occur.[54]

Selected Studies

The following table summarizes information from selected studies on the returns to agricultural promotion.[55]

Table 9. Returns to agricultural promotion.

Study	Country	Commodity	Rate of Return	Benefit/Cost	Comments	Other
Adhikari M, L Paudel, J Houston, and B Paudel, "Measuring the Impacts of US Export Promotion Program for Wheat in Selected Importing Regions," Paper at Southern Agricultural Economics Association Annual Meeting, February 2003	US 1996-2001	Wheat	Marginal return to export promotion: $1.49 in Pacific Rim; $2.01 in Mexico; $0.42 in Middle East Investment in Middle East not profitable		Impact of Foreign Market Development Program (FMDP) and Market Access Program (MAP) Estimated using export demand curve	
Ward R and B Boynton, "US Honey Supply Chain: Structural Change, Promotions and the China Connection," International Journal on Food System Dynamics, 2010	US 1996-2006	Honey Generic Advertising (Domestic & Imported)		These are cost/benefit ratios. Average rate of return: domestic producers 7.91 (1:7.91); import producers 6.03 Total ave rate of return 7.08 these excludes program costs If take program costs into account then total return is 1:6.08	Impact of generic advertizing estimated using demand curves	Interpretation: for each $ of assessment paid by domestic producers, farm value increases by $7.91 Has estimates of other commodities

Kaiser H, "Measuring the Impacts of Generic Fluid Milk and Dairy Marketing," NICPRE, September 2010	US 1995 -2009	Fluid milk Dairy products		Fluid milk: average BCR was 8.88 (each $ invested resulted in additional 8.88 in industry net revenue) Dairy products: average BCR was 6.20 (non fat basis); get better return from generic ad (BCR of 8.56) then non-ad promo (BCR of 6.60)	Estimated using demand equations	Fluid milk consumption in US is decreasing by 1% per year and marketing has helped it from falling further
Comeau A, R Mittelhammer and T Wahl, "Assessing the Effectiveness of MPP and TEA Advertising and Promotion Efforts in the Japanese Markets for Meats," Journal of Food Distribution Research, July 1997	US Need year	US beef, poultry and pork exports to Japan		Found that the net marginal per $ return of incremental advertising and promotion for beef ranged from 6.73 to 1 to 16.1 to 1 in 1994. Direct consumer promotion had no significant impact on US pork and poultry exports to Japan.		
Mounter S, G Griffith and R Piggott, "The Payoff from Generic Advertising by the Australian Pig Industry in the Presence of Trade," Australian Agribusiness Review, 2005	Australia 2003	Australian Pork Promotion in Domestic and Export Markets		For 2003 promotions found producers received the greatest return from domestic advertising of bacon and ham the lowest return from promotion of pork in export markets. Under some assumptions BCR <1.	Ex ante	

Cranfield J and E Goddard, "Open Economy and Processor Oligopoly Power Effects of Beef Advertising in Canada," CJAE, Volume 47, 1999	Canada 1973 to 1991	Beef	Marginal IRR ranges from -0.07% for greater generic advertizing in Canada to 2.84% for greater branded beef advertizing in US		Generic beef advertising increases the demand for beef in both Canada and the US. Generic beef advertising in Canada has historically been beneficial to Canadian producers but additional advertising would have a negative return while brand advertising in Canada or the US, or generic advertising in the US would have a positive return	simulation
Chang H, and H Kinnucan, "Advertising and Structural Change in the Demand for Butter in Canada," CJAE, Volume 38, 1990	Canada 1978 to 1986	Butter			An evaluation of advertising for butter in Canada by the Dairy Bureau of Canada during 1970 and 1978 found that the advertising increased the demand for butter, reduced the demand for margarine and made butter demand less elastic.	Had no costs to calculate cost benefit

Goddard E and A Tielu, "Assessing the Effectiveness of Fluid Milk Advertising in Ontario," CJAE, Volume 36, 1988	Ontario 1971 to 1984	Fluid Milk		Estimated benefit cost ratio of 8:1 (each $ in ad increases net revenue by $8)	During 1971 to 1984, fluid milk advertising expenditures by the OMMB resulted in increases in the demand for fluid milk and tomato juice and decreases in the demand for soft drinks, and orange and apple juices. The advertising increased sales of milk and dairy industry revenue by 4%.	
Kaiser H, J Cranfield, and M Doyan, "An Economic Analysis of Generic Fluid Milk Advertising in Ontario, Quebec, and the Maritime Provinces," NICPRE January 2006	Ontario 1990 to 2004 Quebec 1990 to 2004	Fluid milk		Average rate of return for generic advertising: Quebec 7.35; Ontario 3.39; Maritimes 2.23	(each $ invested in generic advertising generated $7.35 in net returns to dairy farmers)	
World Perspectives and Agrilogic, "United Soybean Board Checkoff Program Return on Investment 1995 to 2001," June 2003	US 1995 to 2001	Soybean Research and Foreign Promotion		BCR of research and foreign promotion was 6.75 to 1	Estimated elasticities for research expenditures (in soybean yield and acreage) and promotion (US exports)	Impact on producer profit
Cranfield J, "Optimal Collective Investment in Generic Advertising, Export Market Promotion and Cost-of-Production Reducing Research," CJAE, Vol 51, 2003	Canada 1995 to 1998	Beef			Simulation found that should reduce export market promotion and increase domestic generic advertising and production research	No numbers

Ward R, “Commodity Checkoff Programs and Generic Advertising,” Choices Q2, 2006	US	Various		Benefit cost ratios typically are between 4:1 and 6:1 (ie for each $ of promotion, “at least 4 to 6 times is generated in new revenue, profit, or economic surplus to the industry”. BCR are as follows: beef 5.6:1; pork 4.8:1; dairy 4.6:1; flowers 6.6:1; prunes 2.7:1; eggs 4.7:1; and processor oranges 2:1 to 4:1		
Hanagriff R, M Lau, and S Rogers, “State Funded Marketing and Promotional Advertising to Support a State’s Winery Business: Are there Economic Returns?: A Case Study Using Texas Senate Bill 1370’s Support of the Texas Wine Industry,” Proceedings of the Southern Association of Agricultural Sciences Conference, February 2009	Texas	Wine		Annual economic impact from supported marketing activities: each $1 in funding increases direct sales by $8.42; economic impact by $15.33; and value added by $1.54		Surveyed TX wineries for data (57% response rate) TX wineries receive 975 K of funding for promotion

Inspection/Quality Assurance

There is a dearth of research on the return to inspection/quality assurance programs. As noted in the selected studies, a study of the introduction of mandatory meat hygiene regulations in New Zealand provides estimates of the social costs and benefits. With estimates of the social benefits (ranging from NZ$255 M to 499 M) and social costs (ranging from $NZ 255 M to 406 M), the benefit cost ratio can be calculated (1.2:1 to 2.4:1).[55]

An exante Canadian study of the Ontario agricultural premises registry estimated the benefits and costs for outbreaks of foot and mouth disease, avian influenza and soybean rust. From these numbers it is possible to calculate BCR's. These ranged from 4:1 to 85:1.[56]

Although the number of studies is small, it does appear that the BCR for inspection/quality assurance programs exceeds one.

Selected Studies

The following table summarizes information from selected studies on the returns to inspection/quality assurance.

Table 10. Returns to inspection/quality assurance.

Study	Country	Commodity	Rate of Return	Benefit/Cost	Comments	Other
Cao K and R Johnson, "The Costs and Benefits of Introducing Mandatory Hygiene Regulations, "Paper for NZ Agriculture and Resource Economics Society Conference, August 2006	New Zealand	Meat		Private benefit (to meat industry) from $NZ 840 M (loss of US market, most likely) to $NZ 23.7 B (loose all markets) Estimated costs of HACCP implementation from $NZ 237 to 337 M BCR 2.5 to 100 Social benefits from NZ$ 255 M to 499 M Social costs from $106 M to 406 M	In 1999, law required HACCP based risk management programs From these estimates the BCR can be calculated (from 1.2:1 to 2.4:1)	Estimated changes in plant costs Estimated benefits from saved costs associated with border closures Simulation
Ontario Traceability Taskforce, "The Development of an Ontario Agricultural Premises Registry: A Business Case," October 2005	Canada Ex ante	Cattle, Sheep, and Pigs (FMD) Poultry (Avian Influenza) Soybean (Soybean Rust)		Estimated cost to Ontario agriculture of FMD outbreak ranges from $1.5 B to $4 B. If the registry saved 5% of costs (savings of $75 M), then BCR is 84.9:1 The estimated cost of avian influenza is $812 M. If the registry saved 5% of costs (savings of $40.6 M), then the BCR is 46:1 The estimated cost of soybean rust is $35 M. If the registry saved 10% of costs (savings of $3.5 M), then the BCR is 4:1	Estimated annual operating costs for Ontario Traceability Node and Ontario Agricultural Premises Registry are $833,000	

Public Capital

Public investment in infrastructure and other types of public capital benefits businesses.

"The historical evolution of public infrastructure has been important to the US economy not simply because it supplemented private sector investments, but because the public investments raised private rates of return over time. National highways and bridges have made possible a shift in the carrying costs of inventory, one consequence of which has been to improve efficiencies in the delivery and availability of consumer goods."[57]

A 2003 study by Statistics Canada researchers examined the contribution of public capital ("defined as the engineering construction component of public administrations' capital stock (federal, provincial and territorial, and local) and includes primarily transportation systems, such as subways and highways, mass transit, water supply, and wastewater treatment facilities") to the economic and productivity growth of 37 Canadian industries. The study found that a $1 increase in net public capital generated cost saving producer benefits of 0.6 cents for agriculture, 0.65 cents for food manufacturing/processing, and 0.09 cents for beverage manufacturing/processing.[58]

A 2004 report found that a 1% increase in government spending on infrastructure results in a 0.3% increase in economic growth rates over the long term.[59]

Better infrastructure allows JIT inventory which reduces costs. Public infrastructure investment has enabled programs such as Wal-Mart's fruit and vegetable program to reduce its cost, increase grower returns, increase the private rate of return in the food sector and increase the availability of healthy products to consumers.[60]

Selected Studies

The following table summarizes information from selected studies on the returns to public capital.

Table 11. Returns to public capital.

Study	Country	Commodity	Rate of Return	Benefit/Cost	Comments	Other
R.J. Shapiro and K.A. Hassett. 2005. "Healthy Returns: The Economic Impact of Public Investment in Surface Transportation." American Public Transportation Association. A comprehensive literature survey is M.I. Nadiri and T. Mamuneas, 1998, "Contributions of Highway Capital to Output and Productivity Growth in the U.S. Economy and Industries." Federal Highway Administration, Department of Transportation.	US			In 2003, direct economic benefits from highways and public transportation was $788.4 B (mainly in lower costs and higher productivity) $185.1 B in taxes and fees to pay for this Net benefit of $603B		
Harchaoui T and F Tarhani, "Public Capital and Its Contribution to the Productivity Performance of the Canadian Business Sector," November 2003	Canada	Sectors of Agriculture, Food Processing, Beverage Processing (along with other sectors)		Calculated marginal benefits ("measure of producers/ willingness to pay for an additional unit of public capital") for agriculture of 0.6 cents; for food processing of 0.65 cents; and for beverage processing of 0.09 cents		

References

1. "The minimum acceptable rate of return, often abbreviated MARR, or hurdle rate is the minimum rate of return on a project a manager or company is willing to accept before starting a project, given its risk and the opportunity cost of forgoing other projects" (http://en.wikipedia.org/wiki/Hurdle_rate).

2. Klein K, "Publicly Funded Research in Agriculture: Time for a Shift in Paradigm?," CAES Annual Meeting 2000.

3. Alston J, "Efficiencies of Income Transfers to Farmers Through Public Agricultural Research: Theory and Evidence from the United States," AJAE, Vol 91, 2009.

4. Producers get 100% of the subsidy if it is decoupled.

5. Alston J, "Efficiencies of Income Transfers to Farmers Through Public Agricultural Research: Theory and Evidence from the United States," AJAE, Vol 91, 2009.

6. This example is solely for pedagogical purposes and is not meant to be prescriptive.

7. The % refers to the amount reaching the producer.

8. Alston J, "Efficiencies of Income Transfers to Farmers Through Public Agricultural Research: Theory and Evidence from the United States," AJAE, Vol 91, 2009.

9. Klein K, "Publicly Funded Research in Agriculture: Time for a Shift in Paradigm?," CAES Annual Meeting 2000.

10. ERS, "Economic Returns to Public Agricultural Research," in Agricultural Research and Development, 1996.

11. Fuglie K and P Heisey, "Economic Returns to Public Research," ERS 2007.

12. Fuglie K and P Heisey, "Economic Returns to Public Research," ERS 2007.

13. Fuglie K and P Heisey, "Economic Returns to Public Research," ERS 2007.

14. Fuglie K and P Heisey, "Economic Returns to Public Research," ERS 2007.

15.http://en.wikipedia.org/wiki/Hurdle_rate.

16. ERS, "Economic Returns to Public Agricultural Research," in Agricultural Research and Development, 1996.

17. ERS, "Economic Returns to Public Agricultural Research," in Agricultural Research and Development, 1996.

18. Fuglie K and P Heisey, "Economic Returns to Public Research," ERS 2007.

19. Williams G and O Capps Jr, "Measuring the Effectiveness of Checkoff Programs," Choices Q2 2006.

20. Fuglie K and P Heisey, "Economic Returns to Public Research," ERS 2007

21. Jaffe A, "Economic Analysis of Research Spillovers: Implications for the Advanced Technology Program," Brandeis University and NBER, 1996.

22. Jaffe A, "Economic Analysis of Research Spillovers: Implications for the Advanced Technology Program," Brandeis University and NBER, 1996.

23. Jaffe A, "Economic Analysis of Research Spillovers: Implications for the Advanced Technology Program," Brandeis University and NBER, 1996.

24. ERS, "Economic Returns to Public Agricultural Research," in Agricultural Research and Development, 1996.

25. ERS, "Economic Returns to Public Agricultural Research," in Agricultural Research and Development, 1996.

26. ERS, "Economic Returns to Public Agricultural Research," in Agricultural Research and Development, 1996.

27. Fuglie K and P Heisey, "Economic Returns to Public Research," ERS 2007.

28. Fuglie K and P Heisey, "Economic Returns to Public Research," ERS 2007.

29. ERS, "Economic Returns to Public Agricultural Research," in Agricultural Research and Development, 1996.

30. ERS, "Economic Returns to Public Agricultural Research," in Agricultural Research and Development, 1996.

31. ERS, "Economic Returns to Public Agricultural Research," in Agricultural Research and Development, 1996.

32. ERS, "Economic Returns to Public Agricultural Research," in Agricultural Research and Development, 1996.

33. Alston J, C Chan-Kang, M Marra, P Pardey, and T Wyatt, "A Meta-Analysis of Rates of Return to Agricultural R&D," IFPRI 2000

34. Alston J, C Chan-Kang, M Marra, P Pardey, and T Wyatt, "A Meta-Analysis of Rates of Return to Agricultural R&D," IFPRI 2000.

35. Malla S, R Gray and P Phillips, "Gains to Research in the Presence of Intellectual Property Rights and Research Subsidies," Review of Agricultural Economics vol 26.

36. Murphy, J.A., W.H. Furtan, and A. Schmitz. "The Gains from Agricultural Research under Distorted

Trade." J. Public Econ. 51(June 1993):161–72.

37. Klein K, "Publicly Funded Research in Agriculture: Time for a Shift in Paradigm?," CAES Annual Meeting 2000.

38. Kinnucan H, H Xiao, and S Yu, "Relative Effectiveness of USDA's Non Price Export Promotion Instruments" , Journal of Agricultural and Resource Economics, Volume 25, 2000.

39. Ward R, "Commodity Checkoff Programs and Generic Advertising," Choices Q2, 2006.

40. Williams G and O Capps Jr, “Measuring the Effectiveness of Checkoff Programs,” Choices Q2 2006.

41. Williams G and O Capps Jr, “Measuring the Effectiveness of Checkoff Programs,” Choices Q2 2006.

42. Williams G and O Capps Jr, “Measuring the Effectiveness of Checkoff Programs,” Choices Q2 2006.

43 Ward R, “Commodity Checkoff Programs and Generic Advertising,” Choices Q2, 2006.

44. Freebairn J, E Goddard, and G Griffith, “When Can a Generic Advertising Program Increase Farmer Returns?,” Australian Agribusiness Review, 2005.

5. Balagtas J and S Kim, “Beggar-Thy-Self Advertising: a Multi-Market Model of Generic Promotion for Dairy Products,” AAEA Annual Meeting paper, 2005.

46. Alston J, J Freebairn, and J James, “Beggar-Thy-Neighbor Advertising: Theory and Application to Generic Commodity Promotion Programs, AJAE, 2001.

47. Wohlgenant M, “Retail-to-Farm Transmission of Generic Advertizing Effects,” Choices Q2, 2006.

48. Beach R, B Murray, N Piggott, and M Wohlgenant “Interaction Effects of Promotion, Research and Price Support Programs for US Cotton,” AAEA Annual Meeting paper, 2002.

49. Sterns J and D Ricks, “Should Imports Free-Ride or Help Pay – Decisions about Generic Promotion Programs for Agricultural Commodities,” IFAM Review 2000.

50. Zhang M and R Sexton, “Optimal Commodity Promotion in Imperfectly Competitive Markets,” AAEA Annual Meeting paper, 2000.

51. Kinnucan H, H Xiao, and S Yu, “Relative Effectiveness of USDA’s Non Price Export Promotion Instruments” , Journal of Agricultural and Resource Economics, Volume 25, 2000.

52. Wohlgenant M, “Retail-to-Farm Transmission of Generic Advertizing Effects,” Choices Q2, 2006.

53. Wohlgenant M, “Retail-to-Farm Transmission of Generic Advertizing Effects,” Choices Q2, 2006.

54. Chung C and h Kaiser, “Distribution of Gains from Research and Promotion in Multi-Stage Production Systems: Further Results,” Cornell University.

55. Cao K and R Johnson, “The Costs and Benefits of Introducing Mandatory Hygiene Regulations, “Paper for NZ Agriculture and Resource Economics Society Conference, August 2006

56. Ontario Traceability Taskforce, “The Development of an Ontario Agricultural Premises Registry: A Business Case,” October 2005

57. Runge CF, “Re-Investing in America’s Infrastructure: Will It Be Easy to be Green?,” Food Industry Center, 2008

58. Harchaoui T and F Tarhani, “Public Capital and Its Contribution to the Productivity Performance of the Canadian Business Sector,” November 2003.

59. Runge CF, “Re-Investing in America’s Infrastructure: Will It Be Easy to be Green?,” Food Industry Center, 2000

60. Runge CF, “Re-Investing in America’s Infrastructure: Will It Be Easy to be Green?,” Food Industry Center, 2008