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An economic evaluation of tick line deregulation in Queensland

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Abstract

Rhipicephalus microplus, the cattle tick, is widely distributed across many tropical and subtropical regions of the world and has been identified as the most economically important species of tick across a number of countries.

Quarantine boundaries currently limit the spread of the cattle tick into northern New South Wales, parts of South East Queensland, the central parts of the Northern Territory and northern parts of Western Australia. The Queensland tick line (or quarantine boundary) largely follows the 500mm rainfall isohyet until it reaches southern Queensland. As the cattle tick is unlikely to become endemic to regions receiving median rainfall less than 500mm per annum, the region most likely to be effected by a deregulation of the tick line is located in the south east corner of the State “inside” the 500mm isohyet but “outside” of the tick line.

There are a number of strategies available to beef producers running susceptible cattle within the region impacted by a deregulation of the tick line. For example, they could:

- choose to apply acaricides into the foreseeable future,
- choose to breed tick resistance into their livestock and apply acaricides during the conversion period,
- replace their susceptible breeding herds with tick resistant stock from within the tick endemic region, or
- continue with susceptible livestock and implement sufficient quarantine and pest management strategies to reduce the risk of tick infestation to a negligible level

The economic evaluation of these strategies indicates that the total costs of deregulation depend upon the type of response made by industry and the level of that response.

Acknowledgements

The evaluation team acknowledge the valuable assistance from a number of people, particularly those from within Biosecurity Queensland who provided willing cooperation, extensive documentation and open and willing assistance during the discussions that provided the basic information upon which this analysis is based.

Special thanks are due to Malcolm Macleod, Principal Policy Officer, Cattle Tick Control & Eradication, and Garry Griffith, Principal Research Scientist of the NSW Department of Industry and Investment who greatly assisted with the evaluation process.

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Summary

Rhipicephalus microplus, the cattle tick, is widely distributed across many tropical and subtropical regions of the world and has been identified as the most economically important species of tick across a number of countries. (FAO 1983)

The cattle tick may reduce the profitability of the beef and dairy industries through:

- transmitting organisms that cause babesiosis and anaplasmosis ('tick fever');
- increasing labour and other production costs;
- suppressing weight gain and increasing the rate of mortality in susceptible cattle;
- potentially reducing milk production in dairy cattle;
- potentially reducing the value of hides and leather products;
- increasing the potential for loss during droughts; and
- requiring treatment to ensure compliance with regulatory protocols for intrastate, interstate and international livestock movement

Chemical treatments (acaricides) can be used to effectively control ticks, however ticks have developed resistance to most current acaricides, and there is a market imperative to reduce chemical residues in both cattle and the environment.

Across northern Australia about 7.8m head of cattle can be found in regions considered tick endemic. Queensland, with about 6.7m beef cattle in the tick endemic region, is the only State or Territory to have the majority of its beef herd (59 per cent) grazing tick infested properties. About 30 per cent of the total Australian beef herd can be found within the tick endemic region of northern Australia.

The cattle tick may cause measureable weight loss in cattle. The level of loss is directly related to the number of engorged female ticks carried and the number of days for which they are carried. Tick resistant cattle, such as those carrying *Bos indicus* genes, carry significantly less cattle ticks. Research into the impact of the cattle tick on tick resistant cattle has shown that, although some small amounts of live weight may be occasionally lost due to tick infestation, invariably there is no significant difference between treated and untreated steers at mature sale weights unless the level of environmental stress and tick infestation are both very high. Research has also shown that fertility in *Bos indicus* based breeder herds is unlikely to be improved by tick control if nutrition is sound. Approximately 85 per cent of the beef cattle across northern Australia, both inside and outside the tick endemic zone, carry more than $^{3}/_{8}$ *Bos indicus* genes.

The vast majority of dairy cattle in northern Australia are based on *Bos taurus* breeds and are therefore highly susceptible to the cattle tick. Production losses in dairy cows due to tick infestation are estimated to be 8.9 mL of milk and 1 gram live weight gain per engorging female tick per day.

Quarantine boundaries currently limit the spread of the cattle tick into northern New South Wales, parts of South East Queensland, the central parts of the Northern Territory and northern parts of Western Australia. The Queensland tick line (or quarantine boundary) largely follows the 500mm rainfall isohyet until it reaches southern Queensland. As the cattle tick is unlikely to become endemic to regions receiving median rainfall less than 500mm per annum, the regions most likely to be effected by a deregulation of the tick line are those in the south east corner of the State "inside" the 500mm isohyet but "outside" of the tick line.

Deregulating the tick line in Queensland potentially saves a number costs (identified as benefits gained in this analysis) and is also likely to cause a number of costs to be incurred by industry and others.

The potential costs saved by deregulation are the costs of moving stock across the current line; tick eradication activities within the free and controlled zones and regulating and managing the tick line. The values of these costs on an annual basis are assessed as:

Moving stock across the line	$5,000,000
Tick eradication	$1,000,000
QPIF tick line management	$3,122,930
Total costs per annum	$9,122,930

Approximately 34 per cent of the total costs to be saved accrue to the State and the deregulation of the tick line in Queensland is assessed as having a Present Value of Benefits (costs saved) of $140 million dollars.

The potential costs incurred as a result of a deregulation of the tick line include the costs incurred moving livestock from tick endemic to tick free regions; new costs incurred by livestock industries as a result of deregulation and residual State based costs associated with tick management and control.

A deregulation of the tick line in Queensland is expected to lead to treatment costs being incurred at the States borders. Although a significant portion of the costs of moving livestock across the current tick line are likely to be saved, some of these costs will be replaced by new costs incurred in moving suscsptible livestock from the tick endemic regions to other regions, both within and across Queenslands borders.

Additional industry costs will be incurred by beef producers and dairy producers impacted by deregulation. They will be relative to the initial proportion of susceptible cattle in newly infected regions, the rate of conversion to tick resistant breeds, the rate of spread of ticks after deregulation and the final level of conversion to tick resistant genetics. It is expected that the vast majotity of beef producers impacted by deregulation will respond similarly to beef producers in the tick endeminc regions of northern Australia and incorporate sufficient genetic resistance to reduce the impact of the cattle tick on their production system to negligible levels. Dairy farmers located in newly infected regions are not expected to convert to resistant genotypes and will incur tick treatment costs into the foreseeable future.

There is some uncertainty about the potential total cost of deregulation as it largely depends upon how the various sections of industry resond to deregulation. Scenarios that ecompass a wide range of possible responses have been constructed to try to identify the total cost of tick line deregulation on industry. They include beef producers choosing to:

- apply acaricides into the foreseeable future (no conversion strategy), or
- breed tick resistance into their livestock and apply acaricides during the conversion period (conversion through breeding strategy), or
- replace their susceptible breeding herds with tick resistant stock from within the tick endemic region (conversion through breed replacement strategy), or
- continue with susceptible livestock and implement sufficient quarantine and pest management strategies to reduce the risk of tick infestation to a negligible level (biosecurity risk management strategy)

- convert to resistant livestock and implement sufficient biosecurity measures during the conversion period to reduce the cost of tick infestation during the conversion period to a negligible level

Dairy producers have very limited strategies available. They can choose to implement biosecurity measures to limit the rate of spread of ticks and can apply acaracides when they become infested.

The economic evaluation of these scenarios indicates that a rapid spread of ticks combined with a slow conversion to resistant livestock causes the sections of industry impacted to incur significantly more costs than are saved in the deregulation process. Conversely, a conversion to resistant genotypes combined with a slow spread of ticks or lower level of tick impact reduces the total costs of deregulation to the point where the benefits of deregulation outweigh the costs associated.

Table 1 Results of scenario analysis for total deregulation costs

Scenario	Description	PVB $m	PVC $m	B/C ratio
1	No conversion strategy	140	372	0.4 to 1
2	Conversion through breeding (50% susceptible cattle convert)	140	266	0.5 to 1
3	Conversion through breeding (85% susceptible cattle convert)	140	189	0.7 to 1
4	Conversion with property biosecurity and phase in (a)	140	113	1.2 to 1
5	Conversion with purchase of resistant stock and no phase in	140	155	0.9 to1
6	Conversion with property biosecurity and phase in (b)	140	74	1.9 to 1
7	Beef and Dairy producers use effective tick vaccine	140	120	1.2 to 1

Table 1 indicates the ecompomic impact of seven of the scenarios tested. The “no conversion” scenario 1 is where all producers with susceptible cattle are subject to rapid infestation with cattle ticks and only use acaricides to control ticks into the foreseeable future. In this scenario, the Present Value of Costs incurred through deregulation would be about $372m (beef industry $311.5m, dairy industry $28.5m and ongoing costs of $32m). The Benefit Cost Ratio for this scenario is assessed as .4 to 1. This response is considered to be very unlikely and is seen as a “worst case” scenario.

Scenario 2 indicates that if only 50 per cent of producers with susceptible cattle slowly convert to resistant stock over about eight years, are subject to a rapid spread of the cattle tick across all regions and extensively use acaracides during the period of conversion, the total costs incurred by the beef industry ($205m) and dairy industry ($28.5m) are still more than the costs saved by deregulating ($140m).

Scenario 3 indicates that if 85 per cent of beef producers impacted by the deregulation of the tick line convert to tick resistant livestock over an eight year period and incur the cost of acaricides during the conversion period due to a rapid spread of ticks, the Present Value of additional costs incurred by the beef industry ($129m), dairy industry ($28.5m) and ongoing costs ($32m) is still likely to be greater than the Present Value of Benefits gained (costs saved) by deregulation ($140m). This percentage of producers converting to tick resistant stock is similar to the level of response shown by producers within the tick endemic regions of north Australia.

The results of the analysis of scenario 4 shown in table 1 indicate that if beef producers impacted by deregulation were provided with a period of time during which to convert to tick resistant livestock and therefore could forego reliance on acaricides to control ticks during the conversion period, then the total costs of deregulation ($112.5m) are significantly less than the Present Value of Benefits gained (costs saved) by deregulation ($140m). This scenario maintains a rapid spread of ticks but still appears to provide net economic benefits for a deregulation of the tick line in

Queensland. Scenario 6 is based on the same assumptions as scenario 4 but extends the period of time taken for ticks to spread to all impacted properties from five to ten years. This scenario is seen as very achievable, given that Biosecurity Queensland will have staff available during the transition period to assist producers implement effective biosecurity measures.

Scenario 7 considers the potential impact of current research to develop a tick vaccine that could provide *Bos taurus* livestock with the level of tick resistance exhibited by resistant *Bos indicus* cross livestock. Economic analysis indicates that an effective tick vaccine is likely to provide a greater level of benefits than costs incurred for tick line deregulation and allow beef and dairy producers to maintain current levels of *Bos taurus* genetics. For this scenario, the Present Value of total Costs incurred of $120m would made up of $85m for the beef industry, $3m for the dairy industry and $32m for ongoing costs.

Overall, the economic analysis indicates that a deregulation of the tick line in Queensland does casue industry to incur significant costs but if deregulation is undertaken so that beef producers can implement suitable property level biosecurity measures and move to resistant livestock before major levels of new tick infestation occur; the total of these costs will be significantly lower than those currently incurred to maintain the line.

Although this economic analysis does not identify how the costs of regulation and deregulation are distributed, an important issue to remember in considering the effects of the current regulations is that the costs and benefits of the tick line are not incurred by the same groups of producers. It appears that the majority of the industry costs of maintaining the tick line accrue to producers located within the tick endemic region of the State. These producers gain no measureable benefits from incurring these costs. The remainder of the costs of maintaining the tick line are incurred by taxpayers and they also appear to gain very few measureable benefits from the maintenance of the tick line. The cost of maintaining the tick line is largely a direct subsidy to the producers who would be infested with cattle tick if the tick line were removed.

A section of the analysis also considered the potential of saving costs by moving part of the tick line in south east Queensland. Such a readjustment of the tick line is expected to:

- reduce the number of tick outbreaks in the tick free region of south east Queensland,
- reduce the number of Biosecurity Queensland inspectors necessary to manage the tick line, and
- reduce the total number of clearing dips

This scenario did not involve deregulation of the tick line or movement of the tick line outside the south east corner of Queensland.

The proportional relationship between costs and benefits for moving part of the tick line is similar to that found for the complete deregulation of the tick line. On this basis the complete deregulation of the tick line, properly managed, would provide the greater long term benefits in absolute terms.

Introduction

The Queensland tick line divides the State into regulated zones for the control of the cattle tick (*Rhipicephalus microplus*[1]*).* The tick line was legislated as part of the provisions of the Stock Act (Qld) 1915 and has been maintained in a similar form for more than a century.

Maintaining the tick line regulations and moving stock from tick infected regions across the tick line incurs cost for both livestock owners and the State. The movement of buffalo, cattle and deer (primary host species) plus camels, donkeys, goats, horses, mules, sheep, alpacas, llamas, vicunas and guanacos (secondary host species) requires inspection and treatment at the line. Cattle, deer and buffalo must receive preliminary treatment supported by a completed declaration before being presented at a clearing facility.

The removal of the regulations creating the tick line would provide economic benefits at least equivalent to the costs created by the tick line regulations. As the cattle tick is a significant economic parasite and maintenance of the line prevents the spread of the pest into regions that are currently tick free, removal of the line would cause costs to be incurred by the owners of susceptible livestock newly infested by the cattle tick. These costs offset the economic benefits gained by deregulation.

The costs and benefits of the tick line are largely incurred by different groups of livestock owners or the State. This leads to ongoing discussion of the relative level of costs prevented for those producers protected in comparison to the level of benefits that may be provided by removing the regulations.

This evaluation will apply an economic framework to consider the net benefits to Queensland of removing the tick line and will include consideration of:

- the distribution and size of costs likely to be saved (benefits gained)
- the distribution and size of costs potentially to be incurred

The evaluation will also consider the impact of continuing the regulations but moving part of the tick line to reduce the share of costs incurred by the State.

The evaluation is undertaken to principally consider the economic impact of the tick line on the Queensland beef and dairy industries. Changes to the regulations governing the Queensland tick line could potentially have significant impacts in a number of jurisdictions/regional economies across northern Australia. The costs and benefits accruing to these regions outside of Queensland will not be considered in detail in this evaluation.

[1] Formerly known as *Boophilus microplus*

The cattle tick

Rhipicephalus microplus, the cattle tick, is widely distributed across many tropical and subtropical regions of the world (Figure 1) and has been identified as the most economically important species of tick across a number of countries (FAO 1983).

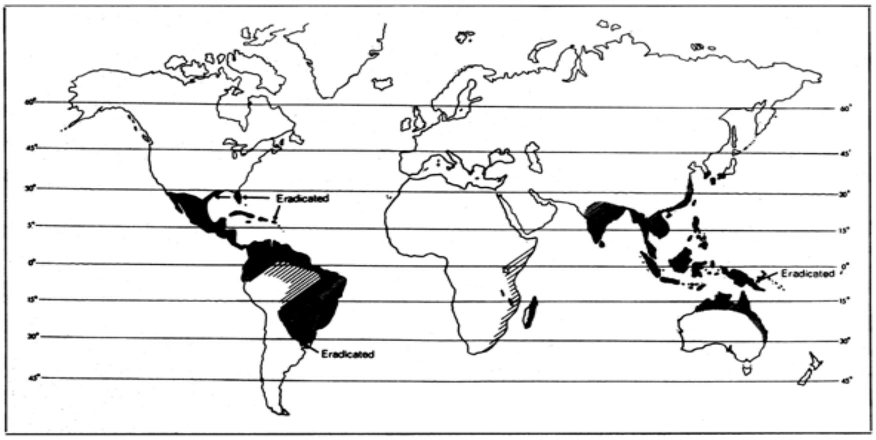

Figure 1. Distribution of Rhipicephalus microplus (after Wharton, 1974)
Source: Wharton 1974 as cited in FAO 1983

Cattle ticks are endemic to most of northern and north eastern Australia. Figure 2 indicates the region of Australia that is currently infested or highly suited to infestation by *R. microplus.* (FAO 1983)

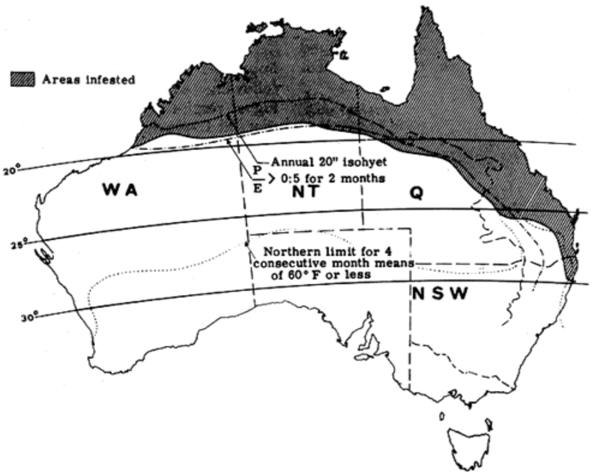

Figure 2. Cattle tick susceptible regions of Australia

In Australia, the demarcation line between the enzootic and tick-free areas is not rigidly defined, but the tick-infested area is generally north of latitude 30°S, where the annual rainfall exceeds 500 millimetres.

Within the tick endemic regions of Australia, the cattle tick may reduce the profitability of the beef and dairy industries through:

- transmitting organisms that cause babesiosis and anaplasmosis ('tick fever');
- increasing labour and other production costs;
- suppressing weight gain and increasing the rate of mortality in susceptible cattle;

- potentially reducing milk production in dairy cattle;
- potentially reducing the value of hides and leather products;
- increasing the potential for loss during droughts; and
- requiring treatment to ensure compliance with regulatory protocols for intrastate, interstate and international livestock movement.

Chemical treatments (acaricides) can be used to effectively control ticks. However, ticks have developed resistance to most current acaricides, and there is a market imperative to reduce chemical residues in both cattle and the environment.

All breeds of cattle can be particularly vulnerable when they first encounter cattle ticks but will develop a degree of resistance after repeated exposure. *Bos indicus* cattle and crosses develop stronger resistance than *Bos taurus.*

Jonsson and Piper (2007) indicated that *Bos indicus* and *Bos taurus* lines of cattle may have separated up to 300 000 years ago, well before the domestication of cattle. *Bos indicus* derived breeds of cattle are generally highly resistant to the cattle tick and have inherently higher tolerance for tick borne diseases like babesiosis (Bock et al. 1999).

The Brahman breed is an example of a *Bos indicus* derived breed of cattle that has been actively introduced into the northern Australian beef industry to assist deal with the problem of cattle ticks and their associated diseases. *Bos taurus* cattle are largely represented by British and European breeds like the Hereford, Shorthorn and Charolais.

The potential impact of climate change on the spread of the cattle tick within Australia has been identified in an analysis by White et al. 2003. Their analysis suggests that if current quarantine boundaries are not maintained and climate change proceeds as predicted, the cattle tick will be endemic to all (mainland) Australian coastal and near coastal regions receiving more than about 500mm of rainfall annually by the end of this century. Figure 3 indicates the potential rate of spread and impact on beef production over the intervening years.

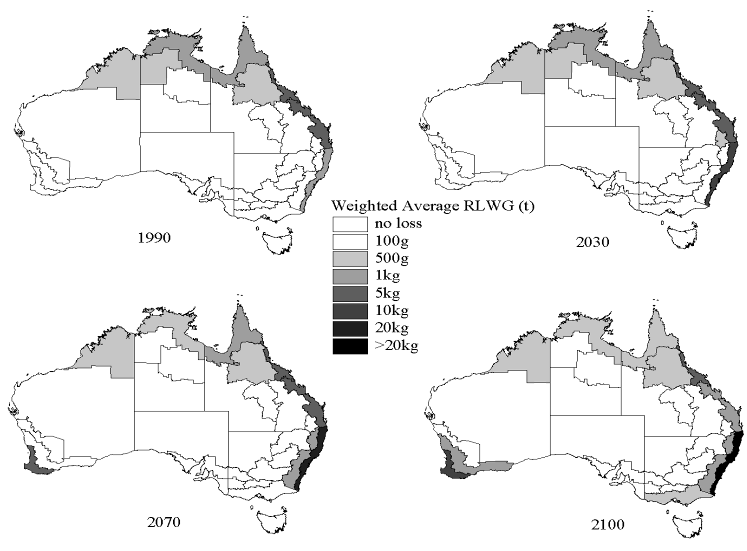

Figure 3. Regional losses of LWG caused by ticks under high sensitivity and constant aerosols scenario with tick control but without adaptive breed changes
Source: White et al. 2003

Cattle tick is a serious economic pest of Queensland's cattle industry. If left unchecked, this external parasite can significantly reduce cattle live-weight gain and milk production in susceptible livestock. It is also responsible for transmitting three blood-borne tick fever organisms, which may cause sickness and death in cattle. If climate change proceeds as predicted, the cattle tick has the potential to become an endemic species across the beef producing regions of Australia.

Tick borne diseases in northern Australia

Tick fever is a serious, often fatal disease of cattle in northern Australia. It is a complex of diseases that is caused by either one or more of the tick-borne parasites *Babesia bovis*, *Babesia bigemina* and *Anaplasma marginale*. It is carried by the common cattle tick (*R. microplus*) and largely transmitted through tick bites. In Australia, *Babesia bovis* is the major cause of disease outbreaks accounting for 80 per cent of reported cases (QPIF 2009).

Tick fever is a significant disease of cattle in Australia with up to 8 million animals potentially at risk. The disease was probably introduced as early as 1829 by cattle from Indonesia infested with the cattle tick. There are currently two main forms of tick fever disease in Australia – babesiosis and anaplasmosis.

Babesiosis and anaplasmosis are only found in eastern and northern parts of Australia where the cattle tick is present. One infected tick is sufficient to transmit the infection but only a very small number of ticks actually carry the disease. As few as 1 in 5 000 ticks may be infected with *B. bovis*, while 1 in 500 ticks could be infected with *B. bigemina*. Thus, *B. bigemina* organisms are usually more prevalent in an infected herd with infection rates usually higher for this organism (Mahoney and Mirre 1971).

Bos taurus breeds are very susceptible to babesiosis with mortality after infection potentially high, especially where *B. bovis* is present. *Bos indicus* breeds such as Brahman, Sahiwal and, to a lesser extent, crosses between *Bos indicus* and *Bos taurus* cattle show resistance to babesiosis with a significantly lower risk of mortality but, despite this, nearly 1 in 5 outbreaks of tick fever involves these breeds. With anaplasmosis, there is no clear evidence that *Bos indicus* cattle are any more resistant to disease than *Bos taurus* (Bock et al. 1999).

Cattle that live in tick endemic regions may naturally develop lifetime immunity to tick fever through exposure to the organisms early in life. Calves can be temporarily protected by receiving maternal antibodies from immune mothers through the colostrum (first milk). This protection lasts about 3 months and can be followed by an age resistance which lasts until the animals are about 9 months old.

Calves exposed to infection during the period of maternal or age resistance rarely show clinical symptoms but develop a solid, long-lasting immunity. Calves that have not been exposed become susceptible to infection later in life as the age resistance gradually wanes with time. A severe, life-threatening infection may well develop with infection and losses likely when tick numbers on a property increase or when susceptible cattle are brought onto a tick-infested property.

Biting flies can transmit the disease (particularly anaplasmosis) but are less efficient vectors than ticks. Mechanical transmission via veterinary instruments (needles, dehorners etc) is also possible and the organism can cross the placenta to the foetus (particularly anaplasmosis).

Tick fever, whether caused by *Babesia* or *Anaplasma*, is known to create considerable risk for unprotected animals entering ticky areas. Although high mortality rates from tick fever could occur where tick numbers fluctuate from season to season or where unprotected cattle are introduced into ticky areas, data on the extent of mortality and morbidity caused by tick fevers is difficult to obtain. In general, tick fever caused by *B. bovis* is normally severe and large numbers of susceptible cattle can get sick and die when an outbreak occurs while disease caused by *B. bigemina* is usually less severe but can develop very rapidly.

Morbidity effects due to tick fever are difficult to identify. Anaemia will presumably affect milk production in lactating animals and weight gains will most likely be affected which in turn could affect reproductive performance in cows. In addition, damage to the vital organs (e.g. liver) can be severe and may be permanent. Fertility can be affected in male animals but there is some evidence that this is only temporary. Although cattle that survive the infection may take several weeks to regain condition, there is ample evidence that such animals make compensatory weight gains on recovery from the disease.

Tick fever vaccine effectively eliminates the disease in tick endemic regions where it is administered appropriately. The major benefit is the reduction in mortality, since the economic impact of morbidity associated with the disease is difficult to measure under extensive grazing conditions within the tick endemic regions of Queensland.

Tick fever vaccine also reduces the risks associated with livestock movement from tick free regions to those infested with the cattle tick. Some of the livestock movements facilitated are associated with the movement of genetic material used to improve the performance of beef cattle in tick infested regions; others are associated with the movement of cattle for fattening or finishing in feedlots. In the past, the vaccine has also facilitated the live cattle export trade, especially to South East Asia.

The Tick Fever Centre (QPIF 2008) estimates that between 6 500 (lower bound estimate) and 23 000 (upper bound estimate) deaths per annum, are prevented through the use of the tick fever vaccine in the Queensland beef industry. On average, the use of tick fever vaccine is estimated to reduce the total losses of beef cattle within the tick endemic region of Queensland by approximately 5 per cent per annum. The Bureau of Agricultural Economics (BAE) in 1959 estimated that total mortalities in the tick infested regions were 0.6 per cent higher than in the tick free. The BAE estimate of 34 283 mortalities saved aligns well with the estimates provided by the Tick Fever Centre when the change in genetic makeup, total numbers and level of animal husbandry of the northern breeding herd over the intervening decades are taken into account.

The tick line

Quarantine boundaries currently limit the spread of the cattle tick into northern New South Wales, parts of South East Queensland, the central parts of the Northern Territory and northern parts of Western Australia.

Under the Stock Act 1915 and in particular the Stock (Cattle Tick) Notice 2005, Queensland is divided into three tick zones for movement control purposes (Figure 4):

- the Queensland infected zone
- the Queensland free zone

- the Queensland control zone

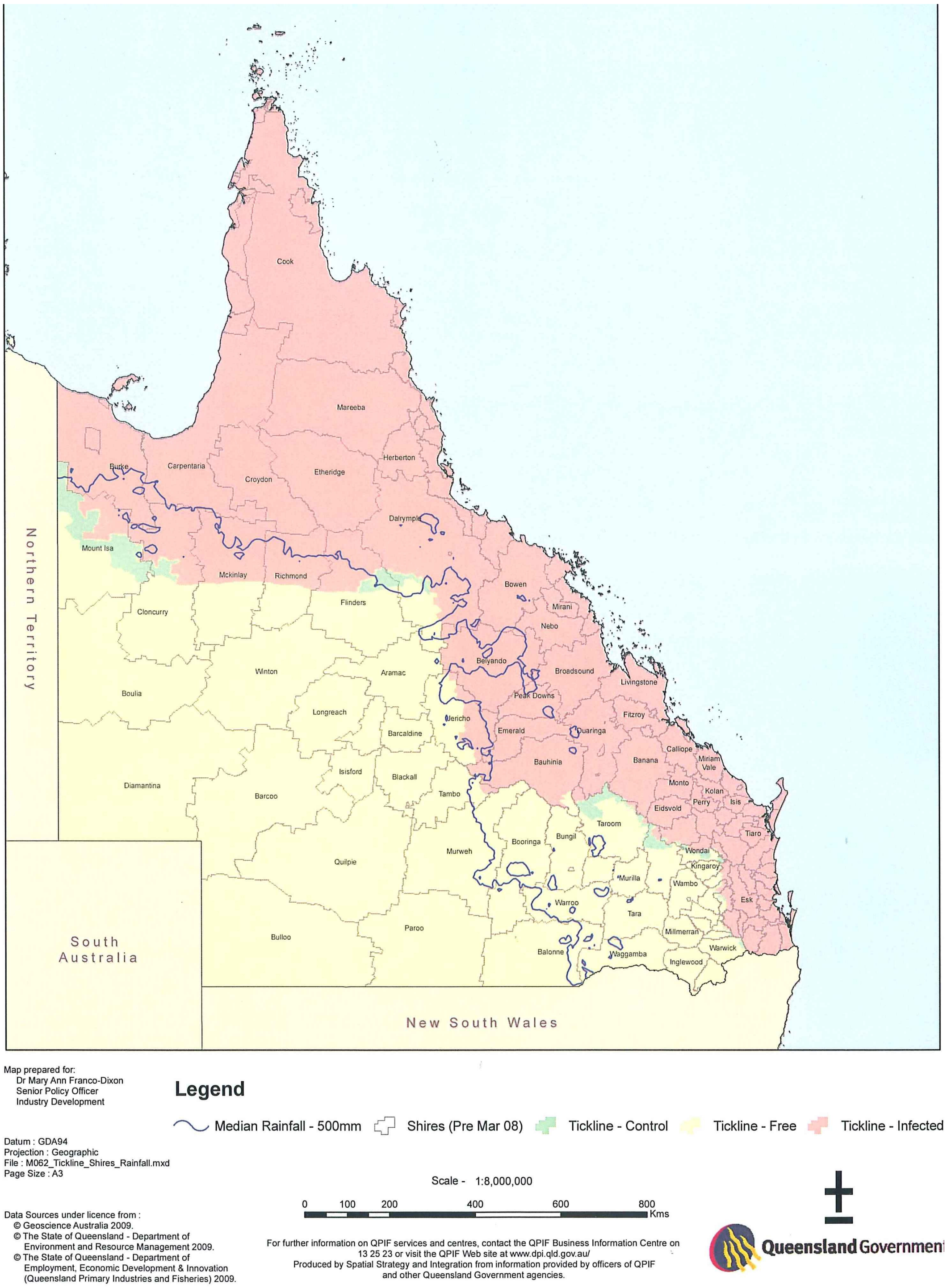

Figure 4. The Queensland tick line and the 500mm median rainfall isohyet

The Queensland tick line largely follows the 500mm rainfall isohyet until it reaches southern Queensland (Figure 4). As the cattle tick is unlikely to become endemic to regions receiving median rainfall less than 500mm per annum, the regions most likely to be effected by a deregulation of the tick line are those in the south east corner of the State “inside” the 500mm isohyet but “outside” of the tick line.

Industry analysis

The north Australian beef industry

Total cattle numbers in northern Australia showed significant growth over recent years. Between 1998 and 2008, the Queensland herd grew from approximately 10.8m head to more than 12m (Table 1). The proportion of the national herd located in the north has also risen steadily with the majority of beef cattle now found in the northern regions of Australia.

Table 2. Australian cattle numbers, by state and territory$_a$

Year	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	Aust
	'000 head	'000 head	'000 head	'000 head	'000 head	'000 head	'000 head	'000 head	'000 head
1998	6 351	4 142	10 867	1 214	1 973	728	1 567	10	26 851
1999	6 291	4 125	10 748	1 183	1 931	724	1 567	10	26 578
2000	5 970	4 264	11 808	1 184	2 165	617	1 571	10	27 588
2001	6 215	4 405	11 376	1 242	2 128	636	1 707	11	27 722
2002	6 021	4 412	11 544	1 381	2 104	619	1 777	10	27 870
2003	5 817	4 388	10 740	1 401	1 945	682	1 683	8	26 664
2004	5 816	4 281	11 500	1 352	2 095	684	1 730	8	27 465
2005	5 837	4 444	11 862	1 403	2 169	689	1 771	9	28 183
2006	6 211	4 403	11 548	1 329	2 391	704	1 798	9	28 393
2007	5 935	4 243	11 684	1 242	2 327	682	1 912	11	28 037
2008	5 824	3 885	12 181	1 202	2 241	636	1 824	6	27 800

Sources: ABS 2008, *Principal Agricultural Commodities, Australia, Preliminary, 2007-08*, cat. no. 7111.0, ABS, Canberra; ABS 2009, *Agriculture, Australia*, cat. no. 7113.0, ABS, Canberra; ABS 2009, *Agricultural Commodities, Australia*, cat. no. 7121.0, ABS, Canberra; ABARE.
a At 31 March, an establishment with an estimated value of agricultural operations (EVAO) of $5 000 or more. From 2000, at 30 June House cows are excluded.

The composition of the northern beef herd has changed little over recent years and largely continues to have a breeding and fattening structure. In Queensland, females make up the majority of beef cattle with finished steers sold mainly between two and four years old (Table 3).

Table 3. Queensland herd composition over recent years (thousand head)

Livestock class	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	Average	Percent of total (%)
Bulls and bull calves used or intended for service	273	233	280	298	287	329	283	2.5
Other calves under one year	2 290	1 949	2 114	2 091	2 132	2 135	2 119	18.9
Cows and heifers one year and over	5 762	5 380	5 638	5 844	5 745	5 589	5 660	50.5
Other cattle one year and over	2 959	2 946	3 213	3 147	3 189	3 442	3 149	28.1
Total meat cattle and calves	11 284	10 507	11 245	11 380	11 354	11 495	11 211	

Source: ABS 2006, *Agricultural Commodities: Small Area Data, Australia, 2005-06 (Reissue),* cat. no. 7125, ABS, Canberra.

The structure of the Queensland herd reflects the extensive grazing conditions prevalent in the State, the high risk of drought and the focus on producing grass fed steers for high value export markets. Mixed breeding herds that produce 30 to 42 month old steers under northern Australian conditions:

- minimise the risk of having proportionally large numbers of lactating and pregnant females during extended dry periods,
- optimise the proportion of relatively higher value steer beef produced by the herd,
- reduce price risk through mitigating the need to purchase large numbers of replacement stock, and

- allow producers to target a number of markets, including markets for live export, store and finished cattle.

Table 4 indicates that Queensland traditionally supplies between 45 percent and 55 per cent of Australian beef and veal production. As Queensland is a net importer of live cattle, some of this output may have been bred in either the Northern Territory or New South Wales (Data not shown). Queensland consumes less than 15 percent of the beef it produces.

Table 4. Queensland and Australia beef and veal production 2001-02 to 2007-08

Month/Year	Queensland	Australia	Percent of Australia
	Kilo tonnes	Kilo tonnes	%
Sep-97	228 478	508 373	45
Sep-98	235 771	510 705	46
Sep-99	251 995	506 314	50
Sep-00	271 148	523 865	52
Sep-01	296 316	547 599	54
Sep-02	275 082	552 323	50
Sep-03	264 038	502 061	53
Sep-04	294 271	562 993	52
Sep-05	284 227	514 753	55
Sep-06	306 832	559 741	55
Sep-07	280 717	541 634	52
Sep-08	275 816	548 418	50

Source: ABS 2009, *Livestock Products Australia* ,cat. no. 7215.0, ABS, Canberra.

The northern beef industry is dominated by large producers. ABARE (2009) indicates that the majority of beef cattle (73 per cent) and the majority of value of cattle sales (71 per cent) for northern Australia are provided by less than 17 per cent of the beef cattle holdings (Table 5). Northern Australia also has significantly more "large" beef cattle properties than southern Australia with the majority of northern stock run under extensive conditions (ABARE 2009 Data not shown).

Table 5. Distribution of Northern Australian broadacre beef cattle farms, by number of cattle, at 30 June (average between 2001-02 and 2007-08)

	Number of farms	Share of farms	Share of beef cattle	Share of value of cattle sales
	no.	%	%	%
less than 100	2 628	24.5	1.0	2.0
100 – 400 head	3 443	32.2	6.0	7.0
400 – 800 head	1 396	13.0	6.0	6.0
800 – 1600 head	1 447	13.5	13.0	13.0
1600 – 5400 head	1 395	13.0	31.0	30.0
more than 5400 head	398	3.7	42.0	41.0
Total	10 707	100.0	100.0	100.0

Source: ABARE 2009, *Australian beef 09.1,* ABARE, Canberra.

ABARE (2009) indicates that about 25 per cent of total beef properties are located in northern Australia (10 707 out of a total of 41 241). ABARE (2009) also indicate that the total area grazed in the north is about 300m hectares with an implied stocking rate of about 25 hectares per head. Southern Australian beef properties graze about 175m hectares and have an implied stocking rate about half that indicated for northern properties.

For this evaluation, ABS statistics and maps of the tick endemic regions of Australia have been combined with regional livestock numbers to estimate the number and proportion of beef cattle to be found within the tick endemic region (Table 6).

Table 6. Beef cattle herd – northern Australia

Beef Cattle	Total northern beef cattle	Percent of Australia	Tick free	Tick infected	Tick infected
	Number	%	Number	Number	%
Queensland	11 353 923	40	4 618 959	6 734 964	59
Northern Territory	1 611 294	6	876 362	734 932	46
Western Australia*	~800 000	3	439 164	360 836	45
Total northern Australia	13 765 217	48	5 934 485	7 830 732	57
Total for Australia	28 393 000				28

Source: ABS 2008 Agricultural Commodities: Small Area Data, Australia, 2005-06 (Reissue) ABS Canberra

* Note cattle numbers for WA are only for the northern part of the State

Table 5 indicates that during the most recent full ABS census (ABS 2006), approximately 13.7m head of beef cattle could be found in the north – that is, across the north of Western Australia, the Northern Territory and all of Queensland. Of these beef cattle, approximately 57 per cent of the northern herd or about 7.8m head can be found in regions considered tick endemic. Queensland, with about 6.7m beef cattle in the tick endemic region, is the only State or Territory to have the majority of its beef herd (59 per cent) grazing tick infested properties. About 30 per cent of the total Australian beef herd can be found within the tick endemic region.

Queensland has about 86 per cent of all beef cattle found in the tick endemic region; the Northern Territory has slightly more than 9 per cent while less than 4 per cent are to be found in Western Australia. (Table 5)

Beef cattle production constraints and breed structure in north Australia

The cattle of northern Australia face a number of environmental challenges. Frisch (1975) identified the main production constraints as “cattle ticks, gastro intestinal helminths, high ambient temperatures and solar radiation, ‘pinkeye’ disease and fluctuations in both quality and quantity of available forage”. These constraints vary in their impact on the production of beef cattle depending upon genetic makeup and location within the northern beef region.

Beef cattle with a high level of *Bos indicus* genes show a higher level of tolerance to these environmental challenges than beef cattle with high levels of *Bos taurus* genetics. Unfortunately for the north Australian beef industry, beef cattle with high levels of *Bos indicus* genes are *inherently* less productive as a number of factors, mainly appetite, limit growth under field conditions of high nutrition and low environmental constraints.

Frisch (1975) developed a model to explain the reasons for low growth rates in the field under northern Australian field conditions. His model was based on a number of detailed experiments undertaken by the CSIRO at “Belmont” research station outside Rockhampton in central Queensland and relates the impact of the listed constraints on live weight in steers at fifteen months. A figure prepared by Frisch is reproduced below (Figure 5).

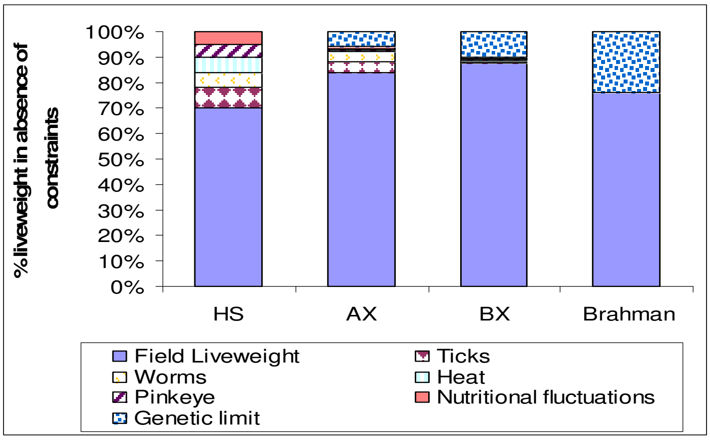

Figure 5. A model of reasons for differences in growth of cattle in the tropics
Source: Frisch 1975

Four separate genotypes are presented in the model:

- "HS" represents cattle with 100 per cent *Bos taurus* genetics and is based on the Hereford and Shorthorn breeds.
- "AX" represents Sanga cattle and is based on the Afrikander breed (50 per cent) crossed with the Hereford and Shorthorn breeds (50 per cent). Sanga cattle, largely found in southern and central Africa, are mainly based on *Bos taurus* genetics but have developed relatively high levels of tolerance to many environmental constraints after long periods of time grazing the pastures of Africa.
- "BX" represents the Brahman breed crossed with Shorthorns and Herefords in proportions of 50:25:25.
- The Brahman breed is derived from *Bos indicus* genetics and has very high levels of inherent tolerance of or resistance to the environmental constraints that apply in northern Australia. Frisch (1975) estimated the genetic potential of this breed for growth to be about 80 per cent of a *Bos taurus* breed under non-limiting conditions.

Each of the identified genotypes provided a major component of the genetic evaluation work undertaken by CSIRO at "Belmont" and other locations over a number of decades. The "AX" genotype was released by CSIRO as the "Belmont Red" breed.

The model presented by Frisch indicates that *Bos taurus* based breeds are likely to underperform Brahman cross cattle where more than one constraint on production such as ticks, gastrointestinal parasites, nutritional fluctuations and heat, including high levels of solar radiation, exist together. For these reasons breeds based on *Bos taurus* genetics are unlikely to show sufficient production response for them to replace *Bos indicus* based breeds where ticks can be eradicated from dry subtropical environments. Even in dry tropical environments that do not maintain the cattle tick, *Bos indicus* derived breeds are still likely to outperform *Bos taurus* derived breeds.

The ability of *Bos indicus* breeds to outperform *Bos taurus* breeds in sub tropical environments is reflected in the changes to the breed composition of the north Australian herd.

Since the introduction of *Bos indicus* genetics into northern Australia over sixty years ago, the genetic composition of the north Australian beef herd has changed dramatically. The introduction of *Bos indicus* genes to the Queensland herd effectively began in 1930 (Kelley 1943) gathered pace during the 1960's and 1970's and is thought to have peaked by the mid 1990's.

The Queensland Tick Fever Centre (TFC) undertook a survey of producers during 1999 (QPIF 2008) and received replies from about 400 beef producers. The results of that survey indicate at that time 85 per cent of respondent producers had more that 3/8 *Bos indicus* genes in their beef cattle (Table 6). The level of beef cattle with at least 3/8 *Bos indicus* genes varied from less than 70 per cent in the Brisbane Moreton region up to 96 per cent in the Far North region.

Table 7. Breed type by region (1999 survey)

ABS region	Bos taurus	¼ B. indicus	3/8 B. indicus	½ B indicus	Over ½ B. indicus	Full B indicus
	%	%	%	%	%	%
Brisbane Moreton	14	16	33	14	12	10
Wide-bay	13	13	27	22	22	5
Fitzroy	6	7	30	14	31	14
Mackay	2	10	22	12	27	27
Northern	4	0	0	21	29	46
Far North	0	5	5	20	55	15
North West	0	3	9	18	30	39
Total	7	9	24	17	27	17

Source: QPIF 2008

ABARE (1995) also reported on the genetic makeup of the beef herd by region during the middle 1990's. The ABARE analysis suggests a similar component of *Bos indicus* genetics in the northern herd (Table 7). Note: The regional descriptions are provided by Holmes (2009) not ABARE.

Table 8. Percentage of cattle in each breed in each region (ABARE 1995)

ABARE region	Region description	*Bos indicus*	*Bos taurus*	*Bos indicus x Bos taurus*	*Tick resistant*
		%	%	%	%
311	Cape York and Nth Gulf	81	0	19	99
312	West Qld	54	21	25	78
313	Central Cape and Goldfields	54	2	44	98
314	Central west	40	31	29	68
321	Darling Downs	16	48	36	51
322	CQ and SQ Brigalow belt	44	17	39	83
331	SQ and CQ Coastal Queensland	66	17	16	82
332	Tropical Coastal Queensland	54	16	30	83
	Queensland	**52**	**17**	**31**	**83**
511	Pindan & Nth Kimberly & Fitzroy Valley	44	14	42	86
713	Katherine (NT)	74	0	26	100
714	Top End (NT)	83	1	16	99

Source ABARE 1995 Australian Farm Surveys Report 1995, Canberra

The final column of Table 7 has been added to the ABARE data to indicate the likely percentage of livestock in the region that would be resistant, to some degree, to cattle ticks.

The proportion of *Bos indicus* beef cattle likely to show tick resistance appears to be broadly in agreement across the two surveys. At the time of the surveys, approximately 85 per cent of the beef cattle across northern Australia would have sufficient *Bos indicus* genes to exhibit resistance to the cattle tick. ABARE (2001) also indicated that *Bos indicus* and *Bos indicus* cross cattle make up more than 83 per cent of the northern beef herd.

Figure 6 indicates the overlay of ABARE regions with the Queensland tick line. The parts of Queensland infected with ticks are shown in pink. Tick control areas are shown in green while tick free regions are shown in yellow.

Comparison of the data in Table 7 with the regions shown in Figure 6 indicates that regions that are tick free or predominately tick free still have a high percentage of livestock that are tick resistant. For example, Region 312 contains a very small area inside the tick line but has 78 per cent of its cattle with *Bos indicus* genes. In the same region 54 per cent of total numbers were considered to be high grade *Bos indicus*. Region 332, located on the tropical coast of Queensland, has a similar percentage of high grade *Bos indicus* at 54 per cent and only a slightly higher percentage of total cattle with *Bos indicus* genes.

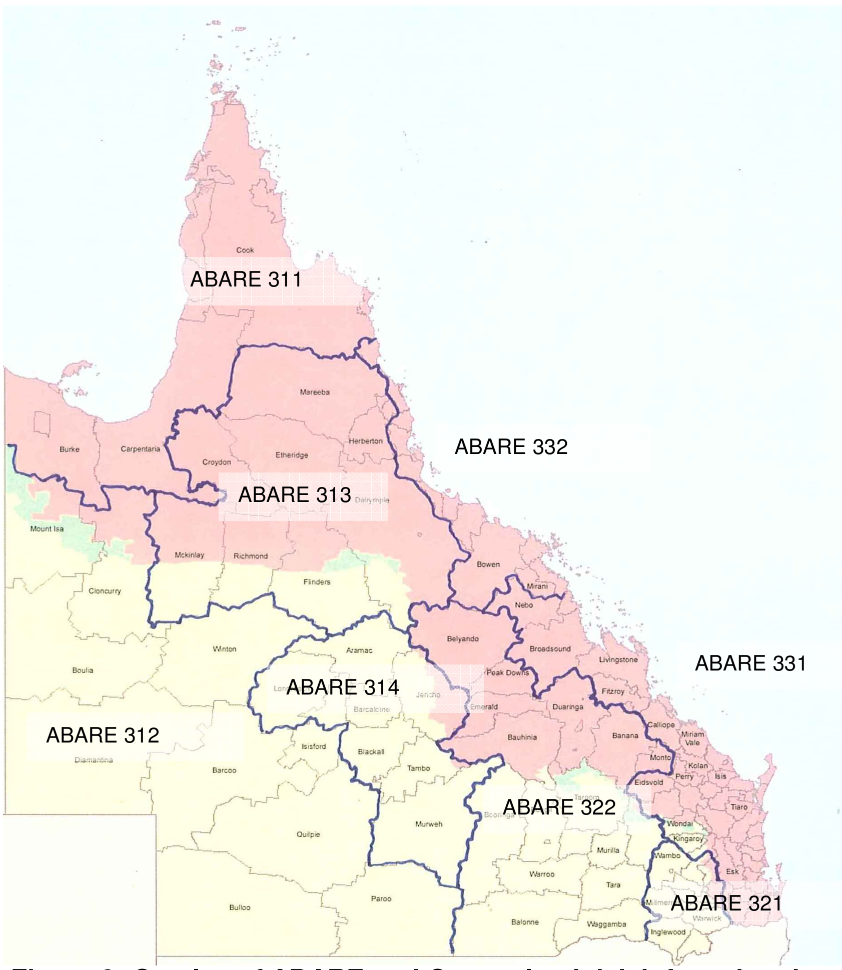

Figure 6. Overlay of ABARE and Queensland tick infected regions

As the tropical coast of Queensland is highly suited to the cattle tick and the dry inland is mostly highly unsuitable and largely tick free, factors other than tick resistance must be encouraging the use of *Bos indicus* genetics. Although the model of Frisch (1975) applies best to the field conditions of “Belmont” research station and does not include estimates of the effect of the constraints on the final live weight of the steers, it does provide some insight into why *Bos indicus* derived breeds of cattle dominate in all regions across northern Australia.

The breed structure of the northern beef industry and the spread of *Bos indicus* genetics across a number of tick free regions suggest that beef producers have adopted levels of *Bos indicus* genetics sufficient to optimise the trade off between environmental constraints and production within their particular environment and production system. Removal of ticks from the production system would not be expected to dramatically change the genetic structure of the northern herd or greatly increase output.

The impact of the cattle tick on beef production

The cattle tick causes measureable weight loss in susceptible cattle. The level of loss is directly related to the number of engorged female ticks carried and the number of days for which they are carried, with resistant cattle carrying significantly fewer ticks (Seifert 1971, Turner and Short 1972, Sutherst et al. 1983).

Trial work has found that tick numbers carried by beef cattle decrease exponentially with increasing *Bos indicus* content (Bourne et al. 1988). Tick numbers carried also vary with seasonal weather, climate, local geography and beef cattle management strategies. Bourne et al. (1988) found that "pure bred Zebu animals carried an average of five ticks per animal per day in central Queensland and only one in southern Queensland". Likewise, cattle with "50 per cent zebu carried 65 ticks per day in central Queensland and 11 in southern Queensland". "*Bos taurus* animals carried 465 and 302 ticks per day in central and southern Queensland respectively". Variation in tick burdens within the herds at the different locations were mainly due to changes in survival rates of parasitic ticks in central Queensland and changes in availability of larvae on the pastures in southern Queensland (Bourne et al. 1988).

The amount of weight lost in beef cattle per engorged female per day has been estimated to average 0.6 grams (Sutherst et al. 1983).

The production response in *Bos indicus* cattle to the control of ticks in differing production environments and levels of stress has been identified in a number of studies. They include:

- Corlis and Sutherland (1976) who identified "that dipping did not increase live weight gain significantly even though considerable numbers of engorged ticks were present on the untreated cattle". This trial was undertaken in a coastal region in central Queensland that receives more than 1700mm annual rainfall;
- Burns, Kearnan, Biggers and Utech (1977) who found that "non-lactating cross bred cattle carrying at least 50 per cent Zebu blood are not disadvantaged if they are not dipped to control ticks"; This trial was undertaken in a 750mm rainfall zone of the Brisbane Valley.
- Sutherst, Maywald, Kerr and Stegeman (1983) who artificially infested Bos indicus cross steers with ticks at Amberley in south east Queensland (850mm rainfall zone) and found "that small tick-induced losses of the order of 6kg will not be reflected in dressed carcasses and so are inconsequential".
- Mellor, O'Rourke and Waters (1983) who ran a trial at Utchee Creek Research Station found that, under wet tropical conditions, Bos indicus cross steers suffered "reductions in weight gains" of 24 and 30 kg live weight over 11 and 17 months respectively. Mean annual rainfall of 3443 mm and 174 wet days are expected at Utchee Creek.
- Bourne, Sutherst, Sutherland, Maywald and Stegeman (1988) who analysed the impact of ticks on breeding animals in two locations and found "that B. microplus has been reduced to a marginal problem on animals with 50 per cent

zebu genes … it is therefore difficult to justify any control measures in southern areas".

- Frisch and O'Neill (1998) who considered cattle breeds of African, European and Indian origin at "Belmont" Research Station located outside of Rockhampton and found "at the low to moderate levels of infestation throughout the study the response on the more resistant genotypes was too low to warrant the costs of treatment".
- Sutherland (2004) who analysed historical data for tick control at "Belmont" research station near Rockhampton in central Queensland (950 mm rainfall) and found "final weights of the treated and untreated groups were not significantly different". The study considered more than two decades of records for Bos indicus based genotypes.

A number of research projects into the impact of the cattle tick on tick resistant cattle have shown that, although some small amounts of live weight may be occasionally lost due to tick infestation, invariably there is no significant difference between treated and untreated steers at mature sale weights unless the level of environmental stress and tick infestation are both very high.

Research has also shown that fertility in *Bos indicus* based breeder herds is unlikely to be improved by tick control if nutrition is sound. Holroyd and Dunster (1978) identified that overall conception rates were unaffected by controlling ticks on *Bos indicus* heifers in north Queensland. In a subsequent trial undertaken on *Bos indicus* cross breeders at Swan's Lagoon located near Ayr in north Queensland, Holroyd et al. (1988) found that "there was no significant relationship between tick count and subsequent conception" but did identify that "the tick infestations influence fertility in lactating cows only under stressful conditions". Even though they only gained a significant response to treatment in one out of three years, they concluded "in environments similar to that in this study, cattle of 50% Bos indicus content…..would still benefit from tick control". The trial was undertaken in the monsoonal subtropics at Swans Lagoon Research Station, southwest of Townsville. No analysis of the economic impact of the trial treatments was undertaken.

The north Australian dairy industry

The north Australian dairy industry is located predominantly in south east Queensland and northern New South Wales (NSW). (Figure 7)

The regions of the northern dairy industry currently exposed to tick infestation all fall within Queensland and include the Atherton Tableland in north Queensland and the dairy farms located north and east of the tick line in south east Queensland. If current quarantine barriers were removed and the cattle tick allowed spread to its current natural ecological boundaries, the majority of dairy farms in northern coastal NSW and southern Queensland would become infested with cattle ticks to some degree.

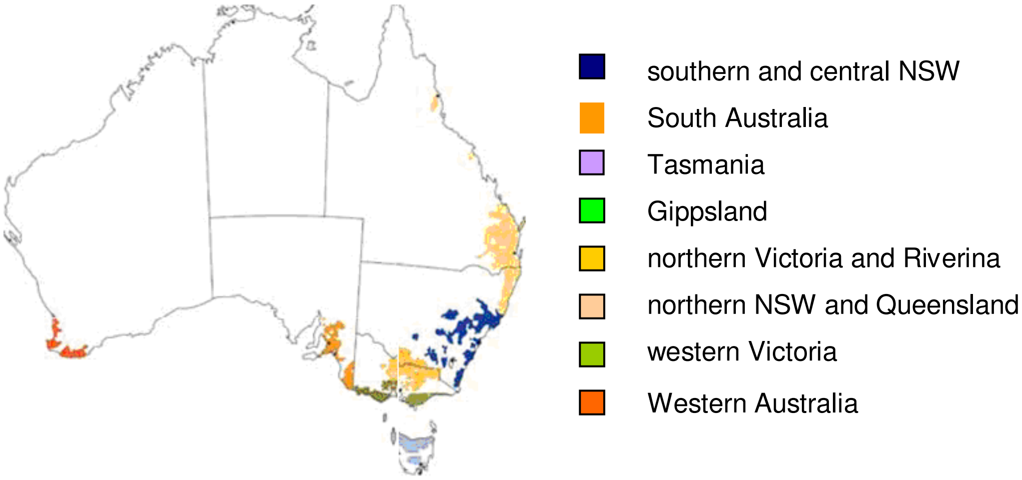

Figure 7. Dairy farming regions of Australia (ABARE 2009a)
Source: ABARE 2009b Australian dairy 09.1

The Queensland dairy industry has reduced as a component of the total Australian dairy industry since 2000. ABARE (2009b) indicated the Queensland share of milking cows has shrunk from approximately 9 per cent of the national total to approximately 6 per cent over recent years (Table 9). Approximately 100 000 milking cows are currently run in Queensland for the production of milk.

Table 9. Australian dairy cow numbers, by state a

Year	New South Wales	Victoria	Queensland	Western Australia	South Australia	Tasmania	Australia
	'000	'000	'000	'000	'000	'000	'000
2000	289	1 377	194	65	105	139	2 171
2001	270	1 360	187	72	132	155	2 176
2002	264	1 363	174	75	110	134	2 123
2003	250	1 303	159	77	117	142	2 050
2004	236	1 322	169	74	106	127	2 038
2005	240	1 319	139	62	93	132	1 942
2006	222	1 217	127	67	104	143	1 880
2007	210	1 150	121	60	114	140	1 796
2008	193	1 036	102	55	103	128	1 617

Sources: ABARE (2009a) Australian dairy 09.1, Canberra
ABS 2008, Principal Agricultural Commodities Australia, 2007-08 cat. no. 7111.0, Canberra;
ABS 2009, Agricultural Commodities, Australia, 2008-08 cat. no. 7121.0, Canberra.
a Cows in milk and dry at 31 March on establishments with an estimated value of agricultural operations (EVAO) of $5 000 or more. From 2000, at 30 June. House cows and heifers are included before 1977-78, but excluded thereafter. Before 1986-87, includes livestock holdings on establishments with an EVAO of $2 500 or more. b Includes data for the Australian Capital Territory and the Northern Territory.

Queensland's share of national milk production has likewise shrunk from approximately 7 per cent in 2000 down to approximately 5 per cent in 2008. (ABARE 2009 data not shown) The long term downward trend for milking cows and dairy output for Queensland in absolute terms and as a proportion of the national total is expected to continue over the medium to longer term.

The numbers of dairy cattle, dairy females and dairy establishments in Queensland has been identified from ABS survey data (ABS 2006). This information is combined with maps of the tick endemic regions of Australia to estimate the number and proportion of dairy cattle to be found within the tick endemic region (Table 10).

Table 10. Distribution of dairy stock and dairy establishments (ABS 2006)

Group	Total	Tick free	Percent of total	Tick infected	Percent of total
	Number	Number	%	Number	%
Total dairy stock	193,602	52,635	27	140,967	73
Female dairy stock	127,385	33,058	26	94,327	74
Establishments	988	332	34	656	66
Adjusted dairy numbers*	102,418	26,579	26	75,839	74

Source: ABS 2006, Agricultural commodities: small area data, Australia, 2005-06 (Reissue), Canberra
*Note: ABS census numbers for 2005/06 have been adjusted downwards to reflect the continuing fall in numbers indicated by the ABARE statistics (Table 8)

The ABARE statistics for 2008 (Table 8) indicate dairy cattle numbers have continued to fall since the 2005-06 ABS census (Table 9). The reduction in dairy cow numbers between 2005-06 and 2008 are thought to be due to a number of factors - predominantly ongoing drought conditions in southern Queensland over the intervening years and low market prices for milk leading up to 2007-08.

More than 70 per cent of Queensland's dairy cattle are currently exposed to the cattle tick to some degree.

The impact of the cattle tick on dairy production

The vast majority of dairy cattle in northern Australia are based on *Bos taurus* breeds and are therefore highly susceptible to the cattle tick. There have been significant attempts in the past to incorporate *Bos indicus* genetics into the Queensland dairy herd but the losses in value of milk output incurred are said to be much greater than the tick resistance benefits gained. (G. Busby 2009, pers. comm.)

Jonsson et al. (2001) provided an estimate of the economic effects of cattle tick infestation on Queensland dairy farms. They used a combination of survey and experimental data to show 49 per cent of tick costs were related to the costs of control while 51 per cent of costs were related to losses in production. Their costs excluded the potential costs of tick fever. Much of the production losses appear related to the willingness of some dairy farmers to accept a level of tick infestation before treatment is commenced. Production losses are costed as equivalent to the amount of extra feed intake required by milking cows to cover the impact of the tick burden. Production losses in dairy cows due to tick infestation are estimated to be 8.9 mL of milk and 1 gram live weight gain per engorging female tick per day (Jonsson et al. 1998).

Analysis of economic benefits provided by deregulating the tick line

The purpose of this section is to identify the potential total costs and benefits of deregulating the tick line in Queensland. Within the cost benefit framework applied benefits are identified as those costs saved in removing the tick line regulations and costs are identified as those costs incurred by industry and others as a result of the tick line deregulation.

Analytical framework applied

This analysis applies a partial equilibrium modelling framework to estimate the economic surplus generated by deregulating the tick line. Impact at the producer level will be measured as variations in the supply of beef and dairy products resulting from the cost of production increase incurred by primary producers as a result of the deregulation of the tick line.

In an economic surplus model, an increase in cost per unit of production at each level of production is represented by an upwards parallel shift in the supply curve. The resulting change is measured as a decrease in economic surplus, shaded in Figure 8 below.

The shift in any given year will be derived from the projected increase in per unit production cost and the number of producers impacted by the change at that time. The projected per unit cost increase is derived from changes in yield and cost of production per unit identified in the farm level analysis.

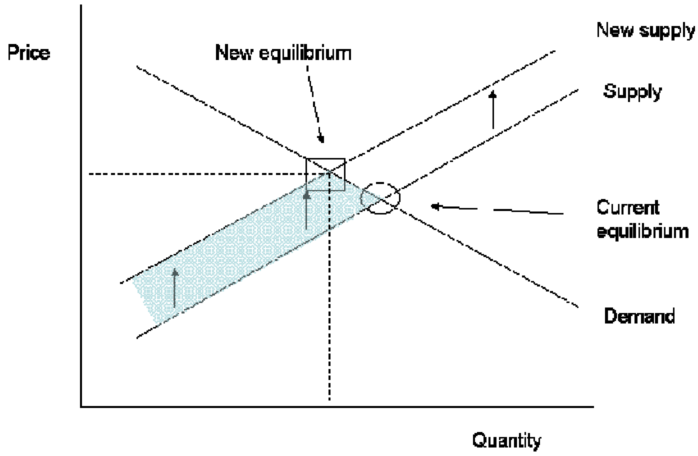

Figure 8. Static model of economic surplus change when costs of production increase

Figure 8 represents a simple static form of the model, in which the change in economic surplus (change in benefits) occurs in a single period of time.

In the model applied in this analysis, the size of the change in surplus will be affected by:

- The responsiveness of supply and demand to productivity changes
- The existing market equilibrium
- The size of the shift in the supply curve
- Characteristics of the industry (e.g. size, rate of adoption)

The DREAM benefit-cost analysis program (Wood et al. 2001) was selected as the modelling framework. This program is based on the economic principles developed in Alston et al (1998), and it has been widely used in impact assessment studies over a number of years by many different national and international institutions.

DREAM has a number of different sub-models representing different types of market situations. One of these is the "horizontal multi-market" option. This provides a means of assessing the economic impact of a change where the product under study is (relatively) freely traded across a number of regions, a situation closely approximated in the Australian beef industry.

The same model can be used to model impacts in the Queensland dairy industry even though Queensland effectively consumes all of the milk it produces. The analysis in this case will use a simplified “multi-market” model to consider the impact of a relaxation of tick control regulations on producers and consumers in both the tick free and tick endemic regions of Queensland.

The benefits of deregulating the tick line

The costs to be saved by deregulation are the costs of:

- moving stock across the line
- tick eradication activities within the free and controlled zones, and
- regulating and managing the tick line

The costs associated with Voluntary Eradication Schemes (VES) are not included as it is expected that this activity will be continued in some form by industry even if the tick line is deregulated. There also does not appear to be differences in market prices for similar classes of beef cattle on either side of the tick line once allowance for differences in transport costs to the final point of sale is made.

Total costs of livestock movement across the line

During 2009, Biosecurity Queensland undertook a review of cattle tick inspection and third party provider services associated with the operation of the tick line (Alliance Resource Economics 2009). The report produced by the review identified the number of cattle and horses crossing the line over the past five years and the direct costs to industry associated with crossing the line (Table 11).

Table 11. Estimation of the cost to livestock owners of inspection and clearance

Year	2004	2005	2006	2007	2008	~Avg. no beef cattle	~Avg. no horses
Beef cattle	607 636	476 456	513 260	608 459	807 288	657 839	9 710
Cost per head ($)*	3.50	3.50	3.50	3.50	3.50	3.50	15.00
Total cost ($)	2 126 726	1 667 596	1 796 410	2 129 607	2 825 508	2 374 188	145 650

*2008/09 $'s

The approximate number of cattle and horses crossing the tick line annually is about 658 000 and 10 000 head respectively. Alliance Resource Economics (2009) indicated that livestock owners pay an average of about $2.52m per year to access the tick free zone. This estimate includes the cost of cattle quarantined at the line but does not include the cost of preliminary treatment and any "out of the way" travel costs.

Livestock producers have to treat cattle and horses at least once prior to leaving their property to ensure that animals are tick free at the line. The costs of tick treatment(s) applied to livestock, handling the livestock to apply the treatments and travelling to the site of inspection are assessed as at least equivalent to the costs incurred by industry at the tick line. On this basis the total costs incurred by industry in crossing the Queensland tick line are in the order of $5m per annum.

Figure 9 indicates the major regional movements of livestock across the Queensland tick line. Although the final destination of the livestock is unknown, the vast majority are thought to be growing cattle moving from the breeder herds of the north to the fattening pastures and feedlots of central and southern Queensland. Given the genetic structure of the breeding herd, it is unlikely that any gain in production is achieved by treating livestock at the tick line.

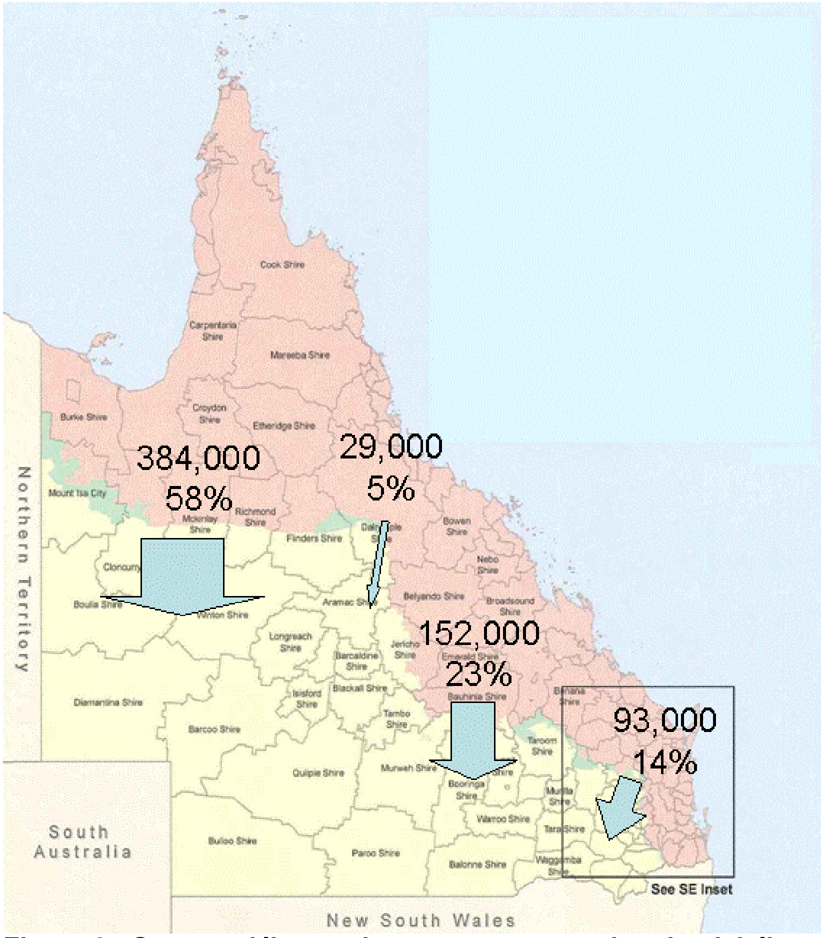

Figure 9. Source of livestock movements crossing the tick line

Queensland also trades large numbers of cattle across its borders on an annual basis. ABS (2006) indicated that some 277 000 head of cattle are exported out of Queensland with the majority going to New South Wales (158 000) and to the Northern Territory (112 000). Imports into Queensland total some 518 000 head, mostly coming from New South Wales (274 000) and the Northern Territory (215 000).

Data available for livestock movements across Queensland's borders can also be gained from interpreting the NLIS[2] database. Table 12 shows NLIS livestock data for movements of cattle to Queensland over recent calendar years and indicates that imports from New South Wales and the Northern Territory continue to show consistent growth in numbers (M. Lancaster, pers. comm.). The destination of livestock once they cross the border into Queensland is not available at this time.

[2] NLIS – National Livestock Identification System – a centrally-stored electronic history of an individual animal's residency operated by a subsidiary of Meat and Livestock Australia

Table 12. Livestock movements to Queensland

	Total 2006	Total 2007	Total 2008	Total 2009*
NSW to QLD	292 661	281 041	341 650	373 653
SA to QLD	6 951	17 322	21 886	11 439
TAS to QLD	353	284	1 089	242
VIC to QLD	11 216	10 040	10 000	4 776
WA to QLD	2 441	902	2 688	221
NT to QLD	85 236	134 041	243 803	80 730
Total into QLD	398 858	443 630	621 116	471 061

*2009 data is for ¾ of the year only

Full NLIS data for transfers of livestock out of Queensland is not available but the available data shows similar numbers to that reported by ABS.

Total costs of tick eradication activities

Each year a number of cattle properties located in the tick free or control zones become infested with ticks. Since 1999, approximately 193 properties per year have been subject to eradication and quarantine activities (Alliance Resource Economics 2009). Data available for subsidy payments since 2003 (the State pays 10 per cent of chemical costs) indicates that an average of $6 600 per year is provided as acaricide subsidy payments by the State to eradicate tick outbreaks in the tick free and tick control zones. (M. MacLeod 2009 pers. comm.) (Table 13)

Table 13. Chemical subsidy paid for tick eradication and number of properties in eradication schemes

Year	Acaracide subsidy paid	CPI	CPI adjusted subsidy	Industry costs (90% of total costs)	Total acaracide costs (2008/09 $'s)	Properties making claims	Total properties in eradication schemes
	$		$	$	$	Number	Number
2003	5 366	141.3	6 251	56 258	62 508	16	155
2004	11 450	144.8	13 016	117 141	130 157	28	160
2005	4 600	148.4	5 102	45 919	51 022	13	143
2006	8 513	154.3	9 081	81 731	90 813	21	150
2007	3 500	157.5	3 658	32 920	36 578	11	190
2008	6 400	164.6	6 400	57 600	64 000	21	220
Average	6 638			65 262	72 513	18.33	169.67

Table 13 indicates that about $3 955 is spent on acaricides by each claimant property. If this is extended to the number of properties under eradication on average (193), then about $765 735 is spent on chemicals applied in eradication activities. As about 25 000 head are involved at any one time, on average $30.63 per head is spent on chemicals applied in eradication activities. The State provides less than 1 per cent of the total chemical costs of tick eradication activities in the tick free and control zones.

The livestock involved in eradication activities need to be mustered to be treated, incurring additional costs. Table 14 provides an estimate of the total extra cost for mustering these livestock. Mustering adds approximately $1.60 per head per treatment to chemical costs.

Table 14. Estimated extra cost of handling cattle involved in eradication activities

25 000	head treated	
4	extra musters per head	
1	man day per	100 head mustered
equals	1 000	man days to muster for tick eradication
	$200	per man day for mustering
	$200 000	annual additional labour cost of treating for tick eradication

Thus, the total cost incurred by industry and the State in eradicating ticks in the tick free and tick control zones is assessed as $1m per annum. The vast majority of this cost is paid by industry.

Total costs of regulating and managing the tick line

Biosecurity Queensland has a large number of staff involved in tick control and management activities. The part of the total work time applied by these staff to activities directly associated with the tick line is assessed as 15.5 full time equivalent positions per annum (M. Macleod 2009 pers. comm.). The total cost to the State of regulating the tick line is assessed as about $3.1m per annum (Table 15).

Table 15. State based costs of tick line regulation

Cost centre	Factor	Total
		$
BQ staff (14.5 FTE's at TO3-4)		900 000
Oncosts allowance	27.77%	249 930
General operating		380 000
Corporate on-costs allowance	1.77	1 593 000
Total State cost of tick line regulation and management		**3 122 930**

The State collects some fee for service funds for inspection services and activities at clearing dips. These are not included in this analysis as they are a transfer within the total cost of the tick line regulations, not an additional cost.

The total annual costs to be saved through deregulating the tick line are assessed as:

- Moving stock across the line $5 000 000
- Tick eradication $1 000 000
- QPIF tick line management $3 122 930
- Total costs per annum $9 122 930

Approximately 34 per cent of total costs accrue to the State.

The cost benefit analysis will apply a 30 year investment horizon and a 5 per cent discount rate. On this basis, the deregulation of the tick line in Queensland is assessed as having a Present Value of Benefits of $140 million dollars.

Use of acaricides at the tick line

Statistics for the use of acaricides used specifically to treat ticks in the northern cattle industry are not readily available. Playford (2005) reported an estimate of total sales for “tickicides” of about $16.8m in 2003 after making contact with a number of industry and regulatory sources. As it seems unlikely that the volume of acaricides sold for this purpose would have increased significantly over recent years, the 2003 sales value has been adjusted using ABS estimates of the CPI to provide an estimate of the current value of relevant acaracide sales of $19.8m.

A survey has recently been conducted by Meat and Livestock Australia (MLA) to discern the acaracide resistance status of the cattle tick in Queensland. (Waltisbuhl et al. 2008) Respondents to the survey also indicated the use of acaricides and the frequency of treatment (133 valid responses). On average, they applied acaricides 5.1 times per annum and spent approximately $3.00 in chemical costs per treatment. This frequency of treatment and cost is taken as a fair indication of the average incurred by those producers within the tick endemic area who treat cattle ticks with acaricides.

Alliance Resource Economics (2009) indicated that during the 2008 calendar year more than 807 000 cattle were treated with acaricides as they crossed the tick line. The vast majority of these livestock would have been treated at least once before presenting at the tick line.

As previously identified, some acaricides are used by industry to eradicate ticks that escape into the tick free and tick control regions of Queensland. At any time about 25 000 head of cattle are involved in eradication activities and are treated with acaricides (M. Macleod 2009, pers. comm.)

These various sources of data have been combined to provide an estimate of the number of beef cattle treated on a regular basis with acaricides in Queensland (Table 16).

Table 16. Acaracide use by the beef and dairy industries

Factor	Value
Total spent on acaricides (MLA 2003 adjusted by CPI)	$20,000,000
Average annual spend per treatment	$3.00
Total number of treatments applied	6 666 711
Number of livestock moving through the tick line (Alliance Resource Economics 2009)	807 288
Number of treatments per movement through the tick line (estimate)	2.25
Total number of tick treatments accounted for by movement through tick line	1 816 398
Number of cattle on tick control and eradication properties (Malcolm Macleod pers. comm.)	25 000
Total number of treatments applied to cattle in tick control and quarantine regions	150 000
Total treatments applied due to tick regulations	1 966 398
Total number of treatments applied by industry to control ticks	4 700 313
Number of treatments applied per head per annum by industry to control ticks (Waltisbuhl 2008)	5.1
Total number of cattle treated on a regular basis to control ticks	926 267
Dairy cattle in the tick infested regions (ABS 2006)	193 602
Total beef cattle treated for tick control	732 665
Beef cattle in the tick endemic region (ABS 2006)	7 830 732
Dairy cattle in the tick endemic region (ABS 2006)	193 602
Total cattle	8 024 334
% of total cattle in the tick endemic region treated for ticks	11.54%
% of beef cattle in the tick endemic region treated for ticks	9.36%
% of tick treatments applied as a part of tick line regulations	29.5%

The available data shown in Table 15 suggests that about 10 per cent of beef cattle located within the tick endemic region are treated regularly for ticks with acaricides. About 30 per cent of the total application of acaricides for the control of cattle ticks appears to be as a result of tick line regulations.

The estimates provided above are thought to be the best available but could be subject to some revision. The average cost of acaricide treatment is thought to be a little high but then the Beef CRC website reports - *"Resistance to acaricides is a huge* *economic cost to the northern beef industry which already spends about $8 million dollars each year in controlling ticks*"[3]. The original source of this estimate cannot be determined but reminds us of the difficulty of gaining accurate statistics for acaricide use to control ticks.

Costs incurred with tick line deregulation

There are a large number of potential scenarios available when considering the deregulation of the tick line. This analysis will consider a complete deregulation scenario which allows industry to transfer livestock anywhere within Queensland without State regulated inspection for cattle ticks. It is expected that the regulations for transfer of livestock across State and Territory boundaries will not change and that some form of industry based quality assurance scheme will be implemented under which guarantees of tick freedom can be arranged for an inspection/clearance fee.

Ongoing costs incurred moving livestock from tick endemic regions

It is not expected that all of the current "regulation" costs of moving livestock from tick endemic regions of the State will be saved by deregulation. Under a complete deregulation/industry quality assurance scheme scenario, it is envisaged that those industry participants who want to be assured of tick free livestock will continue to incur some inspection and clearance costs, although they will not be regulated by the State. It is also expected that some of the livestock currently exported live out of Queensland will be from regions that are currently tick free and may incur a new cost to be cleared at the Queensland Border. There appears to be no statistics available on which to base an estimate of the net number of extra cattle likely to incur such a cost but numbers are unlikely to be large given that no more than 200 000 to 300 000 cattle per annum in total are currently exported live out of Queensland to other jurisdictions[4]. Many of these cattle are sourced from the tick endemic, northern breeding regions of the State and already incur a tick related clearance cost.

The saving in costs arising from deregulation is expected to be equivalent to:

- the cost of clearance at the line, plus
- the cost of treating livestock originating from regions with low levels of tick infestation or high levels of tick resistant cattle and travelling to the drier regions of the State.

For example, it is envisaged that costs will be saved in moving *Bos indicus* based livestock from the north to the fattening regions of the channel country or central west where it is too dry for the cattle tick to survive. Movements of livestock across the tick line to feedlots and abattoirs are also expected to show some savings in costs.

As many producers will still want to be assured that the livestock they are purchasing or moving are tick free, it is expected that some form of industry based quality assurance scheme will be negotiated under which part of the resources of the current Third Party Provider arrangement (Alliance Resource Economics 2009) will be maintained and industry funded.

On this basis, approximately 75 per cent of the current costs associated with the movement of livestock from the tick endemic regions of Queensland could be saved leaving residual costs of $1.25m per annum to continue to be incurred into the future by industry seeking assurance of tick free livestock after deregulation of the tick line.

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[3] see http://www.beefcrc.com.au/Acaricideresistancetest
[4] Estmate based on ABS, NLIS and Northern Territory data gathered during the evaluation

This estimate of expense should cover the ongoing treatment and clearance costs of up to 300 000 head per annum.

Ongoing costs of tick eradication activities

The expenses associated with compulsory tick eradication activities will cease. Producers currently directly impacted by tick eradication regulations will incur ongoing costs related to tick line deregulation and these will be considered in the section that identifies the costs likely to be incurred by industry as a result of deregulation.

Ongoing State based costs associated with ticks

Biosecurity Queensland is expected to reduce staff allocated to tick line management activities as a result of deregulation. The current 15.5 FTE’s employed are expected to reduce to 2 FTE’s by the sixth year after deregulation and continue at that level into the foreseeable future (Figure 10).

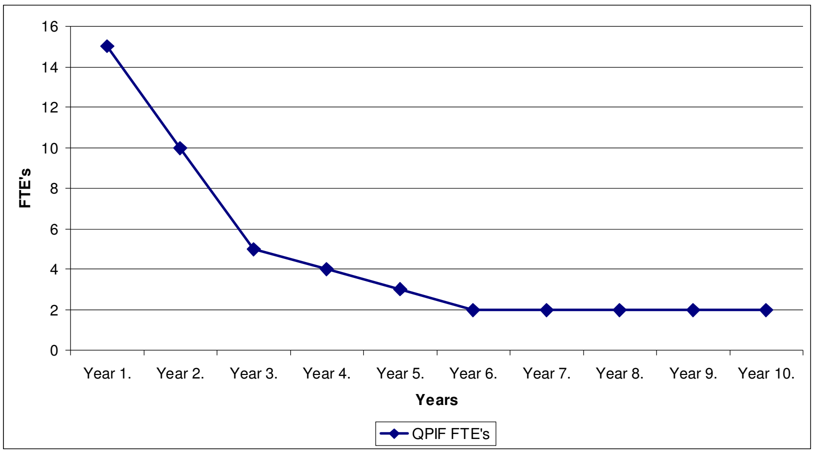

Figure 10. Reduction in Full Time Equivalent positions employed by the State in managing the tick line

The number of FTE’s continuing to be engaged after tick line deregulation is based on an expected requirement to help industry establish and maintain the quality assurance scenario. It is also expected that not all positions will be saved due to the long term need to work with industry in managing the cattle tick. Ongoing State based costs are expected to average more than $400 000 per annum in current dollar terms.

The annual total costs saved by deregulation of the tick line are expected to increase from approximately $4.5m per annum at deregulation to about $7.5m per year by year six and continue at this level into the foreseeable future (Figure 11).

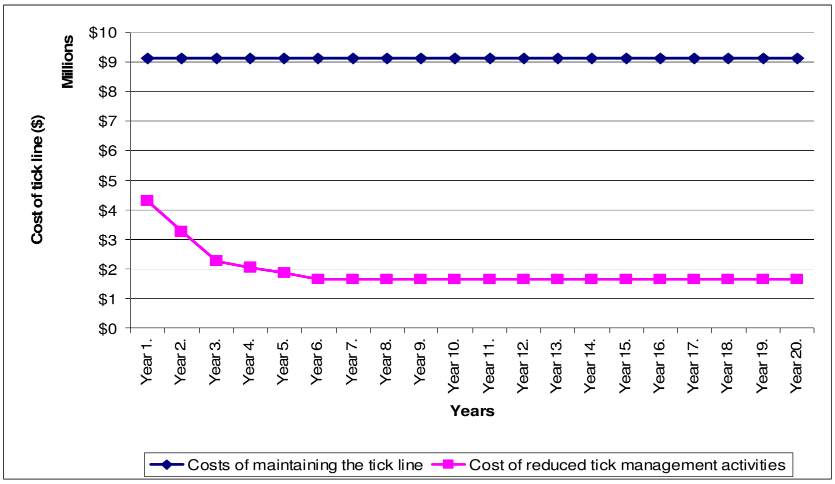

Figure 11. Cost change scenario for tick line deregulation

Costs incurred by livestock industries as a result of deregulation

In a review of research needs undertaken for the MLA, Playford (2005) identified a number of potential impacts of cattle ticks on beef cattle production. They were listed as:

- decrease in live weight gain
- decrease in milk production
- hide damage
- morbidity and mortality due to tick fever
- labour cost of mustering and treatment
- capital cost of facilities for treatment
- cost of chemicals for treatment
- veterinary costs to treat sick animals
- costs of maintaining regulatory controls
- costs of research and policy making
- welfare costs
- trade related of fertility losses due to inability to use the most desirable breeds

Susceptible breeds of cattle exposed to the cattle tick by the deregulation of the tick line are likely to suffer measureable economic damage from reduced live weight gain, decreased milk production, tick fever and tick treatment costs. There is considerable uncertainty as to whether there is a measureable economic cost associated with restricting breed choice or value of hides. Veterinary and welfare costs are seen as nominal and unmeasurable respectively. The costs of regulation and policy making will be removed by deregulation.

Livestock impacted by tick line deregulation

Deregulation is most likely to expose additional beef cattle in the south east corner of Queensland to substantial attack by the cattle tick. Glanville (1985) considered the region most likely to gain a viable population of damaging ticks, “with” tick line deregulation, to be bound by the current tick line and a line from Goondiwindi north through Mitchell. Using that analysis as a guide, a map showing the pre 2008 local government shires most impacted by the tick line deregulation scenario has been put together (Figure 12).

Not all shires potentially exposed to tick infestation will be impacted to the same degree. Variations in local climate, topography, and current land use patterns are expected to vary the impact of the cattle tick across the region.

The total region identified in Figure 12 has been broken into four broad subregions to reflect the expected “relative” levels of tick infestation. The “north east” subregion is expected to be most suitable for ticks and is marked as “100 per cent”. This indicates that ticks will become established and maintain a sufficient population under field conditions to seriously impact the production of susceptible livestock in all years.

The “central north” subregion marked “75 per cent” is expected to incur tick infestation only ¾ as much as the most susceptible subregion. That is, ticks are likely to impact production in susceptible cattle three years in four. Likewise, the “southern downs” subregion is expected to be only ½ as susceptible as the “north east” subregion while the “south west” subregion is expected to be about a ¼ as susceptible as the “north east”. These levels of expected tick infestation will be used to guide the relative costs of tick management on properties within each of these subregions.

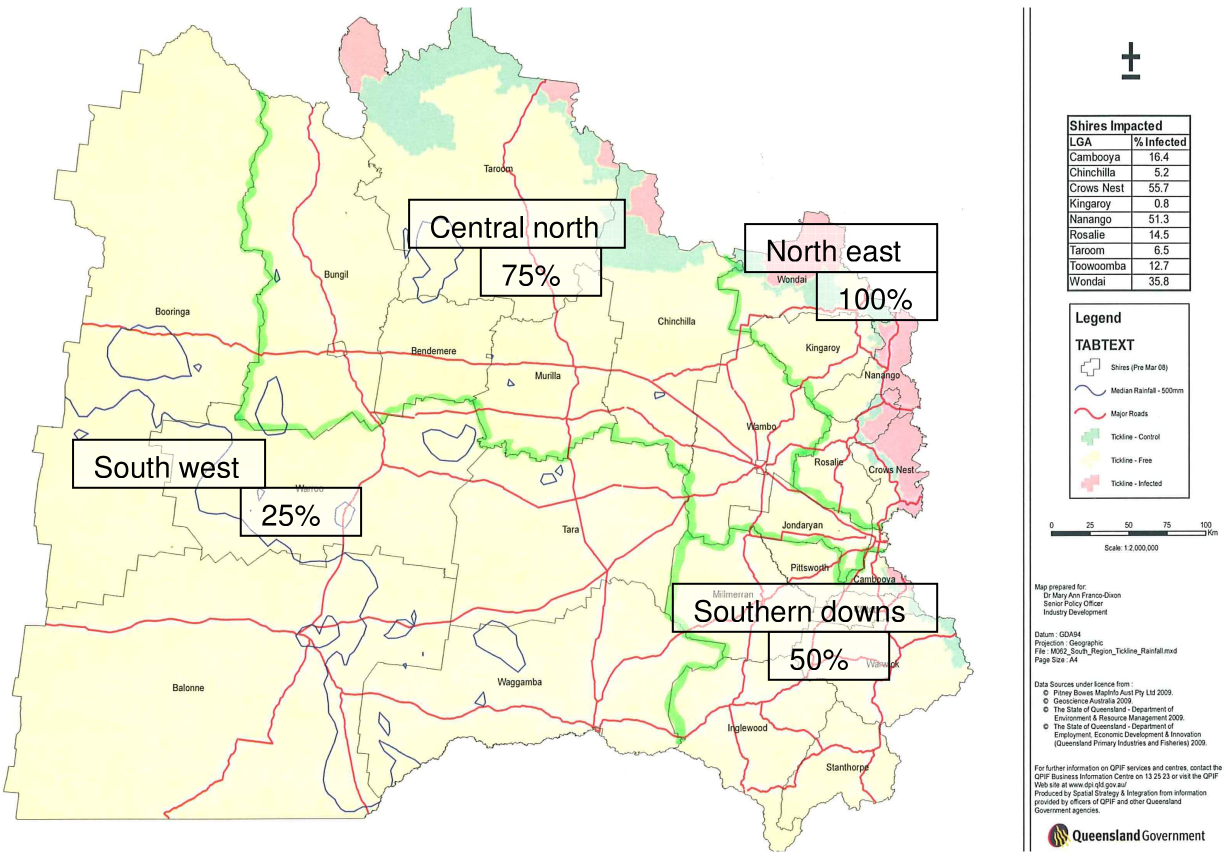

Figure 12. Pre 2008 Queensland Shires and expected level of impact with tick line deregulation

Although some of the cattle in the south and west of the region are unlikely to ever see ticks with or without deregulation, they have been added to the analysis undertaken by Glanville (1985) to cover other livestock outside of the region shown in Figure 12 that may also be impacted by deregulation.

The number of beef cattle in each shire at the time of the 2006 ABS Census has been identified and combined with the ABARE (1995) data for breed composition. (Table 17),

Table 17. Cattle susceptible to tick infestation under a deregulated tick line scenario.

Sub-region	Number of mixed stock	Susceptible stock in the region (%)	Number susceptible stock
South West - low impact	750 379	40	303 713
Central North - moderate impact	954 815	40	386 458
Southern Downs - median impact	295 614	57	169 528
North East - high impact	207 192	40	83 860
Dairy cattle	52 635	100	52 635
Total	2 260 636		996 195

About 2.26 million head of cattle can be found in the region to be wholly or partially infested with ticks under the tick line deregulation scenario. Of those cattle, about one million are considered to be highly susceptible to damage by the cattle tick.

Note: the ABARE data for breed composition has been modified to allow for the proportion of *Bos indicus* cross cattle in each subregion likely to be tick susceptible, even though they carry *Bos indicus* genes. A quarter of *Bos indicus* cross cattle in each subregion have been included in the susceptible group to allow for tick susceptible cross bred livestock.

Beef industry costs incurred

The impact of deregulating the tick line depends upon the rate of spread of ticks and the strategy applied by livestock owners to manage tick infestation. For this initial analysis, ticks are allowed to spread rapidly across the total region with all zones fully infested with ticks by the end of the fifth year after deregulation. It is unlikely that it is possible for ticks to spread more rapidly than this across newly deregulated zones. The impact on total costs of slower rates of spread will be tested later in the anlaysis.

Two discrete strategies are initially analysed. Producers can choose to apply acaricides indefinitely or they can choose to breed tick resistance into their livestock and apply acaricides during the conversion period. Variations of the proportion of producers converting to resistant breeds and the time taken to convert are also included in the initial analysis.

Continue to apply acaricides

The impact of deregulating the tick line on producers who currently have susceptible livestock and who do not choose to convert to tick resistant *Bos indicus* livestock will be the additional ongoing costs of treating their livestock for tick infestation. The cost of treating tick susceptible stock in the “north east” subregion is expected to average $25 per head per annum in chemicals and application costs. This is based on the application of popular pour on tick treatments including Fluazuron or Macrocyclic lactone based products that appear to make up about 70% of acaracide sales nationally[5]. These chemicals are applied at a sufficient level of treatment to reduce the damage done by ticks to susceptible beef cattle to a negligible level so that there is no production damage ever likely to be incurred by the treated beef cattle. The remaining subregions are expected to incur costs in the proportions previously identified.

[5] Based on unpublished audited sales data made available by the Animal Health Alliance

The level of treatment costs included in the analysis are not seen as excessive but are likely to represent close to the maximum average treatment costs likely to be incurred by impacted beef producers as a result of deregulation.

To test whether the proportional value of the additional treatment costs varied with herd size, a number of herd sizes and business operations were modelled across the various sub regions. As ABARE (2009) indicates that 73 per cent of cattle are held on approximately 17 per cent of properties in northern Australia, these values were applied to the ABS (2006) data for livestock numbers across the sub-regions to provide an indication of the relative herd size expected within each subregion (Table 18).

Table 18. Expected "typical" herd size for subregions

Subregion	Total head	Total properties	73% cattle	17% properties	Herd size	Sample herds
South west - low impact	750 379	1 213	547 777	206	2 656	2 700
Central north - moderate impact	954 815	2 302	697 015	391	1 781	1 800
Southern downs - median impact	295 614	1 986	215 798	338	639	600
North east - high impact	207 192	1 554	151 250	264	573	600
	2 208 001	7 055	1 611 840	1 199		

The cost of applying acaricides on Queensland beef properties of about these sizes that are running *Bos taurus* or tick susceptible cross bred livestock and located inside the zone impacted most by deregulation has been estimated using data for beef property performance (ABARE 2009) combined with a steady state profit models.

Although the larger properties have proportionally less overhead costs making up their total costs, the change measured in property financial performance was fairly uniform across the range of herd sizes. Table 19 indicates the expected median impact on costs of a tick infestation in a susceptible herd in the high impact "north east" subregion. Additional detail of the farm models used is provided in Appendix 1.

Table 19. Expected beef farm impact of tick infestation in a susceptible beef herd in the "north east" subregion

Assets	Without ticks	With ticks	Difference	Change
Gross Margin per Adult Equivalent	$175	$151.5	$23.5	-13.43%
Cost per Kg Beef	$0.99	$1.15	$0.16	+16.1%
Kilograms of Beef Sold	89 570	89 570	0	0%

Note: the increase in costs is due to the application of acaricides to all livestock as well as the application of tick fever vaccine to branded calves. Tick fever costs have been adjusted upwards to allow for the fact that while not all livestock in the region are susceptible to ticks, most are susceptible to tick fever.

At the property level, the total cost of producing beef increases by about 16 per cent in the high impact subregion when an "acaricides only" strategy is followed. When this is applied across the four subregions of interest, the "north east" incurs a proportional increase in cost of 16 per cent, the "southern downs" a cost increase of 8 per cent, the "central north" by 12 per cent and the "south west" by 4 per cent.

Convert to Bos indicus

As shown in Appendix 1, introducing *Bos indicus* bulls into a *Bos taurus* herd and converting to tick resistant stock is expected to take eight years before all susceptible females are removed from the herd (Powell and Reid 1982). Some producers may choose this method while others may purchase replacement breeders with sufficient *Bos indicus* content to manage a tick infestation on their property. This analysis will initially apply the slower process of converting to a *Bos indicus* based breeder herd over eight years to estimate the impact of tick control on costs. Acaricides will be applied to susceptible cattle within the herd while the conversion is underway.

A number of studies over recent decades have identified the performance improvements available through cross breeding programs using *Bos indicus* and *Bos taurus* livestock in both subtropical and temperate production systems in southern Queensland and northern New South Wales (Arthur et al. 1994; Hearnshaw et al. 1995; Thompson et al. 1981; Newman et al. 2002 and Schutt et al. 2009). As well as research activities, workshops held as part of the *"MLA Beef Genetic Horizons"* activity have presented producer experience in measuring the impact of introducing tropically adapted sires to a Hereford herd (*Bos taurus*) in tick free southern Queensland. (Table 20)

The producer example provided is for an initially 100 per cent Hereford herd. It is located in the tick free region of the Brigalow belt and was historically selected on expected genetic performance and reproductive function. A crossbreeding process began in 1995 using up to six breeds but initially focussed on producing Hereford (HH) x Belmont Red (BR) dams. These were then mated to bulls that incorporated Charbray (CB) and Belmont Red genes to give dams that were [HHBR] 50 per cent x [CBBR] 50 per cent. The gross margin performance of this 50 per cent tropically adapted composite was measured as more than 35 per cent better than the original Hereford breed.

Table 20. Benefits in a small beef enterprise by Crossbreeding – Turn-off at 16.5mths

	HHHH 1995	HHBR 1997	HHBRCBBR 1998
Average Daily Gain Birth-Brand (Kg/dy)	0.83	0.74	0.9
Average Daily Gain Brand-Wean (Kg/dy)	0.2	0.51	0.8
Average Daily Gain Whole life (Kg/dy)	0.72	0.75	0.99
Average Weight at 16.5mth (500dys)	360kg	375kg	495kg
Return @$1.30/kg; Relative to HHHH	$468 -	$487.50 4.1%	$643.50 37.5%

Source: Crossbreeding theory, practice and the bottom line, MLA Beef Genetic Horizons Workshop, Rockhampton, 26-27th August 2004

Within the region most impacted by deregulation of the tick line, the benefits available to crossbreeding activities that provide adequate tick resistance are equal to or better than crossbreeding activities that do not. These benefits are available with or without the deregulation of the tick line and, as ABARE (1995) statistics identify, many beef producers in the tick free regions of the State currently avail themselves of these benefits.

The impact of deregulating the tick line on producers who currently have tick susceptible livestock and who choose to convert to *Bos indicus* cross livestock is seen as the additional cost of acaricides applied to susceptible stock remaining in the herd during the conversion period. Research indicates that cross breeding activities are unlikely to significantly impact on the price paid for livestock as meat quality and suitability for feed lotting are not reduced (Schutt et al. 2009). The benefits of crossbreeding to those producers who convert from susceptible *Bos taurus* stock are not counted in the analysis as they would be available with or without deregulation.

In the scenario used for this analysis, the beef producer converting to tick resistant cattle faces cost increases during the early years of the conversion due to the need to treat susceptible breeder stock. The annual cost increases (by subregion) for producers who begin to treat for ticks from year one after deregulation are shown in Table 21.

Table 21. Percentage change in cost per kilogram of producing beef for producers converting to *Bos indicus* cross livestock due to tick line deregulation

% change in average cost	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
	%	%	%	%	%	%	%	%	%
North east (100%)	16.00	15.97	10.54	8.66	6.87	6.84	4.14	4.14	1.46
Central north (75%)	12.00	11.98	8.03	6.66	5.36	5.33	3.36	3.36	1.41
Southern downs (50%)	8.00	7.99	5.51	4.64	3.82	3.80	2.56	2.56	1.33
South western (25%)	4.00	3.99	2.93	2.57	2.20	2.19	1.66	1.66	1.13

The cost of acaricide treatment largely finishes in year eight and from year nine onwards the remaining cost increase is due to the ongoing use of tick fever vaccine. This cost will continue indefinitely and has been adjusted upwards to account for the fact that while only a portion of the beef herd in the region is susceptible to the cattle tick, most of the herd will be susceptible to tick fever. The costs of applying tick fever vaccine across the beef cattle at risk in the region should be covered by making this adjustment.

Dairy industry costs incurred

Jonsson et al. (2001) surveyed dairy farmers across the tick endemic regions of Queensland to ascertain the economic effects of cattle tick infestation on dairy farms. They found that about 49 per cent of total costs were related to control costs and 51 per cent were related to losses in production.

Production losses were estimated to be equivalent to the cost of the fodder necessary to make up tick losses. They also estimated the variable costs of treatment to range between $10 and $25 per head per annum (2001 $'s) for dairy cattle located within the tick endemic region of south east Queensland. Adjusting their costs to express them in current dollar values and making allowance for the potentially lower tick burdens of the region to be deregulated suggests that the current estimate of $25 per head per annum for tick treatment costs applied to *Bos taurus* beef cattle in the "north east" region can also be applied to dairy cattle. Because of the higher energy requirements and stresses associated with milk production in dairy cattle, an allowance for production losses will be added to the costs of treatment. This is different to the expected costs for beef cattle where the expenditure on tick contro reduced the production impact of ticks to a negligible level. If the proportions identified by Jonsson et al. (2001) are used to calculate the value of lost production per dairy cow, the total cost of tick infestation in dairy cows due to tick line deregulation is expected to be about $50 per cow per annum.

In the analysis of impact on dairy farms, ticks also spread rapidly across dairy farms and it is modelled that all will be infested by the end of five years after deregulation. As dairy farmers located in the tick endemic regions of the State have chosen to maintain highly tick susceptible *Bos taurus* base dairy stock, it appears very unlikely that newly tick infested properties will change their genetic structure to combat ticks.

The expected impact on the dairy industry of deregulating the tick line has been estimated using data for dairy property performance (QPIF 2008) combined with a steady state profit model (Table 22). The cost of treatment with tick fever vaccine has been included in the analysis of cost. (See Appendix 1 for further detail of the dairy farm model used).

Table 22. Expected dairy farm impact of tick infestation due to tick line deregulation

	Without ticks	With ticks	Difference

	$	$	$	%
Farm Income	924 415	924 415	0	
Total variable expenses	419 766	441 366	21 600	
Farm gross margin	504 649	483 049	-21 600	
Fixed expenses	155 940	155 940	0	
Net farm income	348 708	327 108	-21 600	
Gross margin per milking cow	2 336	2 236	-100	-4.28
Cost per litre of milk produced	0.4615	0.4788	0.0173	3.75
Litres of milk sold	1 247 523	1 247 523	0	

Tick infestation on dairy properties in the region impacted by tick line deregulation is expected to be a maximum reduction in gross margin of approximately $100 per milking cow. The cost of producing milk increases by 3.75 per cent on average.

Measuring the economic impact of tick line deregulation in the beef industry

Economic benefits for the northern beef industry are calculated in DREAM by combining the estimates of farm level impact for the deregulation of the tick line with measures of elasticity, supply, consumption and price for Queensland, Australian and World beef production respectively provided by Griffith *et al.* (2006).

Griffith et al. (2006) choose the year 2001-02 as the base year for the price and quantity data as this was the most recent year where the full set of required data was available. This year was also "*considered to be broadly representative of the peaks and troughs of the world beef market during the coming couple of decades, taking into account the inevitable consequences of the US cattle cycle (Griffith and Alford 2002, 2005) and the increasing risks associated with market disruptions caused by droughts and disease outbreaks*" (Griffith et al. 2006).

The original base price and quantity data used by Griffith et al. (2006) are given in Table 23. Notes explaining calculations relating to these data are provided below the table.

Table 23. Base Price and Quantity Data, Beef and Veal, 2001/02

Region	Production (ktcw)	Consumption (ktcw)	Beef Exports (ktcw)	Beef Exports (ktsw)	Cattle Exports (ktcw)	Cattle Exports (head)	Price ($AU/tonne)
NSW	474	296	204		0.733	3877	3130
VIC	355	171	144		8.464	44785	3223
QLD	978	129	556		28.507	150829	2634
SA	86	54	37		4.571	24184	2714
WA	96	68	21		62.608	331258	2550
TAS	45	17	21		-		2773
NT	1	7	-		50.121	265190	2592
AUSTRALIA	2034	742	1292	984	155	820139	
US	11762	12268	-506				4016
JAPAN	457	1207	-750				5110
KOREA	190	580	-390				4295
ROW	35753	35399	354				4016
WORLD	50196	50196	0				

Source: Unless otherwise noted, all data are from MLA Statistical Review July 2001 - June 2002
Notes: Consumption in each state is calculated as 35.5 kg/capita times state population for 2001/02 as given in ABS (2003), Australia at a Glance, Cat. No.1309.9; live weight of 350kg and an average dressing percentage of 54 per cent. In the model, these equivalents are added to production in each Australian State, to ROW consumption and to both world production and consumption; In the model WA is split into north and south. In the absence of firm data, production is set equal in both halves and demand is set to 50 in the south and to 18 in the north; Domestic prices are for steers 260-300 kg HSCW; NT price is an average of QLD and WA; US price is Australian boneless cow beef, 90%CL, FAS; Japan price is Australian chilled boneless grassfed fullset, FAS; Korea price is unit value of all Australian beef and veal exports to Korea, FOB

The values used in the Beef CRC analysis were able to be aggregated and simplified for use in the current analysis due to the concentration on impacts within Queensland. Table 24 provides the base price and quantity data applied in the current analysis. Note: the sub regions impacted by tick line deregulation have been separated from the remainder of Queensland to facilitate the analysis.

Table 24. Tick vaccine beef model parameters

Tick line Parameters	Consumption	Production	Price
	(ktcw)	(ktcw)	($AU/tonne)
South West - low impact	0.50	78.67	2 634
Central North - moderate impact	3.00	100.11	2 634
Southern Downs - median impact	3.00	30.99	2 634
North East - high impact	2.00	21.72	2 634
Rest of Queensland	120.50	746.50	2 634
Rest of Australia	613.00	1 056.00	3 130
Rest of World	49 454.00	48 162.00	4 016
Total	50 196.00	50 196.00	

The base elasticity values for the Beef CRC analysis have been used as the inputs for the current analysis (Table 25). The values applied in the current analysis are marked with an *.

Table 25. Base Supply and Demand Elasticity Values

Region	Supply Elasticity	Demand Elasticity
NSW*	1	-0.33
VIC*	1	-0.33
QLD*	0.75	-0.27
SA	1	-0.33
WA (north/south)	0.75/1.00	-0.27/-0.33
TAS	1	-0.33
NT	0.75	-0.27
US	1	-3
JAPAN	0.7	-2
KOREA	0.7	-2
ROW*	1	-5

The rate of spread of ticks across each region is an important variable in the analysis. All regions are expected to be infested by the end of the fifth year after deregulation. The impact of tick line deregulation will be considered over a 30 year period following deregulation. A discount rate of 5 per cent is applied.

Measuring the economic impact of tick line deregulation in the dairy industry

Economic benefits for the northern dairy industry are also calculated in DREAM by combining estimated farm level impact with measures of elasticity, supply, consumption and price.

Recent commodity statistics for the dairy industry[6] indicate that Queensland produced 485 mega litres (ML) of milk in 2008-09. The average Australian milk price for the same period was 49.6 cents per litre. This figure is very close to the average milk price revealed in QDAS survey data (Busby et al. 2008) for 2007-08 of 51.3 cents per litre. As the QDAS data represents a survey of 89 “better performing” dairy farms, the national estimate provided by ABARE will be used as the price for milk.

Consumption of fresh milk averaged 103 litres of milk and 28 kg of other milk products per person across Australia in 2006-07 (See ABARE downloaded data

[6] Downloaded from http://www.abareconomics.com/interactive/08acs_dec/excel/Dairy.xls

footnote). The Queensland population of 4.4 million therefore consumed the equivalent of the States dairy production.

A review of Queensland dairy legislation (Queensland Dairy Legislation Review Committee 1998) estimated the price elasticity of demand for milk in Queensland to be -0.15 with a supply elasticity of 0.9.

In the first scenario assessed, all dairy cows within the deregulated region will be impacted by the end of the fifth year after deregulation.

Results for analysis of tick line deregulation scenarios

A range of scenarios have been considered to assess the potential impact of deregulation of the tick line on the beef industry.

The first considered is that no beef producer with susceptible livestock converts to tick resistant stock.

The second and third are that 50 per cent or 85 per cent of beef producers convert to resistant livestock over an eight year conversion period. It is expected that no more than 85 per cent will convert given that only about this percentage of producers have converted to tick resistant stock within the tick endemic regions of Queensland.

Another scenario looks at providing a period of time prior to deregulation to allow time for beef producers to convert to tick resistant livestock, thereby removing the majority of the costs associated with the application of acaricides during the conversion period.

Further scenarios that consider the impact of a shortened period of time taken to convert to resistant cattle as well as the use of a tick vaccine that provides effective resistance to ticks for *Bos taurus* based breeds of cattle were also considered.

The dairy industry is initially included in the results with only one response scenario. That is, apply acaricides into the foreseeable future. Other variations such as a slower rate of spread for ticks and the implementation of biosecurity measures to reduce tick impacts on farm are both considered later in the analysis.

Scenario 1. Deregulation with ongoing use of acaricides only

The inputs to the modelling framework were implemented in the DREAM program for the two separate livestock industries. Results of the analysis of Scenario 1 are presented in Tables 26 and 27.

In this scenario, beef and dairy producers impacted by tick line deregulation only use acaricides to control ticks into the long term future and ticks spread rapidly over the five years after deregulation. Results are shown as the Present Value of the discounted stream of costs incurred over the thirty years after the tick line is deregulated. A discount rate of 5 per cent has been applied.

Table 26 Results for the beef industry scenario 1 (Present value from 2008/09 to 2028/29)

Region	Producer	Consumer	Total
	‘000 $	‘000 $	‘ 000 $
Central north	-168 538	-3.6	-168 542
North east	-48 482	-2.4	-48 484
South west	-44 595	-0.6	-44 596
Southern downs	-49 605	-3.6	-49 609

Rest of Queensland	906	-146.3	760
Rest of Australia	1 282	-744.2	538
Rest of World	58 473	-60 038	-1 565
Total	-250 559	-60 939	-311 498

Table 27. Results for the dairy industry scenario 1 (Present value from 2008/09 to 2028/29)

Region	Producer	Consumer	Total
	'000 $	'000 $	'000 $
Queensland tick endemic	17 357	-17 275	82
Queensland tick free	-21 152	-7 404	-28 556
Total	-3 795	-24 679	-28 474

If the tick line were deregulated and producers with susceptible cattle used only acaricides to control ticks, the Present Value of Costs incurred would be about $340m by industry ($311.5m beef industry and $28.5m dairy industry) located within the newly infested regions. The Present Value of ongoing costs incurred by the State is assessed as $32m. The Present Value of all costs incurred "with" deregulation is assessed as $372m, about 2.6 times the benefits of $140m gained by deregulation. The Benefit Cost Ratio is assessed as .4 to 1.

Beef consumers within Australia would gain no real benefits while consumers of milk in Queensland incur significant reductions in benefits. Dairy producers currently located within the tick infested region may gain some benefits.

Scenario 2. 50 per cent of beef producers convert to resistant genetics over eight years

This scenario considers the impact of deregulating the tick line and having 50 per cent of beef producers with susceptible cattle convert to resistant stock over eight years. The remainder continue to use acaricides indefinitely to control ticks. No dairy farmers are expected to change from applying acaricides and the impact of deregulation remains the same as the previous scenario. Total costs and benefits foregone are again calculated over an investment period of thirty years with a 5 per cent discount rate. The results for the beef industry are shown in Table 28.

Table 28. Results for the beef industry Scenario 2 (Present value from 2008-09 to 2028-29)

Region	Producer	Consumer	Total
	$'000	$'000	$'000
South west – acaricides	-22 316	-0.2	-22 316
South west – resistant	-10 219	-0.2	-10 219
Central north - acaricides	-85 037	-1.2	-85 038
Central north - resistant	-28 495	-1.2	-28 497
Southern downs – acaricides	-24 816	-1.2	-24 818
Southern downs - resistant	-9 239	-1.2	-9 240
North east - acaricides	-24 245	-0.8	-24 246
North east - resistant	-758	-0.8	-759
Rest of Queensland	616	-99.3	516
Rest of Australia	871	-505.6	365
Rest of World	39 727	-40 792	-1 065
Total	-163 912	-41 404	-205 315

Production and consumption are apportioned within the DREAM model according to the expected change in breed composition within regions impacted by the deregulation.

The results of the DREAM model suggest that the producers who maintain the use of acaricides to prevent tick damage will be significantly worse off than those who do not. This scenario suggests that deregulating the tick line will not be economically positive if only 50 per cent of producers of beef cattle convert to tick resistant livestock and ticks spread rapidly. Total costs incurred by the beef industry ($205m), dairy industry ($28.5m) and ongoing costs ($32m) total significantly more than the costs saved by deregulating ($140m). The Benefit Cost Ratio is assessed as .53 to 1.

Scenario 3. 85 per cent of beef producers convert to resistant genetics over eight years

This scenario considers the impact of deregulating the tick line and having 85 per cent of beef producers with susceptible cattle convert to resistant stock over eight years. The results are shown in Table 28.

Production and consumption are apportioned according to breed composition within regions impacted by the deregulation. Results for the dairy industry are again not changed in this scenario.

Table 29. Results for the beef industry Scenario 3 (Present value from 2008-09 to 2028-29)

Region	Producer	Consumer	Total
	'000 $	'000 $	'000 $
South west – acaricides	-6 697	0	-6 697
South west – resistant	-17 389	0	-17 389
Central north - acaricides	-25 296	0	-25 297
Central north - resistant	-48 037	-1	-48 038
Southern downs – acaricides	-7 446	0	-7 446
Southern downs - resistant	-15 708	-1	-15 709
North east - acaricides	-7 279	0	-7 279
North east - resistant	-1 295	-1	-1 295
Rest of Queensland	408	-66	342
Rest of Australia	577	-335	242
Rest of World	26 294	-26 998	-705
Total	-101 868	-27 404	-129 272

This scenario suggests that more than 85 per cent of current beef producers in the zones impacted by deregulating the tick line would need to convert to tick resistant livestock before the costs saved (benefits gained) would be greater than the costs incurred. The additional costs incurred by the beef industry ($129m), dairy industry ($28.5m) and the ongoing costs ($32m) are still likely to be greater than the costs saved by deregulation ($140m). The Benefit Cost Ratio is assessed as .74 to 1.

Scenario 4. 85 per cent convert to resistant genetics with a phase in period

This scenario provides a five year gap between the announcement of the deregulation of the tick line and the implementation of the change. If beef producers use this period to incorporate tick resistance into 85 per cent of the susceptible cattle, then most of the expense of acaricides can be saved. Dairy farmers also gain a five year delay in the onset of the beginning of tick infestation. After the phase in period, ticks are still spread rapidly across the impacted regions even though most of the beef cattle will be tick resistant by the time they appear at the property level. The results for the beef industry are shown in Table 30. The present value of costs for the dairy industry is reduced by more than $10m.

Table 30. Results for the beef industry Scenario 4 (Present value from 2008-09 to 2028-29)

Region	Producer	Consumer	Total
	'000 $	'000 $	'000 $
South west – acaricides	-4 754	0	-4 754
South west – resistant	-8 604	-0.1	-8 604
Central north - acaricides	-17 955	-0.1	-17 955
Central north - resistant	-16 681	-0.7	-16 682

Southern downs – acaricides	-5 285	-0.1	-5 285
Southern downs - resistant	-6 308	-0.7	-6 309
North east - acaricides	-5 166	-0.1	-5 166
North east - resistant	-404	-0.5	-404
Rest of Queensland	199	-32	167
Rest of Australia	281	-163	118
Rest of World	12 833	-13 177	-344
Total	-51 843	-13 375	-65 218

This scenario suggests that if 85 per cent of current beef producers in the zones impacted by deregulating the tick line began to convert to tick resistant livestock over the phase in period, the total costs saved (benefits gained) through deregulation would be greater than the costs incurred. The additional costs incurred by the beef industry ($65m), dairy industry ($18m) and the ongoing costs ($32m) are less than the costs saved by deregulation ($140m). The Benefit Cost Ratio is assessed as 1.2 to 1.

Scenario 5. 85 per cent of beef producers convert to resistant genes through purchasing tick resistant replacement stock

This scenario does not provide a five year phase in period but shows beef producers with susceptible livestock purchasing tick resistant replacement breeding stock. This allows the conversion to tick resistant stock to occur more rapidly and also reduces the reliance on acaricides during the conversion period. Ticks are still spread rapidly across the impacted regions. Summarised results are shown in Table 31.

Table 31. Results for the beef industry Scenario 5 (Present value from 2008-09 to 2028-29)

Region	Producer	Consumer	Total
	$‘000	$‘000	$‘000
Total			

This scenario suggests that if 85 per cent of current beef producers in the zones impacted by deregulating the tick line rapidly convert to tick resistant livestock the costs saved (benefits gained) would be slightly less than the costs incurred. The additional costs incurred by the beef industry ($95m), dairy industry ($28.5m) and the ongoing costs ($32m) are greater than the costs saved by deregulation ($140m). The Benefit Cost Ratio is assessed as 0.9 to 1.

A strategy that encouraged the rapid conversion to resistant stock by beef producers with susceptible livestock during a phase in period for the deregulation of the tick line would make it economically positive for the State to deregulate the tick line.

Scenario 6. 85% of beef producers convert to resistant stock and use property level biosecurity to slow tick spread

This scenario considers the impact of deregulating the tick line and having 85 per cent of beef producers with susceptible cattle convert to resistant stock over eight years. The impacted dairy and beef cattle producers also implement property level biosecurity measures to limit the spread of ticks onto their own and neighbouring properties. In this scenario, the rate of spread of ticks across all impacted properties is reduced from five years before all are infested to ten years.

The analysis of this scenario suggests that if a phase in period is combined with property level measures to delay the spread of ticks, the total costs saved (benefits gained) through deregulation would be greater than the costs incurred. The additional costs incurred by the beef industry ($28m), dairy industry ($14m) and the ongoing costs ($32m) are less than the costs saved by deregulation ($140m). The Benefit Cost Ratio is assessed as 1.9 to 1.

Scenario 7. Beef and dairy producers use a tick vaccine

Research currently underway to develop an effective tick vaccine has been reviewed as a component of the evaluation of investments made to manage and control ticks by QPIF. The potential outcome of the research activity is a vaccine that can be applied to *Bos taurus* livestock and provide them with the level of tick resistance exhibited by resistant *Bos indicus* cross livestock.

There are two main scenarios for the incorporation of an effective tick vaccine into the analysis of tick line deregulation. The vaccine could be used over the longer term by producers to maintain the proportion of *Bos taurus* livestock at the same level as it is now or it could be used during the process of converting to resistant cattle as a substitute for acaricides.

The economic impact of an effective vaccine that requires one dose plus an annual booster at a cost of $5 per animal and is used over the longer term to maintain *Bos taurus* genetics at their current level is shown in Tables 32 and 33.

Table 32. Results for the beef industry Scenario 4 (Present value from 2008-09 to 2028-29)

Region	Producer	Consumer	Total
	'000 $	'000 $	'000 $
Central north	-34 735	-1	-34 736
North east	-7 536	-1	-7 537
South west	-27 296	0	-27 296
Southern downs	-15 304	-1	-15 305
Rest of Queensland	244	-39	205
Rest of Australia	345	-200	145
Rest of World	15 746	-16 169	-422
Total	-68 535	-16 411	-84 947

Table 33. Results for the dairy industry scenario 4 (Present value from 2008-09 to 2028-29)

Region	Producer	Consumer	Total
	'000 $	'000 $	'000 $
Queensland tick endemic	1 706	-1 705	1
Queensland tick free	-2 109	-731	-2 840
Total	-403	-2 436	-2 839

Both the beef and dairy industries incur the cost of the tick vaccine and the tick fever vaccine as a result of deregulation in this scenario.

If an effective tick vaccine became available it is likely that deregulating the tick line could save more costs than benefits foregone, even if beef producers maintained their *Bos taurus* genetics. The Present Value of total Costs incurred of $120m would made up of $85m for the beef industry, $3m for the dairy industry and $32m for ongoing costs. This is less than the costs saved (benefits gained) by deregulating. This scenario also provides a prospect of a positive Benefit Cost Ratio (1.2 to 1). A scenario that incorporated a conversion to resistant stock and used the vaccine during the conversion period would provide a larger positive benefit than that shown above.

Sensitivity of the major parameters to variation

The initial scenarios selected for analysis generally contain parameter values set at the high end of expectations. For example, the cost of treating beef cattle for ticks in the north-east sub region was initially set at $25 per head per annum. As the chemical cost of eradicating ticks on properties in the same region is calculated to be about $30 per head, the annual cost of treatment to reduce the impact of ticks to a negligible level may prove to be overstated. Also the rate of spread of ticks has initially been set so that all susceptible livestock in each region are likely to need treatment by the end of the fifth year after deregulation. Some persons interviewed during the evaluation process indicated that implementation of adequate property level biosecurity protocols in regions that are not highly susceptible to tick infestation may see some properties never or very rarely need to treat for ticks.

As the current costs of maintaining the tick line are also considered to be at the low end of expectations, particularly the estimate of industry costs associated with clearance at the tick line, it is likely that the net benefits identified for deregulation of the tick line in Queensland are also understated.

Partial movement of the tick line scenario

This section of the analysis will briefly consider the potential of saving costs by moving part of the tick line in south east Queensland. The readjustment of the tick line is expected to:

- reduce the number of tick outbreaks in south east Queensland,
- reduce the number of Biosecurity Queensland inspectors necessary to manage the tick line, and
- reduce the total number of clearing dips

This scenario does not involve deregulation of the tick line or movement of the tick line outside the south east corner of Queensland. Figure 13 indicates the "very" approximate location of an adjusted tick line that would significantly reduce the total number of tick outbreaks and remove the need for a number of out of date clearing dips.

The final location of an "adjusted" tick line would be subject to considerable discussion but for the purposes of this exercise it is placed to the west of the major problem areas for tick outbreaks in the free and control zones. Clearing dips would be located at or near Auburn, Durong South, to the west of Toowoomba and Warwick. A large number of the current clearing dips to the north of Toowoomba could be closed.

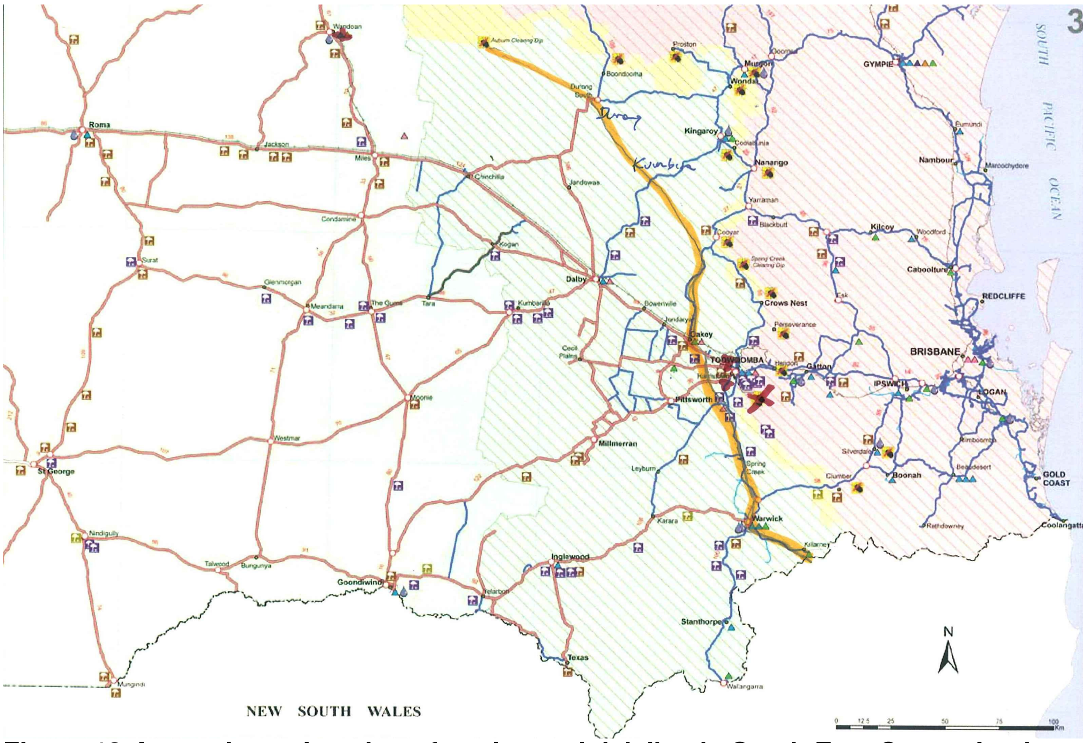

Figure 13. Approximate location of a relocated tick line in South East Queensland

Costs saved (benefits gained) in partially moving the tick line

In this scenario, the costs saved in moving the tick line would be largely in tick eradication expenses and QPIF costs of managing clearing dips in the south east corner of Queensland. Most of the eradication expenses are expected to be saved and total FTE's employed in managing and controlling ticks along the tick line are shown as falling by 50 per cent over the five years after the tick line is moved.

Costs incurred in partially moving the tick line

Table 34 indicates the number and location of livestock impacted by a partial tick line movement.

Table 34. Cattle susceptible to tick infestation under a shift in the tick line scenario.

Sub-region	Mixed stock	Susceptible stock in the region	Susceptible stock
	Number	%	Number
South West - low impact	0	40	0
Central North - moderate impact	40 943	40	16 572
Southern Downs - median impact	33 685	57	19 317
North East - high impact	191 838	40	77 646
Dairy cattle	33 058	100	33 058
Total	299 524		146 593

Beef and dairy industries will incur similar cost increases as previously described.

The economic impact of partially moving the tick line

The partial movement of the current tick line in south east Queensland is unlikely to provide benefits (costs saved) greater than costs incurred without the majority of beef cattle producers converting rapidly to livestock with sufficient *Bos indicus* genetic content to prevent tick damage (Table 35).

Table 35. Results of partially shifting the tick line in south east Queensland

Scenario 1. No tick susceptible stock convert to Cross bred cattle	0.54	to 1
Scenario 2. 50% tick susceptible stock convert to Cross bred cattle	0.72	to 1
Scenario 3. 75% tick susceptible stock convert to Cross bred cattle	0.88	to 1

Moving part of the tick line to reduce the costs to Government of tick outbreaks and the management of low throughput clearing dips would cause sections of industry currently protected by the tick line to incur significant costs. The proportional relationship between costs and benefits for moving part of the tick line is similar to that found for the complete deregulation of the tick line. On this basis the complete deregulation of the tick line, properly managed, would provide the greater long term benefits in absolute terms.

Other issues

The economic analysis included in this evaluation considers a range of options for the deregulation of the tick line but cannot completely consider all of the potential scenarios. On this basis, this evaluation is seen as a starting point that allows detailed strategies for the deregulation of the tick line to be identified and evaluated.

Other issues that may be included in a full impact assessment of detailed deregulation strategies will be briefly discussed in this section.

Threats to the efficacy of the tick line

The tick line is a regulated line on a map that, in South East Queensland and northern NSW, does not align well with the expected natural boundaries of the spread of the cattle tick. Two major threats to the efficacy of the tick line were identified by interviewed staff during the evaluation process. Namely acaracide breakdown and climate change.

Acaracide breakdown

Most acaricides introduced for tick control in Queensland have short effective lives. (Table 36)

Table 36. History of acaricides in Queensland

Chemical Group	Chemical	Trade name	Introduced	Resistance	Years of efficacy
	Arsenic trioxide	Maxidip, Agrico	1895	1937	42
Chlorinated Hydrocarbons	DDT	Rucide, Deetik	1946	1954	8 (Banned)
	BHC	Gammatik	1950	1953	3 (Banned)
	Toxaphene	Flit 222, Coopertox	1954		Banned
	Dieldrin	Dieltix, Dielspray	1957		Banned
Organophosphates	Bromophos ethyl + Chlorfenvinphos	Nexagan 'S'	1957	1970	13
	Carbophenothion	Dagadip	1958	1963	5 (Withdrawn 1968)
	Chlorpyrifos	Dursban	1967	1970	3
	Coumaphos	Asuntol	1959	1966	7
	Crotoxyphos	Parazon, Ciodrin	1967		n/a
	Diazinon	Neocidol	1956	1963	7 (Withdrawn 1967)
	Dioxathion	Bercotox, Ruphos	1958	1963	5 (Withdrawn 1982)
	Ethion	Coopathon	1962	1966	4
	Phosmet	Prolate, Bophox	1967		Withdrawn 1985
Carbamates	Carbaryl	Sevin	1959	1963	4 (Withdrawn 1968)
	Promacyl	Promicide	1974		Withdrawn 1990
Amidines	Amitraz	Taktic	1975	1980	5
	Clenpyrin	Bimarit	1972		Withdrawn 1983
	Chloromethiuron	Dipophene 60	1973	1980	7 (Withdrawn 1987)
	Chlordimeform	Spike, Fundex	1971		Withdrawn 1976
	Cymiazole	Tifatol	1979	1980	1 (Withdrawn 1986)
Synthetic Pyrethroids	Cyhalothrin	Grenade	1982	1984	2 (Withdrawn 1997)
	Cypermethrin	Barricade 'S'	1981	1984	3
	Cypermethrin + Chlorfenvinphos	Blockade 'S'			

	Deltamethrin + Ethion	Tixafly	1981	1984	3
	Flumethrin	Bayticol	1985	1986	2
Macrocyclic Lactones	Avermectin BI	Avomec	1985		
	Doramectin	Dectomax	1996		
	Eprinomectin	Eprinex	1998		
	Ivermectin	Ivomec	1988		
	Moxidectin	Cydectin	1994		
Benzoylphenylureas	Fluazuron	Acatak	1994	2007	13

Source: Kevin Duff and Louise Jackson QPIF, Nick Jonsson University of Queensland – based on records of the DPI Standards Branch

It is noticeable (Table 36) that no new acaricides have been registered in Queensland for the control of cattle ticks for more than a decade.

Holdsworth et al. (2005) identified "for many years, companies have been extensively screening for new chemicals that will control ticks" and they found it "surprising … relatively few targets … have been identified ... for chemicals that will control ticks". It seems that new chemical formulations to control ticks are very difficult to find. On the basis of these records and comments, it seems reasonable to assume that there will be few new products available for the control of cattle ticks in Queensland and that resistance will develop to any new product within a decade of its release.

Although Macrocyclic Lactones (ML's) show no record of resistance in Table 36, a recent survey undertaken by MLA (Waltisbuhl 2005) indicated that 19 per cent of producers surveyed believed that there is resistance to the product. In the same survey, 44 per cent of producers indicated resistance to synthetic pyrethroids (SP's), 33 per cent to amitraz and 2 per cent to fluazuron.

Resistance to amitraz is critical as it is the principal active ingredient of acaricides used as a "knock-down" at tick clearance sites plus "no alternative knock down product is available on the market or believed to be in development" (Waltisbuhl 2005). Currently amitraz remains the most common treatment for ticks in Queensland. Approximately 57 per cent of treatments applied in Queensland are amitraz while ML's make up 19 per cent, SP's 14 per cent and fluazuron 10 per cent (Waltisbuhl 2005).

Amitraz resistance is thought to be widespread with the highest incidence in South East Queensland (Waltisbuhl 2005). In the same survey it was reported that among dairy producers the proportion of properties showing resistance to amitraz was 40 per cent. This was seen as a substantial increase from the 10 per cent incidence reported in 1997 by Jonsson et al. (2001). Given that treatments at the tick line constitute approximately 30 per cent of total acaricide treatments to control ticks in Queensland, it would appear that the requirement to use amitraz in clearance dips contributes significantly to the total use of the chemical in Queensland.

Alliance Resource Economics (2009), when undertaking a review of tick inspection and Third Party Providers for Biosecurity Queensland, reported *"the current status of resistance to the widely used products for tick control means there is an increasing chance that dipping or spraying at clearing facilities will fail to eliminate infestations. There is about a 50% chance that flumethrin spraying of horses will be ineffective. With respect to cattle movements, the likelihood of failure of the dipping in Amitraz varies with the place of origin of the cattle, being very low in the north and west of the State but up to 50% in dairy cattle from SEQ"*.

The potential failure of amitraz in clearing dips is a major threat to the efficacy of the tick line, particularly in south east Queensland. The remaining useful life of the product is uncertain but there appear to be strategies available that may extend the life of the product if it does begin to show high rates of failure as a clearing dip. (L. Jackson 2009, pers. comm.) All of these strategies involve significantly higher cost being incurred by industry to maintain the tick line and potentially more regulations being implemented by the State. For example, the requirement to use a high cost compound or an extended quarantine period as a treatment prior to crossing the tick line instead of a treatment by amitraz could easily double the budgeted cost to industry of crossing the tick line. The additional regulations required to maintain the efficacy of the tick line in the event of the failure of amitraz to provide effective clearance at the line are unlikely to reduce the cost to government of maintaining the tick line.

The reliance by QPIF on amitraz as a clearing dip, the high rate of its use by industry and the increasing rate of resistance by ticks to the compound indicate that the costs of maintaining the tick line are likely to increase sooner rather than later. The potential imposition of these additional costs provides no measureable benefit to the payee. More data is required on the potential timing of some of these events and the cost of alternative clearance strategies before they could be effectively included in an economic analysis.

Climate change

As previously discussed, the potential impact of climate change on the spread of the cattle tick within Australia has been identified in an analysis by White et al 2003. Their analysis identified that if current quarantine boundaries are not maintained and climate change proceeds as predicted, the cattle tick will be endemic to all (mainland) Australian coastal and near coastal regions receiving more than about 500mm of rainfall annually by the end of this century. Figure 3 on page 12 of this report indicates the potential rate of spread and impact on beef production over the intervening years.

When the spread analysis provided by White et al. (2003) is compared to the expected spread of ticks in Queensland if the tick line is deregulated, it appears that the regions currently identified as most likely to be impacted by deregulation are the ones in Queensland most likely to be impacted by a change in climate that facilitates the spread of ticks.

Most inland regions of Queensland are expected to become hotter, potentially drier with more irregular rainfall patterns under many climate change scenarios. These conditions are unlikely to facilitate the spread of the tick further inland than it currently is although the south east corner of the state outside of the tick line but inside the 500mm isohyet is likely to become more suitable for ticks. Eradication of tick outbreaks in the current control and free areas of South East Queensland is likely to become significantly more difficult to achieve.

Regions in coastal northern New South Wales are likely to become much more difficult to maintain tick free under most climate change scenarios.

Other aspects of deregulation

Impact on market access

A small number of persons interviewed during the evaluation process identified that there may be changes to market access for producers located within the current tick free zone of the State.

Discussion of international market requirements for export live cattle indicates that a small market for purebred Angus steers to Japan may be impacted by the deregulation of the tick line. The total market is said to be for about 1800 head per month and the proportion of this derived from the tick free region of Queensland is unknown.

No identifiable impact on chilled or frozen exports of beef could be identified and, as many producers in the tick free zone transport their stock to abattoirs in the infected zone for sale, this area of activity is also unlikely to be impacted. Transfer of stock from the region of Queensland that is currently tick free to other jurisdictions that limit the movement of tick infested stock is likely to incur additional costs. The level of these costs is uncertain but the estimate of residual cost of tick clearance after deregulation included in the analysis is expected to more than cover these costs.

Impact on land values

The prevalence of a disease or pest in a region that reduces farm output is expected to reduce the underlying value of a property compared to one located in a nearby, similar region that does not have the pest. This proposition was put to a Department of Environment and Mines employee who undertakes real property valuation. He replied: "*The only real experience I have with the tick line is in the Wandoan/Taroom district and in the twenty odd years I've been valuing properties in that area, I have never encountered any difference in property prices on the clean side of the line compared to ticky country"*. (M. Farrington 2009, pers. comm..)

The point was made in a previous section of the evaluation report that *Bos indicus* genetics are widespread across the various regions of Queensland due to the range of constraints inherent in local beef production systems. If the only change across the tick line in any Queensland region was the presence or absence of ticks, it appears that this creates insufficient difference in the potential output of localised beef production systems to alter the value of the underlying land asset.

Response by other jurisdictions

A review of the activities of the Northern Territory, Western Australian and New South Wales authorities suggests that the most likely jurisdiction to react adversely to the deregulation of the Queensland tick line would be New South Wales. It appears certain that all cattle leaving Queensland for the foreseeable future would need to pass a clean inspection at the border prior to them being allowed to into New South Wales.

ABS (2006) indicates that about 158 000 cattle travelled from Queensland to New South Wales in the previous financial year. How many of these came from the tick free or the tick infested regions of Queensland is unknown. NLIS data (Michael Lancaster personal communication) suggests that about 103 000 transferred to New South Wales during the 2006 calendar year and about 89 000 are likely to transfer during this calendar year (2009). Data for the intervening years is currently unavailable.

The estimated cost of clearing these cattle has been included in the estimate of ongoing costs of clearance likely to be incurred after deregulation.

The impact on cattle travelling from New South Wales to Queensland is uncertain. According to NLIS data, over the past five years 292 661 (2006), 281 041(2007), 341 650 (2008) and 373 653 (2009 est.) head have been transferred to Queensland. (M. Lancaster 2009, pers.l comm.) If the destination of these animals is either abattoirs or feedlots then no impact is expected. If some of the livestock are *Bos taurus* breed steers heading for fattening properties in the region to be tick infested by deregulation, then the impact is likely to be minor at best.

The average number of livestock processed in Queensland abattoirs over the past four calendar years is about 3.7m head (QPIF Prospects data). On this basis the proportion of livestock movements impacted by a change to tick line regulation is likely to be quite small.

Changes in acaracide use

The level of acaricide use after a deregulation of the tick line depends on the response by industry and the strategy chosen to deregulate.

It is possible to predict that the total acaricide use across Queensland may fall, even though, in the short term, up to an additional 1m head of susceptible cattle could be theoretically exposed to the cattle tick.

Over the medium term, it is expected that acaracide use in the region impacted by any deregulation will mirror that in the tick infested regions of Queensland. On this basis, a deregulation of the tick line would lead to a long term reduction of between 18 per cent and 20 per cent in the total applications of acaricides to control the cattle tick.

Voluntary Eradication Schemes

A process by which the integrity of Voluntary Eradication Schemes can be maintained and a deregulation of the tick line progressed needs to be found. This aspect of the current management of the cattle tick in Queensland does provide localised industry benefit and is likely to continue to do so under a deregulation scenario. What form the agreements should take and how they should be implemented and managed has not been part of the considerations of this evaluation.

Impact on jobs and industry productivity

A switch from *Bos taurus* to crossbred livestock as a result of a deregulation of the tick line may increase the total beef output of the affected region. The level of increase is unlikely to significantly impact on employment in Queensland but productivity is expected to slightly rise on the properties making the change.

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Appendix 1. Farm models

North East Region farm model – acaracide use

	Without ticks	With ticks	Difference	
Land	$5 400 000	$5 400 000	$0	
Plant and Equipment	$234 250	$234 250	$0	
Livestock (Breeder cattle)	$354 004	$354 004	$0	
Total Value Assets	$5 988 254	$5 988 254	$0	
Grazing Pressure (Adult Equivalents)	606	606	0	
Total Farm Income	$135 886	$135 886	0	
Total Variable Expenses	$29 889	$44 124	$14 235	
GROSS MARGIN	**$105 997**	**$91 762**	**($14 235)**	
Fixed Expenses	$38 483	$38 483	$0	
Net farm Income	**$67 514**	**$53 279**	**($14,235)**	
G.M per breeder	$432.64	$374.54	($58.10)	
G.M. per A.E.	$174.91	$151.42	($23.49)	-13.43%
Cost per Kg beef	$0.99	$1.15	$0.16	16.11%
Kilograms of Beef Sold	89570	89570	0	0.00%

North East Region farm model – tick vaccine

	Without ticks	With ticks	Difference	
Land	$5 400 000	$5 400 000	$0	
Plant and Equipment	$234 250	$234 250	$0	
Livestock (Breeder cattle)	$354 004	$354 004	$0	
Total Value Assets	$5 988 254	$5 988 254	$0	
Grazing Pressure	606	606	0	
Total Farm Income	$135 886	$135 886	0	
Total Variable Expenses	$29 889	$32 049	$2 160	
GROSS MARGIN	**$105 997**	**$103 837**	**($2 160)**	
Fixed Expenses	$38 483	$38 483	$0	
Net farm Income	**$67 514**	**$65 354**	**($2 160)**	
G.M per breeder	$432.64	$423.83	($8.82)	
G.M. per A.E.	$174.91	$171.35	($3.56)	-2.04%
Cost per Kg Beef (dressed weight)	$0.99	$1.01	$0.02	2.44%
Kilograms of Beef Sold	89570	89570	0	0.00%

Dairy farm model – acaracide use

Farm Operating Budget

Herd size 216 cows

Without ticks					With ticks				
Asset value					**Asset value**				
Farm area		140.48115	ha		Farm area		140.48115	ha	
Land value		20000	$/ha		Land value		20000	$/ha	
Value of land and fixed improvements		$2 809 623			**Value of land and fixed improvements**		$2 809 623		
Farm Income		QDAS data	Total	$/cow	**Farm Income**		QDAS data	Total	$/cow
	Milk receipts (c/L)	51.3	$639 979	$2 963		Milk receipts	51.3	$639 979	$2 963
	Non-milk receipts (c/litre)	22.8	$284 435	$1 317		Non-milk receipts (c/litre)	22.8	$284 435	$1 317
	Total		$924 415	$4 280		**Total**		$924 415	$4 280
Expenditure					**Expenditure**				
Variable operating (c/L)					Variable operating (c/L)				
	Purchased feed	19	$237 029	$1 097		Purchased feed	19	$237 029	$1 097
	Fertiliser	2.9	$36 178	$167		Fertiliser	2.9	$36 178	$167
	Fuel & Oil	1.7	$21 208	$98		Fuel & Oil	1.7	$21 208	$98
	Seed	0.9	$11 228	$52		Seed	0.9	$11 228	$52
	Irrigation	0.5	$6 238	$29		Irrigation	0.5	$6 238	$29
	Repairs & Maintenance	1.8	$22 455	$104		Repairs & Maintenance	1.8	$22 455	$104
	Other feed costs	3.4	$42 416	$196		Other feed costs	3.4	$42 416	$196
	Animal health	1.15	$14 321	$66		Animal health	2.88	$35 921	$166
	Herd improvement	0.6	$7 485	$35		Herd improvement	0.6	$7 485	$35
	Dairy shed electricity	0.6	$7 485	$35		Dairy shed electricity	0.6	$7 485	$35
	Dairy shed chemicals	0.5	$6 238	$29		Dairy shed chemicals	0.5	$6 238	$29
	Cartage	0.1	$1 248	$6		Cartage	0.1	$1 248	$6
	Levies	0.3	$3 743	$17		Levies	0.3	$3 743	$17
	Sundry variable costs	0.2	$2 495	$12		Sundry variable costs	0.2	$2 495	$12
Fixed operating (c/litre)					Fixed operating (c/litre)				
	Administration	2.80	$34 931	$162		Administration	2.80	$34 931	$162
	Permanent labour	4.00	$49 901	$231		Permanent labour	4.00	$49 901	$231
	Plant replacement allowance	2.00	$24 950	$116		Plant replacement allowance	2.00	$24 950	$116
	Imputed labour	3.70	$46 158	$214		Imputed labour	3.70	$46 158	$214
Total operating			$575 706	$2 665	**Total operating**			$597 306	$2 765
	Gross margin		$504 649	$2 336	Gross margin			$483 049	$2 236
	Operating return		$348 708	$1 614	Operating return			$327 108	$1 514
	Return on assets		12.41	%	Return on assets			11.64	%
	Cost per litre of milk produced		$0.4615					$0.4788	$0.0173

Dairy farm model – tick vaccine

Farm Operating Budget

Herd size 216 cows

	Without ticks				With ticks			
Asset value					**Asset value**			
Farm area		140.48115	ha		Farm area	140.48115	ha	
Land value		20 000	$/ha		Land value	20000	$/ha	
Value of land and fixed improvements		$2 809 623			**Value of land and fixed improvements**	$2 809 623		
Farm Income		QDAS data	Total	$/cow	**Farm Income**	QDAS data	Total	$/cow
	Milk receipts (c/L)	51.3	$639 979	$2 963	Milk receipts	51.3	$639 979	$2 963
	Non-milk receipts (c/litre)	22.8	$284 435	$1 317	Non-milk receipts (c/litre)	22.8	$284 435	$1 317
	Total		$924 415	$4 280	**Total**		$924 415	$4 280
Expenditure					**Expenditure**			
Variable operating (c/L)					Variable operating (c/L)			
	Purchased feed	19	$237 029	$1 097	Purchased feed	19	$237 029	$1 097
	Fertiliser	2.9	$36 178	$167	Fertiliser	2.9	$36 178	$167
	Fuel & Oil	1.7	$21 208	$98	Fuel & Oil	1.7	$21 208	$98
	Seed	0.9	$11 228	$52	Seed	0.9	$11 228	$52
	Irrigation	0.5	$6 238	$29	Irrigation	0.5	$6 238	$29
	Repairs & Maintenance	1.8	$22 455	$104	Repairs & Maintenance	1.8	$22 455	$104
	Other feed costs	3.4	$42 416	$196	Other feed costs	3.4	$42 416	$196
	Animal health	1.15	$14 321	$66	Animal health	1.32	$16 481	$76
	Herd improvement	0.6	$7 485	$35	Herd improvement	0.6	$7 485	$35
	Dairy shed electricity	0.6	$7 485	$35	Dairy shed electricity	0.6	$7 485	$35
	Dairy shed chemicals	0.5	$6 238	$29	Dairy shed chemicals	0.5	$6 238	$29
	Cartage	0.1	$1 248	$6	Cartage	0.1	$1 248	$6
	Levies	0.3	$3 743	$17	Levies	0.3	$3 743	$17
	Sundry variable costs	0.2	$2 495	$12	Sundry variable costs	0.2	$2 495	$12
Fixed operating (c/litre)					Fixed operating (c/litre)			
	Administration	2.80	$34 931	$162	Administration	2.80	$34 931	$162
	Permanent labour	4.00	$49 901	$231	Permanent labour	4.00	$49 901	$231
	Plant replacement allowance	2.00	$24 950	$116	Plant replacement allowance	2.00	$24 950	$116
	Imputed labour	3.70	$46 158	$214	Imputed labour	3.70	$46 158	$214
Total operating			$575 706	$2 665	**Total operating**		$577 866	$2 675
	Gross margin		$504 649	$2 336	Gross margin		$502 489	$2 326
	Operating return		$348 708	$1 614	Operating return		$346 548	$1 604
	Return on assets		12.41	%	Return on assets		12.33	%
	Cost per litre of milk produced		$0.4615				$0.4632	$0.0017

Converting from Bos Taurus to Bos indicus crossbreds

Mating	Breeders			Bulls		Calves			Heifer replacements		
	Bos Taurus	*½ Bos Taurus ½ Bos Indicus*	*Bos Indicus cross*	*Bos indicus*	*Bos Indicus cross*	*Bos taurus*	*½ Bos Taurus ½ Bos Indicus*	*Bos Indicus cross*	*Bos taurus*	*½ Bos Taurus ½ Bos Indicus*	*Bos Indicus cross*
	%	%	%	%	%	%	%	%	%	%	%
Year 1	100			100		100			100		
Year 2	100			100			100		100		
Year 3	100			100			100		100		
Year 4	80	20		80	20		100			100	
Year 5	60	40		60	40		74	26		100	
Year 6	42	58		42	58		55	45		100	
Year 7	26	69	5	26	74		38	62		75	25
Year 8	12	74	14	12	88		24	76		55	45
Year 9		75	25		100		10	90		40	60

By the ninth year of mating, all *Bos taurus* cows and purebred *Bos indicus* bulls are phased out and the breeding herd will carry approximately 50 per cent *Bos indicus* blood.

Appendix 2. Sample Dream model output

Scenario 1. Beef Producers use acaricides

Study: Tick line deregulation beef
Scenario: Chemical tick control
Commodity: Meat Regions: 7 Horizontal Multimarket - Spillover: No
Period: 30 years Base year: 2009
Discount: 5.0% Benefit:1000AUD$ Quantity: 1000 T

SUMMARY OF INITIAL MARKET CONDITIONS

Region	Production	Consumptn	Price	Elasticity Sup.	Elasticity Dem.	Transmission Wedge	Transmission Elast	Exog. Growth Sup.	Exog. Growth Dem.	Tax/Sudsidy Sup.	Tax/Sudsidy Dem.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	<--quantity units--->		<pr units>			<pr un>		%/yr	%/yr	%/yr	%/yr
Rest of Queensland	746.5	120.5	2634.00	0.750	-0.270	****.**	1.00	0.00	0.00	0.00	0.00
South west	78.6	0.5	2634.00	0.750	-0.270	****.**	1.00	0.00	0.00	0.00	0.00
Central north	100.1	3.0	2634.00	0.750	-0.270	****.**	1.00	0.00	0.00	0.00	0.00
Southern downs	30.9	3.0	2634.00	0.750	-0.270	****.**	1.00	0.00	0.00	0.00	0.00
North east	21.7	2.0	2634.00	0.750	-0.270	****.**	1.00	0.00	0.00	0.00	0.00
Rest of Australia	1056.0	613.0	3130.00	1.000	-0.330	-875.77	1.00	0.00	0.00	0.00	0.00
Rest of World	48162.0	49454.0	4016.00	1.000	-5.000	10.22	1.00	0.00	0.00	0.00	0.00
	50195	50196									

SUMMARY OF R&D & ADOPTION DATA

Region	K Pot.	Prob.of Success	Max. Adopt	Price	K Max	Shift Type	K Var	Time Lags R&D	Time Lags Adopt	Time Lags AtMax	Adopt Aband	Form
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	-%-	-%-	-%-	<price units>			%/yr	-yrs-	-yrs-	-yrs-	-yrs-	
Rest of Queensland	0.00	100.0	0.0	2634.00	0.00	S	0.00	0.0	0.0	99.0	0.0	L
South west	-4.00	100.0	40.0	2634.00	-42.14	S	0.00*	0.0	5.0	25.0	0.0	L
Central north	-12.00	100.0	40.0	2634.00	-126.43	S	0.00*	0.0	5.0	25.0	0.0	L
Southern downs	-8.00	100.0	57.0	2634.00	-120.11	S	0.00*	0.0	5.0	25.0	0.0	L
North east	-16.00	100.0	40.0	2634.00	-168.57	S	0.00*	0.0	5.0	25.0	0.0	L

Rest of Australia	0.00	100.0	0.0	3130.00	0.00	S	0.00	0.0	0.0	99.0	0.0	L
Rest of World	0.00	100.0	0.0	4016.00	0.00	S	0.00	0.0	0.0	99.0	0.0	L

Kmax is maximum absolute unit cost reduction (in price units). Product of Cols 2-5
Kvar is the variable unit cost reduction (%/year), if specified.
Shift type: S - Supply, D - Demand   Adoption Form: L - Linear, X - Logistic
* WARNING! - This combination of Kpot and Kvar produces negative Ktotal in some years

Region: 1 Rest of Queensland   Price transmission (v,w): ****.**, 1.000

	Producers					Consumers					Government			
	<---no R&D--->		<------- with R&D ------>			<-- no R&D --->		<------- with R&D ------>			< Tax Rev.>			Research
Year	Price	Quantity	Price	Quantity	Benefits	Price	Quantity	Price	Quantity	Benefits	"Prod"	"Cons"	Benefits	Costs
2009	2634.0	746.5	2634.0	746.5	13.3	2634.0	120.5	2634.0	120.4	-2.1	0.0	0.0	0.0	4830.0
2010	2634.0	746.5	2634.0	746.5	26.7	2634.0	120.5	2634.0	120.4	-4.3	0.0	0.0	0.0	5844.3
2011	2634.0	746.5	2634.0	746.5	40.1	2634.0	120.5	2634.0	120.4	-6.4	0.0	0.0	0.0	6858.6
2012	2634.0	746.5	2634.0	746.5	53.4	2634.0	120.5	2634.0	120.4	-8.6	0.0	0.0	0.0	7061.4
2013	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	7264.3
2014	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	7062.0
2015	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	7467.2
2016	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	7467.2
2017	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	7467.2
2018	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	7467.2
2019	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	7467.2
2020	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	7467.2
2021	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	7467.2
2022	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	7467.2
2023	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	7467.2
2024	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	7467.2
2025	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	7467.2
2026	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	7467.2
2027	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	7467.2
2028	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	7467.2
2029	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	0.0
2030	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	0.0
2031	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	0.0
2032	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	0.0
2033	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	0.0

2034	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	0.0
2035	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	0.0
2036	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	0.0
2037	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	0.0
2038	2634.0	746.5	2634.0	746.5	66.8	2634.0	120.5	2634.0	120.4	-10.7	0.0	0.0	0.0	0.0
Present value of benefits					906.3					-146.2			0.0	92141.1

					-- Price ---		------------- Production -----------				----------- Consumption ------------			
Year	K Total	K Base	K Spill	K Var	NoR&D	R&D	--R&D change in – Price	Quantity	Value of Productn	Benefits /VoP (%)	--R&D change in – Price	Quantity	Value of Consumptn	Benefits /VoC (%)
2009	0.00	0.00	0.0	0.00	2634.0	2634.0	0.01	0.0	1966304	0.0	0.01	-0.0	317398	-0.0
2010	0.00	0.00	0.0	0.00	2634.0	2634.0	0.03	0.0	1966327	0.0	0.03	-0.0	317400	-0.0
2011	0.00	0.00	0.0	0.00	2634.0	2634.0	0.05	0.0	1966351	0.0	0.05	-0.0	317401	-0.0
2012	0.00	0.00	0.0	0.00	2634.0	2634.0	0.07	0.0	1966374	0.0	0.07	-0.0	317403	-0.0
2013	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2014	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2015	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2016	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2017	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2018	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2019	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2020	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2021	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2022	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2023	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2024	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2025	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2026	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2027	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2028	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2029	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2030	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2031	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2032	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2033	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2034	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2035	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0

2036	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2037	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0
2038	0.00	0.00	0.0	0.00	2634.0	2634.0	0.08	0.0	1966398	0.0	0.08	-0.0	317404	-0.0

Region: 2 South west Price transmission (v,w): ****.**, 1.000

	Producers					Consumers					Government			
	<---no R&D--->		<------- with R&D ------>			<-- no R&D --->		<------- with R&D ------>			< Tax Rev.>			Research
Year	Price	Quantity	Price	Quantity	Benefits	Price	Quantity	Price	Quantity	Benefits	"Prod"	"Cons"	Benefits	Costs
2009	2634.0	78.6	2634.0	78.4	-660.8	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2010	2634.0	78.6	2634.0	78.2	-1320.1	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2011	2634.0	78.6	2634.0	78.1	-1977.9	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2012	2634.0	78.6	2634.0	77.9	-2634.0	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2013	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2014	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2015	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2016	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2017	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2018	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2019	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2020	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2021	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2022	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2023	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2024	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2025	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2026	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2027	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2028	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2029	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2030	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2031	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2032	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2033	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2034	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2035	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2036	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0

2037	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
2038	2634.0	78.6	2634.0	77.7	-3288.6	2634.0	0.5	2634.0	0.5	-0.0	0.0	0.0	0.0	0.0
Present value of benefits					-44595.3					-0.6			0.0	0.0

					-- Price ---		------------- Production -----------				----------- Consumption ------------			
Year	K Total	K Base	K Spill	K Var	NoR&D	R&D	--R&D change in - Price	Quantity	Value of Productn	Benefits /VoP (%)	--R&D change in - Price	Quantity	Value of Consumptn	Benefits /VoC (%)
2009	-8.42	-8.42	0.0	0.00	2634.0	2634.0	0.01	-0.1	206721	-0.3	0.01	0.0	1317	-0.0
2010	-16.85	-16.85	0.0	0.00	2634.0	2634.0	0.03	-0.3	206227	-0.6	0.03	0.0	1317	-0.0
2011	-25.28	-25.28	0.0	0.00	2634.0	2634.0	0.05	-0.5	205732	-0.9	0.05	0.0	1317	-0.0
2012	-33.71	-33.71	0.0	0.00	2634.0	2634.0	0.07	-0.7	205237	-1.2	0.07	0.0	1317	-0.0
2013	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2014	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2015	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2016	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2017	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2018	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2019	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2020	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2021	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2022	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2023	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2024	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2025	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2026	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2027	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2028	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2029	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2030	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2031	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2032	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2033	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2034	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2035	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2036	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2037	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0
2038	-42.14	-42.14	0.0	0.00	2634.0	2634.0	0.08	-0.9	204742	-1.6	0.08	0.0	1317	-0.0

Region: 3 Central north Price transmission (v,w): ****.**, 1.000

	Producers					Consumers					Government			
	<---no R&D--->		<------- with R&D ------>			<-- no R&D --->		<------- with R&D ------>			< Tax Rev.>			Research
Year	Price	Quantity	Price	Quantity	Benefits	Price	Quantity	Price	Quantity	Benefits	"Prod"	"Cons"	Benefits	Costs
2009	2634.0	100.1	2634.0	99.3	-2520.5	2634.0	3.0	2634.0	3.0	-0.0	0.0	0.0	0.0	0.0
2010	2634.0	100.1	2634.0	98.6	-5022.8	2634.0	3.0	2634.0	3.0	-0.1	0.0	0.0	0.0	0.0
2011	2634.0	100.1	2634.0	97.9	-7506.9	2634.0	3.0	2634.0	3.0	-0.1	0.0	0.0	0.0	0.0
2012	2634.0	100.1	2634.0	97.2	-9972.9	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2013	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2014	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2015	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2016	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2017	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2018	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2019	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2020	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2021	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2022	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2023	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2024	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2025	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2026	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2027	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2028	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2029	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2030	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2031	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2032	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2033	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2034	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2035	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2036	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2037	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2038	2634.0	100.1	2634.0	96.5	-12420.6	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0

Present value of benefits -168538.6 -3.6 0.0 0.0

Year	K Total	K Base	K Spill	K Var	Price NoR&D	Price R&D	Production: R&D change in Price	Production: R&D change in Quantity	Value of Productn	Benefits /VoP (%)	Consumption: R&D change in Price	Consumption: R&D change in Quantity	Value of Consumptn	Benefits /VoC (%)
2009	-25.28	-25.28	0.0	0.00	2634.0	2634.0	0.01	-0.7	261794	-0.9	0.01	0.0	7902	-0.0
2010	-50.57	-50.57	0.0	0.00	2634.0	2634.0	0.03	-1.4	259898	-1.9	0.03	0.0	7902	-0.0
2011	-75.85	-75.85	0.0	0.00	2634.0	2634.0	0.05	-2.1	258003	-2.9	0.05	0.0	7902	-0.0
2012	-101.14	***.**	0.0	0.00	2634.0	2634.0	0.07	-2.8	256107	-3.8	0.07	0.0	7902	-0.0
2013	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2014	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2015	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2016	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2017	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2018	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2019	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2020	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2021	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2022	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2023	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2024	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2025	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2026	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2027	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2028	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2029	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2030	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2031	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2032	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2033	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2034	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2035	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2036	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2037	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0
2038	-126.43	***.**	0.0	0.00	2634.0	2634.0	0.08	-3.6	254212	-4.8	0.08	0.0	7902	-0.0

Region: 4 Southern downs Price transmission (v,w): ****.**, 1.000

	Producers					Consumers					Government			
	no R&D		with R&D			no R&D		with R&D			Tax Rev.			Research
Year	Price	Quantity	Price	Quantity	Benefits	Price	Quantity	Price	Quantity	Benefits	"Prod"	"Cons"	Benefits	Costs
2009	2634.0	30.9	2634.0	30.7	-741.3	2634.0	3.0	2634.0	3.0	-0.0	0.0	0.0	0.0	0.0
2010	2634.0	30.9	2634.0	30.5	-1477.6	2634.0	3.0	2634.0	3.0	-0.1	0.0	0.0	0.0	0.0
2011	2634.0	30.9	2634.0	30.3	-2208.7	2634.0	3.0	2634.0	3.0	-0.1	0.0	0.0	0.0	0.0
2012	2634.0	30.9	2634.0	30.1	-2934.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2013	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2014	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2015	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2016	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2017	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2018	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2019	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2020	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2021	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2022	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2023	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2024	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2025	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2026	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2027	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2028	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2029	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2030	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2031	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2032	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2033	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2034	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2035	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2036	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2037	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
2038	2634.0	30.9	2634.0	29.9	-3655.8	2634.0	3.0	2634.0	3.0	-0.2	0.0	0.0	0.0	0.0
Present value of benefits					-49605.2					-3.6			0.0	0.0

Year	K Total	K Base	K Spill	K Var	Price NoR&D	Price R&D	Production: R&D change in Price	Production: R&D change in Quantity	Value of Productn	Benefits /VoP (%)	Consumption: R&D change in Price	Consumption: R&D change in Quantity	Value of Consumptn	Benefits /VoC (%)
2009	-24.02	-24.02	0.0	0.00	2634.0	2634.0	0.01	-0.2	81070	-0.9	0.01	0.0	7902	-0.0
2010	-48.04	-48.04	0.0	0.00	2634.0	2634.0	0.03	-0.4	80512	-1.8	0.03	0.0	7902	-0.0
2011	-72.06	-72.06	0.0	0.00	2634.0	2634.0	0.05	-0.6	79955	-2.7	0.05	0.0	7902	-0.0
2012	-96.08	-96.08	0.0	0.00	2634.0	2634.0	0.07	-0.8	79398	-3.6	0.07	0.0	7902	-0.0
2013	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2014	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2015	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2016	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2017	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2018	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2019	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2020	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2021	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2022	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2023	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2024	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2025	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2026	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2027	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2028	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2029	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2030	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2031	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2032	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2033	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2034	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2035	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2036	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2037	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0
2038	-120.11	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	78840	-4.6	0.08	0.0	7902	-0.0

Region: 5 North east Price transmission (v,w): ****.**, 1.000

---------------- Producers -------------- ------------- Consumers ------------------ ----- Government ---- ----------

	<---no R&D--->		<------- with R&D ------>			<-- no R&D --->		<------- with R&D ------>			< Tax Rev.>			
Year	Price	Quantity	Price	Quantity	Benefits	Price	Quantity	Price	Quantity	Benefits	"Prod"	"Cons"	Benefits	Research Costs
2009	2634.0	21.7	2634.0	21.5	-728.3	2634.0	2.0	2634.0	2.0	-0.0	0.0	0.0	0.0	0.0
2010	2634.0	21.7	2634.0	21.3	-1449.7	2634.0	2.0	2634.0	2.0	-0.0	0.0	0.0	0.0	0.0
2011	2634.0	21.7	2634.0	21.0	-2164.1	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2012	2634.0	21.7	2634.0	20.8	-2871.4	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2013	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2014	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2015	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2016	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2017	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2018	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2019	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2020	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2021	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2022	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2023	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2024	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2025	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2026	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2027	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2028	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2029	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2030	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2031	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2032	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2033	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2034	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2035	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2036	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2037	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
2038	2634.0	21.7	2634.0	20.6	-3571.7	2634.0	2.0	2634.0	2.0	-0.1	0.0	0.0	0.0	0.0
Present value of benefits					-48481.7					-2.4			0.0	0.0

					-- Price ---		------------- Production -----------				----------- Consumption ------------			
							--R&D change in -		Value of	Benefits	--R&D change in -		Value of	Benefits
Year	K Total	K Base	K Spill	K Var	NoR&D	R&D	Price	Quantity	Productn	/VoP (%)	Price	Quantity	Consumptn	/VoC (%)

2009	-33.71	-33.71	0.0	0.00	2634.0	2634.0	0.01	-0.2	56661	-1.2	0.01	0.0	5268	-0.0
2010	-67.43	-67.43	0.0	0.00	2634.0	2634.0	0.03	-0.4	56113	-2.5	0.03	0.0	5268	-0.0
2011	-101.14	***.**	0.0	0.00	2634.0	2634.0	0.05	-0.6	55564	-3.8	0.05	0.0	5268	-0.0
2012	-134.86	***.**	0.0	0.00	2634.0	2634.0	0.07	-0.8	55016	-5.2	0.07	0.0	5268	-0.0
2013	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2014	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2015	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2016	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2017	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2018	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2019	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2020	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2021	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2022	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2023	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2024	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2025	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2026	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2027	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2028	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2029	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2030	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2031	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2032	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2033	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2034	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2035	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2036	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2037	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0
2038	-168.57	***.**	0.0	0.00	2634.0	2634.0	0.08	-1.0	54467	-6.5	0.08	0.0	5268	-0.0

Region: 6 Rest of Australia Price transmission (v,w): -875.77, 1.000

	Producers					Consumers					Government			
	<---no R&D--->		<------- with R&D ------>			<-- no R&D --->		<------- with R&D ------>			< Tax Rev.>			Research
Year	Price	Quantity	Price	Quantity	Benefits	Price	Quantity	Price	Quantity	Benefits	"Prod"	"Cons"	Benefits	Costs

2009	3130.0	1056.0	3130.0	1056.0	18.9	3130.0	613.0	3130.0	612.9	-10.9	0.0	0.0	0.0	0.0
2010	3130.0	1056.0	3130.0	1056.0	37.8	3130.0	613.0	3130.0	612.9	-21.9	0.0	0.0	0.0	0.0
2011	3130.0	1056.0	3130.0	1056.0	56.7	3130.0	613.0	3130.0	612.9	-32.9	0.0	0.0	0.0	0.0
2012	3130.0	1056.0	3130.0	1056.0	75.6	3130.0	613.0	3130.0	612.9	-43.9	0.0	0.0	0.0	0.0
2013	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2014	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2015	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2016	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2017	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2018	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2019	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2020	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2021	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2022	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2023	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2024	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2025	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2026	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2027	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2028	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2029	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2030	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2031	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2032	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2033	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2034	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2035	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2036	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2037	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
2038	3130.0	1056.0	3130.0	1056.0	94.5	3130.0	613.0	3130.0	612.9	-54.8	0.0	0.0	0.0	0.0
Present value of benefits					1282.0					-744.2			0.0	0.0

					-- Price ---		------------- Production -----------				----------- Consumption ------------			
Year	K	K	K	K			--R&D change in –		Value of	Benefits	--R&D change in –		Value of	Benefits
	Total	Base	Spill	Var	NoR&D	R&D	Price	Quantity	Productn	/VoP (%)	Price	Quantity	Consumptn	/VoC (%)
2009	0.00	0.00	0.0	0.00	3130.0	3130.0	0.01	0.0	3305317	0.0	0.01	-0.0	1918697	-0.0
2010	0.00	0.00	0.0	0.00	3130.0	3130.0	0.03	0.0	3305355	0.0	0.03	-0.0	1918704	-0.0

2011	0.00	0.00	0.0	0.00	3130.0	3130.0	0.05	0.0	3305393	0.0	0.05	-0.0	1918712	-0.0
2012	0.00	0.00	0.0	0.00	3130.0	3130.0	0.07	0.0	3305431	0.0	0.07	-0.0	1918719	-0.0
2013	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2014	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2015	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2016	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2017	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2018	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2019	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2020	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2021	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2022	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2023	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2024	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2025	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2026	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2027	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2028	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2029	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2030	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2031	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2032	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2033	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2034	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2035	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2036	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2037	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0
2038	0.00	0.00	0.0	0.00	3130.0	3130.0	0.08	0.0	3305469	0.0	0.08	-0.0	1918726	-0.0

Region: 7 Rest of World — Price transmission (v,w): 10.22, 1.000

	Producers					Consumers					Government			
	no R&D		with R&D			no R&D		with R&D			Tax Rev.			Research
Year	Price	Quantity	Price	Quantity	Benefits	Price	Quantity	Price	Quantity	Benefits	"Prod"	"Cons"	Benefits	Costs
2009	4016.0	48162.0	4016.0	48162.2	862.6	4016.0	49454.0	4016.0	49452.8	-885.7	0.0	0.0	0.0	0.0
2010	4016.0	48162.0	4016.0	48162.4	1725.3	4016.0	49453.9	4016.0	49451.7	-1771.5	0.0	0.0	0.0	0.0
2011	4016.0	48162.0	4016.0	48162.6	2588.0	4016.0	49453.9	4016.0	49450.6	-2657.3	0.0	0.0	0.0	0.0

2012	4016.0	48162.0	4016.0	48162.8	3450.7	4016.0	49453.9	4016.0	49449.5	-3543.0	0.0	0.0	0.0	0.0
2013	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2014	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2015	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2016	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2017	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2018	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2019	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2020	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2021	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2022	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2023	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2024	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2025	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2026	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2027	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2028	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2029	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2030	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2031	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2032	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2033	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2034	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2035	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2036	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2037	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
2038	4016.0	48162.0	4016.0	48163.0	4313.3	4016.0	49453.9	4016.0	49448.4	-4428.8	0.0	0.0	0.0	0.0
Present value of benefits					58473.3					-60038.1			0.0	0.0

					-- Price ---		------------- Production -----------				----------- Consumption ------------			
Year	K Total	K Base	K Spill	K Var	NoR&D	R&D	--R&D change in - Price	Quantity	Value of Productn	Benefits /VoP (%)	--R&D change in - Price	Quantity	Value of Consumptn	Benefits /VoC (%)
2009	0.00	0.00	0.0	0.00	4016.0	4016.0	0.01	0.2	193420317	0.0	0.01	-1.1	198603720	-0.0
2010	0.00	0.00	0.0	0.00	4016.0	4016.0	0.03	0.4	193422055	0.0	0.03	-2.2	198600150	-0.0
2011	0.00	0.00	0.0	0.00	4016.0	4016.0	0.05	0.6	193423781	0.0	0.05	-3.3	198596607	-0.0
2012	0.00	0.00	0.0	0.00	4016.0	4016.0	0.07	0.8	193425506	0.0	0.07	-4.4	198593064	-0.0
2013	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0

2014	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2015	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2016	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2017	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2018	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2019	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2020	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2021	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2022	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2023	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2024	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2025	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2026	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2027	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2028	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2029	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2030	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2031	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2032	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2033	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2034	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2035	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2036	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2037	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0
2038	0.00	0.00	0.0	0.00	4016.0	4016.0	0.08	1.0	193427231	0.0	0.08	-5.5	198589520	-0.0

PRESENT VALUE SUMMARIES

Group 01

	Present Value of R&D Benefits				Costs	Returns		
Region	Producer	Consumer	Government	Total		(B−C)	B/C	IRR
1 Rest of Queensland	906.3	-146.2	0.0	760.0	92141.1	-91381.0	0.00	-38.6%
2 South west	-44595.3	-0.6	0.0	-44595.9	0.0	-44595.9	--.--	--.-
3 Central north	-168538.6	-3.6	0.0	-168542.2	0.0	-168542.2	--.--	--.-
4 Southern downs	-49605.2	-3.6	0.0	-49608.8	0.0	-49608.8	--.--	--.-
5 North east	-48481.7	-2.4	0.0	-48484.1	0.0	-48484.1	--.--	--.-
6 Rest of Australia	1282.0	-744.2	0.0	537.8	0.0	537.8	--.--	--.-
7 Rest of World	58473.3	-60038.1	0.0	-1564.7	0.0	-1564.7	--.--	--.-

Total NPV Benefits	-250559.1	-60938.9	0.0	-311498.1	92141.1	-403639.2	-3.38	--.-

Cost and Benefit Summary Across All Regions in Group

	<--------------- Benefits		------------------>		Total	
Year	Producer	Consumer	Government	Total	Costs	B-C
2009	-3756.2	-899.0	0.0	-4655.2	4830.0	-9485.2
2010	-7480.5	-1798.1	0.0	-9278.6	5844.3	-15122.9
2011	-11172.9	-2697.2	0.0	-13870.1	6858.6	-20728.7
2012	-14833.4	-3596.2	0.0	-18429.6	7061.4	-25491.1
2013	-18462.0	-4495.2	0.0	-22957.3	7264.3	-30221.6
2014	-18462.0	-4495.2	0.0	-22957.3	7062.0	-30019.3
2015	-18462.0	-4495.2	0.0	-22957.3	7467.2	-30424.5
2016	-18462.0	-4495.2	0.0	-22957.3	7467.2	-30424.5
2017	-18462.0	-4495.2	0.0	-22957.3	7467.2	-30424.5
2018	-18462.0	-4495.2	0.0	-22957.3	7467.2	-30424.5
2019	-18462.0	-4495.2	0.0	-22957.3	7467.2	-30424.5
2020	-18462.0	-4495.2	0.0	-22957.3	7467.2	-30424.5
2021	-18462.0	-4495.2	0.0	-22957.3	7467.2	-30424.5
2022	-18462.0	-4495.2	0.0	-22957.3	7467.2	-30424.5
2023	-18462.0	-4495.2	0.0	-22957.3	7467.2	-30424.5
2024	-18462.0	-4495.2	0.0	-22957.3	7467.2	-30424.5
2025	-18462.0	-4495.2	0.0	-22957.3	7467.2	-30424.5
2026	-18462.0	-4495.2	0.0	-22957.3	7467.2	-30424.5
2027	-18462.0	-4495.2	0.0	-22957.3	7467.2	-30424.5
2028	-18462.0	-4495.2	0.0	-22957.3	7467.2	-30424.5
2029	-18462.0	-4495.2	0.0	-22957.3	0.0	-22957.3
2030	-18462.0	-4495.2	0.0	-22957.3	0.0	-22957.3
2031	-18462.0	-4495.2	0.0	-22957.3	0.0	-22957.3
2032	-18462.0	-4495.2	0.0	-22957.3	0.0	-22957.3
2033	-18462.0	-4495.2	0.0	-22957.3	0.0	-22957.3
2034	-18462.0	-4495.2	0.0	-22957.3	0.0	-22957.3
2035	-18462.0	-4495.2	0.0	-22957.3	0.0	-22957.3
2036	-18462.0	-4495.2	0.0	-22957.3	0.0	-22957.3
2037	-18462.0	-4495.2	0.0	-22957.3	0.0	-22957.3
2038	-18462.0	-4495.2	0.0	-22957.3	0.0	-22957.3

Scenario 1 Dairy producers use acaricides

Study: Ticks and dairy
Scenario: acaricides
Commodity: Milk Regions: 2 Horizontal Multimarket - Spillover: No
Period: 20 years Base year: 2009
Discount: 5.0% Benefit: AU$ Quantity: 1000 T

SUMMARY OF INITIAL MARKET CONDITIONS

Region	Production	Consumptn	Price	Elasticity Sup.	Elasticity Dem.	Transmission Wedge	Transmission Elast	Exog. Growth Sup.	Exog. Growth Dem.	Tax/Sudsidy Sup.	Tax/Sudsidy Dem.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	<--quantity units--->		<pr units>			<pr un>		%/yr	%/yr	%/yr	%/yr
Queensland tick en	339.5	339.5	496.00	0.900	-0.150	0.00	1.00	0.00	0.00	0.00	0.00
Queensland tick fr	145.5	145.5	496.00	0.900	-0.150	0.00	1.00	0.00	0.00	0.00	0.00
	485	485									

SUMMARY OF R&D & ADOPTION DATA

Region	K Pot.	Prob.of Success	Max. Adopt	Price	K Max	Shift Type	K Var	-Time Lags R&D	Adopt	AtMax	----- Adopt Aband	----- Form
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	-%-	-%-	-%-	<price units>			%/yr	-yrs-	-yrs-	-yrs-	-yrs-	
Queensland tick en	1.33	100.0	70.0	496.00	4.61	S	0.00	5.0	5.0	10.0	0.0	L
Queensland tick fr	0.00	100.0	0.0	496.00	0.00	S	0.00	0.0	0.0	99.0	0.0	L

Kmax is maximum absolute unit cost reduction (in price units). Product of Cols 2-5
Kvar is the variable unit cost reduction (%/year), if specified.
Shift type: S - Supply, D - Demand Adoption Form: L - Linear, X - Logistic
* WARNING! - This combination of Kpot and Kvar produces negative Ktotal in some years

Region: 1 Queensland tick endemic Price transmission (v,w): 0.00, 1.000

---------------- Producers --------------		------------- Consumers ------------------		----- Government ----	----------
<---no R&D--->	<------- with R&D ------>	<-- no R&D --->	<------- with R&D ------>	< Tax Rev.>	Research

Year	Price	Quantity	Price	Quantity	Benefits	Price	Quantity	Price	Quantity	Benefits	"Prod"	"Cons"	Benefits	Costs
2009	496.0	339.5	496.0	339.5	0.0	496.0	339.5	496.0	339.5	0.0	0.0	0.0	0.0	0.0
2010	496.0	339.5	496.0	339.5	0.0	496.0	339.5	496.0	339.5	0.0	0.0	0.0	0.0	0.0
2011	496.0	339.5	496.0	339.5	0.0	496.0	339.5	496.0	339.5	0.0	0.0	0.0	0.0	0.0
2012	496.0	339.5	496.0	339.5	0.0	496.0	339.5	496.0	339.5	0.0	0.0	0.0	0.0	0.0
2013	496.0	339.5	496.0	339.5	0.0	496.0	339.5	496.0	339.5	0.0	0.0	0.0	0.0	0.0
2014	496.0	339.5	495.4	339.7	125.4	496.0	339.5	495.4	339.5	188.1	0.0	0.0	0.0	0.0
2015	496.0	339.5	494.8	339.9	251.0	496.0	339.5	494.8	339.6	376.3	0.0	0.0	0.0	0.0
2016	496.0	339.5	494.3	340.1	376.6	496.0	339.5	494.3	339.6	564.5	0.0	0.0	0.0	0.0
2017	496.0	339.5	493.7	340.4	502.3	496.0	339.5	493.7	339.7	752.7	0.0	0.0	0.0	0.0
2018	496.0	339.5	493.2	340.6	628.1	496.0	339.5	493.2	339.7	941.0	0.0	0.0	0.0	0.0
2019	496.0	339.5	493.2	340.6	628.1	496.0	339.5	493.2	339.7	941.0	0.0	0.0	0.0	0.0
2020	496.0	339.5	493.2	340.6	628.1	496.0	339.5	493.2	339.7	941.0	0.0	0.0	0.0	0.0
2021	496.0	339.5	493.2	340.6	628.1	496.0	339.5	493.2	339.7	941.0	0.0	0.0	0.0	0.0
2022	496.0	339.5	493.2	340.6	628.1	496.0	339.5	493.2	339.7	941.0	0.0	0.0	0.0	0.0
2023	496.0	339.5	493.2	340.6	628.1	496.0	339.5	493.2	339.7	941.0	0.0	0.0	0.0	0.0
2024	496.0	339.5	493.2	340.6	628.1	496.0	339.5	493.2	339.7	941.0	0.0	0.0	0.0	0.0
2025	496.0	339.5	493.2	340.6	628.1	496.0	339.5	493.2	339.7	941.0	0.0	0.0	0.0	0.0
2026	496.0	339.5	493.2	340.6	628.1	496.0	339.5	493.2	339.7	941.0	0.0	0.0	0.0	0.0
2027	496.0	339.5	493.2	340.6	628.1	496.0	339.5	493.2	339.7	941.0	0.0	0.0	0.0	0.0
2028	496.0	339.5	493.2	340.6	628.1	496.0	339.5	493.2	339.7	941.0	0.0	0.0	0.0	0.0
Present value of benefits					4214.0					6313.8			0.0	0.0

Year	K	K	K	K	-- Price ---		------------- Production -----------				----------- Consumption ------------			
	Total	Base	Spill	Var	NoR&D	R&D	--R&D change in - Price	Quantity	Value of Productn	Benefits /VoP (%)	--R&D change in - Price	Quantity	Value of Consumptn	Benefits /VoC (%)
2009	0.00	0.00	0.0	0.00	496.0	496.0	0.00	0.0	168392	0.0	0.00	0.0	168392	0.0
2010	0.00	0.00	0.0	0.00	496.0	496.0	0.00	0.0	168392	0.0	0.00	0.0	168392	0.0
2011	0.00	0.00	0.0	0.00	496.0	496.0	0.00	0.0	168392	0.0	0.00	0.0	168392	0.0
2012	0.00	0.00	0.0	0.00	496.0	496.0	0.00	0.0	168392	0.0	0.00	0.0	168392	0.0
2013	0.00	0.00	0.0	0.00	496.0	496.0	0.00	0.0	168392	0.0	0.00	0.0	168392	0.0
2014	0.92	0.92	0.0	0.00	496.0	495.4	-0.55	0.2	168316	0.0	-0.55	0.0	168232	0.1
2015	1.84	1.84	0.0	0.00	496.0	494.8	-1.10	0.4	168240	0.1	-1.10	0.1	168072	0.2
2016	2.77	2.77	0.0	0.00	496.0	494.3	-1.66	0.6	168165	0.2	-1.66	0.1	167911	0.3
2017	3.69	3.69	0.0	0.00	496.0	493.7	-2.21	0.9	168088	0.2	-2.21	0.2	167751	0.4
2018	4.61	4.61	0.0	0.00	496.0	493.2	-2.77	1.1	168012	0.3	-2.77	0.2	167591	0.5

2019	4.61	4.61	0.0	0.00	496.0	493.2	-2.77	1.1	168012	0.3	-2.77	0.2	167591	0.5
2020	4.61	4.61	0.0	0.00	496.0	493.2	-2.77	1.1	168012	0.3	-2.77	0.2	167591	0.5
2021	4.61	4.61	0.0	0.00	496.0	493.2	-2.77	1.1	168012	0.3	-2.77	0.2	167591	0.5
2022	4.61	4.61	0.0	0.00	496.0	493.2	-2.77	1.1	168012	0.3	-2.77	0.2	167591	0.5
2023	4.61	4.61	0.0	0.00	496.0	493.2	-2.77	1.1	168012	0.3	-2.77	0.2	167591	0.5
2024	4.61	4.61	0.0	0.00	496.0	493.2	-2.77	1.1	168012	0.3	-2.77	0.2	167591	0.5
2025	4.61	4.61	0.0	0.00	496.0	493.2	-2.77	1.1	168012	0.3	-2.77	0.2	167591	0.5
2026	4.61	4.61	0.0	0.00	496.0	493.2	-2.77	1.1	168012	0.3	-2.77	0.2	167591	0.5
2027	4.61	4.61	0.0	0.00	496.0	493.2	-2.77	1.1	168012	0.3	-2.77	0.2	167591	0.5
2028	4.61	4.61	0.0	0.00	496.0	493.2	-2.77	1.1	168012	0.3	-2.77	0.2	167591	0.5

Region: 2 Queensland tick free Price transmission (v,w): 0.00, 1.000

	Producers					Consumers					Government			
	<---no R&D--->		<------- with R&D ------>			<-- no R&D --->		<------- with R&D ------>			< Tax Rev.>			Research
Year	Price	Quantity	Price	Quantity	Benefits	Price	Quantity	Price	Quantity	Benefits	"Prod"	"Cons"	Benefits	Costs
2009	496.0	145.5	496.0	145.5	0.0	496.0	145.5	496.0	145.5	0.0	0.0	0.0	0.0	0.0
2010	496.0	145.5	496.0	145.5	0.0	496.0	145.5	496.0	145.5	0.0	0.0	0.0	0.0	0.0
2011	496.0	145.5	496.0	145.5	0.0	496.0	145.5	496.0	145.5	0.0	0.0	0.0	0.0	0.0
2012	496.0	145.5	496.0	145.5	0.0	496.0	145.5	496.0	145.5	0.0	0.0	0.0	0.0	0.0
2013	496.0	145.5	496.0	145.5	0.0	496.0	145.5	496.0	145.5	0.0	0.0	0.0	0.0	0.0
2014	496.0	145.5	495.4	145.3	-80.5	496.0	145.5	495.4	145.5	80.6	0.0	0.0	0.0	0.0
2015	496.0	145.5	494.8	145.2	-161.0	496.0	145.5	494.8	145.5	161.2	0.0	0.0	0.0	0.0
2016	496.0	145.5	494.3	145.0	-241.5	496.0	145.5	494.3	145.5	241.9	0.0	0.0	0.0	0.0
2017	496.0	145.5	493.7	144.9	-321.8	496.0	145.5	493.7	145.5	322.6	0.0	0.0	0.0	0.0
2018	496.0	145.5	493.2	144.7	-402.1	496.0	145.5	493.2	145.6	403.2	0.0	0.0	0.0	0.0
2019	496.0	145.5	493.2	144.7	-402.1	496.0	145.5	493.2	145.6	403.2	0.0	0.0	0.0	0.0
2020	496.0	145.5	493.2	144.7	-402.1	496.0	145.5	493.2	145.6	403.2	0.0	0.0	0.0	0.0
2021	496.0	145.5	493.2	144.7	-402.1	496.0	145.5	493.2	145.6	403.2	0.0	0.0	0.0	0.0
2022	496.0	145.5	493.2	144.7	-402.1	496.0	145.5	493.2	145.6	403.2	0.0	0.0	0.0	0.0
2023	496.0	145.5	493.2	144.7	-402.1	496.0	145.5	493.2	145.6	403.2	0.0	0.0	0.0	0.0
2024	496.0	145.5	493.2	144.7	-402.1	496.0	145.5	493.2	145.6	403.2	0.0	0.0	0.0	0.0
2025	496.0	145.5	493.2	144.7	-402.1	496.0	145.5	493.2	145.6	403.2	0.0	0.0	0.0	0.0
2026	496.0	145.5	493.2	144.7	-402.1	496.0	145.5	493.2	145.6	403.2	0.0	0.0	0.0	0.0
2027	496.0	145.5	493.2	144.7	-402.1	496.0	145.5	493.2	145.6	403.2	0.0	0.0	0.0	0.0
2028	496.0	145.5	493.2	144.7	-402.1	496.0	145.5	493.2	145.6	403.2	0.0	0.0	0.0	0.0

Present value of benefits	-2698.6	2705.9	0.0	0.0

Year	K Total	K Base	K Spill	K Var	Price: NoR&D	Price: R&D	Production: R&D change in Price	Production: R&D change in Quantity	Production: Value of Productn	Production: Benefits /VoP (%)	Consumption: R&D change in Price	Consumption: R&D change in Quantity	Consumption: Value of Consumptn	Consumption: Benefits /VoC (%)
2009	0.00	0.00	0.0	0.00	496.0	496.0	0.00	0.0	72168	0.0	0.00	0.0	72168	0.0
2010	0.00	0.00	0.0	0.00	496.0	496.0	0.00	0.0	72168	0.0	0.00	0.0	72168	0.0
2011	0.00	0.00	0.0	0.00	496.0	496.0	0.00	0.0	72168	0.0	0.00	0.0	72168	0.0
2012	0.00	0.00	0.0	0.00	496.0	496.0	0.00	0.0	72168	0.0	0.00	0.0	72168	0.0
2013	0.00	0.00	0.0	0.00	496.0	496.0	0.00	0.0	72168	0.0	0.00	0.0	72168	0.0
2014	0.00	0.00	0.0	0.00	496.0	495.4	-0.55	-0.1	72014	-0.1	-0.55	0.0	72099	0.1
2015	0.00	0.00	0.0	0.00	496.0	494.8	-1.10	-0.2	71861	-0.2	-1.10	0.0	72030	0.2
2016	0.00	0.00	0.0	0.00	496.0	494.3	-1.66	-0.4	71709	-0.3	-1.66	0.0	71962	0.3
2017	0.00	0.00	0.0	0.00	496.0	493.7	-2.21	-0.5	71556	-0.4	-2.21	0.0	71893	0.4
2018	0.00	0.00	0.0	0.00	496.0	493.2	-2.77	-0.7	71404	-0.5	-2.77	0.1	71825	0.5
2019	0.00	0.00	0.0	0.00	496.0	493.2	-2.77	-0.7	71404	-0.5	-2.77	0.1	71825	0.5
2020	0.00	0.00	0.0	0.00	496.0	493.2	-2.77	-0.7	71404	-0.5	-2.77	0.1	71825	0.5
2021	0.00	0.00	0.0	0.00	496.0	493.2	-2.77	-0.7	71404	-0.5	-2.77	0.1	71825	0.5
2022	0.00	0.00	0.0	0.00	496.0	493.2	-2.77	-0.7	71404	-0.5	-2.77	0.1	71825	0.5
2023	0.00	0.00	0.0	0.00	496.0	493.2	-2.77	-0.7	71404	-0.5	-2.77	0.1	71825	0.5
2024	0.00	0.00	0.0	0.00	496.0	493.2	-2.77	-0.7	71404	-0.5	-2.77	0.1	71825	0.5
2025	0.00	0.00	0.0	0.00	496.0	493.2	-2.77	-0.7	71404	-0.5	-2.77	0.1	71825	0.5
2026	0.00	0.00	0.0	0.00	496.0	493.2	-2.77	-0.7	71404	-0.5	-2.77	0.1	71825	0.5
2027	0.00	0.00	0.0	0.00	496.0	493.2	-2.77	-0.7	71404	-0.5	-2.77	0.1	71825	0.5
2028	0.00	0.00	0.0	0.00	496.0	493.2	-2.77	-0.7	71404	-0.5	-2.77	0.1	71825	0.5

PRESENT VALUE SUMMARIES

Group 01

Region	Present Value of R&D Benefits: Producer	Consumer	Government	Total	Costs	Returns: (B-C)	B/C	IRR
1 Queensland tick en	4214.0	6313.8	0.0	10527.8	0.0	10527.8	--.--	--.-
2 Queensland tick fr	-2698.6	2705.9	0.0	7.2	0.0	7.2	--.--	--.-
Total NPV Benefits	1515.4	9019.7	0.0	10535.1	0.0	10535.1	--.--	--.-

Cost and Benefit Summary across All Regions in Group

Year	Benefits: Producer	Consumer	Government	Total	Total Costs	B-C
2009	0.0	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0	0.0	0.0
2014	44.8	268.7	0.0	313.6	0.0	313.6
2015	89.9	537.5	0.0	627.5	0.0	627.5
2016	135.1	806.4	0.0	941.5	0.0	941.5
2017	180.4	1075.3	0.0	1255.8	0.0	1255.8
2018	226.0	1344.3	0.0	1570.3	0.0	1570.3
2019	226.0	1344.3	0.0	1570.3	0.0	1570.3
2020	226.0	1344.3	0.0	1570.3	0.0	1570.3
2021	226.0	1344.3	0.0	1570.3	0.0	1570.3
2022	226.0	1344.3	0.0	1570.3	0.0	1570.3
2023	226.0	1344.3	0.0	1570.3	0.0	1570.3
2024	226.0	1344.3	0.0	1570.3	0.0	1570.3
2025	226.0	1344.3	0.0	1570.3	0.0	1570.3
2026	226.0	1344.3	0.0	1570.3	0.0	1570.3
2027	226.0	1344.3	0.0	1570.3	0.0	1570.3
2028	226.0	1344.3	0.0	1570.3	0.0	1570.3