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Economic issues surrounding wheat quality assurance: the case of late maturing alpha-amylase policy in Australia

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Abstract

Late maturing α-amylase (LMA) is a genetic defect in some wheat lines that when triggered by particular environmental conditions damages the grains' starch and reduces its suitability in processing. To lessen the risk of LMA expression in Australia's wheat crops, a testing regime is now part of the nation's varietal classification system. This paper analyses the impact of relaxing the testing regime and thereby providing farmers with the option to grow higher yielding varieties with higher risks of expressing an LMA defect that causes a price downgrade. We model the potential for quality downgrade by incorporating an expected price into the wheat supply and demand functions. The expected price is generated using the price differential between milling and feed grades and the probability of LMA exhibition. The net benefit from shifting between the current and more relaxed testing regimes is evaluated as the change in producer surplus. The analysis is based on the Western Australian wheat industry that supplies around half of Australia's wheat exports. Initial findings indicate that the expected net benefit to the wheat industry in Western Australia from a relaxation of the current LMA policy is around $18m per annum.

Introduction

Wheat production is the key industry in much of the Western Australia's agricultural region. Of the 7.5 million hectares sown to grain in the grain belt, farmers sow 63 per cent of the area to wheat, making wheat the dominant crop in Western Australia (WA). The state is heavily reliant on export markets and from the average of 7.1mmt of wheat produced per annum, 90 per cent is exported (ABARES, 2014). With such a strong export bias, yet facing strong competition in international markets, the WA wheat industry requires access to technology that improves productivity to reduce the cost of wheat production in order to maintain competitiveness. Such technology includes new grain varieties that out-yield existing varieties.

However, prior to their release, new wheat varieties are subject to tests for a range of quality characteristics to ensure they are suitable for our markets. One such test is for late maturing α-amylase. Late maturing α-amylase (LMA) is a genetic defect that when triggered by particular environmental conditions results in damaging levels of the enzyme α-amylase in wheat grain.

High levels of α-amylase cause starch damage, low falling numbers and reduce the grain's suitability for processing (Blakeney at al., 2009). Growers' deliveries of wheat affected by low falling numbers can be downgraded to feed quality, thereby incurring a price penalty. As outlined by Wheat Quality Australia (2013), the LMA phenomenon occurs when amylase is produced in the latter stages of grain development – prior to ripening. The enzyme remains in the ripened grain and causes apparently sound, ripe grain to have low falling number. Falling number is a key quality parameter for buyers of grain and so this can negatively affect grain value. As the falling number test is not standard at grain delivery sites, and LMA affected grain is not identifiable through a visual check, there is potential for LMA affected grain to enter the export supply chain. The tendency for a variety to produce LMA is genetic while the trigger for LMA production is often environmental – a cold temperature shock at a critical point in grain development. It is acknowledged that not all varieties have the genetic potential to produce LMA. Mares and Mrva (2008) point out that LMA expression appears to be controlled by one or two recessive genes acting alone or in combination, when triggered by a temperature shock, though in highly vulnerable varieties the expression may occur randomly without any recognised trigger (Lambe, *pers. comm*.).

LMA affects various stakeholders within Australia's wheat industry. Farmers are affected when wheat is downgraded, following poor results from the falling number test. The bulk handler would implement the test at a grain receival site on a discretionary basis, where the grower delivers the grain, at the same time as other mandatory wheat quality tests including those for protein, screenings, moisture and hectolitre weight. If LMA-affected grain is detected, aside from the additional testing fee accrued by the grower, there is potentially a $20-$50/t penalty for both LMA affected grain and sprouted grain, if the grain is segregated into the General Purpose (GP) or Feed (FED1) grades instead of the regular Australian Prime White (APW) grade.

Processors can also be affected when their purchases of wheat perform less well during processing than anticipated. The reputation of marketers of Australian grain can also be affected if they sell shipments of grain adversely affected by LMA, and subsequently receive unfavourable feedback and criticism from the end-users of the affected grain. Lastly, wheat breeder activity is also affected in ways that require some explanation.

Firstly, no low-cost, large volume throughput test for LMA is currently available for use by wheat breeders. Secondly, since LMA is inherited as a recessive trait, for LMA testing to be accurate, pure seed of genetically fixed lines is required. Accordingly, the test for LMA can only be applied to very advanced lines. Hence wheat breeders, after incurring significant development costs, then risk having some of their advanced high-yielding lines screened out due to LMA problems. Anecdotal evidence suggests that current LMA testing has disallowed the release of some breeding lines with up to a 10 per cent yield benefit over current varieties.

The activation of LMA is climate-induced and variety dependent (Mares and Mrva, 1993). The current laboratory test for LMA that seeks to mimic those climatic conditions can only currently be implemented near the end of the breeding selection process, with 30 lines tested per breeding company per year, prior to widespread geographical testing of potential varieties. This causes breeders to accrue nearly the full cost of breeding a new variety before the test determines whether the LMA risk is sufficient to require the variety to be classified as feed wheat or whether it can remain as a candidate for milling wheat. Breeding companies mostly discard varieties classified as feed wheat, as it is not likely that growers will adopt them. The breeders rely on growers to adopt their varieties as their revenue is dependent on an end point royalty system (Kingwell, 2005) where growers pay a royalty based on production.

Of further concern to breeders is that the LMA test can generate 'false negatives' – i.e. generation of low or nil LMA expression when the variety may be capable of high expression. Accordingly, there is a small chance that a variety may achieve milling wheat status, only to subsequently experience receival point downgrades in some regions in some seasons when the LMA is expressed. In these particularly adverse situations Wheat Quality Australia, the body responsible for varietal classification, has stated that it reserves the right to downgrade any variety that expresses LMA in the field, meaning growers would no longer be able to deliver the variety into high priced grades, if at all. This limits the possibility of growers delivering LMA affected grain.

There are large differences between the wheat breeding companies in Australia regarding the proportion of material discarded due to failure to pass the LMA test. Over time the proportion of advanced lines liable to be rejected will diminish as breeders alter their parental material in crossing programs to favour those with less risk of containing the LMA defect. However, in recent years and in the near term it is likely that a similar proportion of advanced lines will continue to fail the LMA test. If a cost-effective and accurate LMA test could be implemented earlier in the breeding and release schedule, then a significant portion of the breeding effort could then focus on bringing forward more lines in which the LMA risk was low.

So, in summary, the current key issues for breeders are the test's limited throughput capacity, the late stage application of the existing LMA test, its cost, its efficacy in representing field conditions and the 'cliff face' or binary nature of the test outcomes whereby an intended milling variety can be appraised to only qualify as a milling wheat or a feed wheat.

The advantages of the current policy of managing the LMA risk is that it ensures growers avoid the risk of delivering grain that otherwise might be downgraded to feed if the test was not employed. Furthermore, marketers and processors are better protected against the risk of selling or using grain affected by LMA and so overall the reputation of the quality of Australian grain is upheld. However, conversely it means that growers might not have access to potentially high-yielding lines that are not released due to their LMA risk.

The cost of foregone yield may be high for growers in regions where the climatic risk of LMA expression is low. This cost of possibly foregone yield may diminish through time if breeding companies re-adjust their crossing programs to ensure more genetic material with low inherent LMA risk is included as parental stock. However, this period of transition may not be brief for a couple of reasons. Firstly, as pointed out by Mares and Mrva (2008) "with the advent of screening methods based on the imposition of a standard cool temperature shock treatment midway through grain development (Mrva and Mares, 2001), substantial numbers of commercial cultivars and breeding lines prone to LMA have been identified." (p. 8). Secondly, breeders may be loathe to lessen the genetic diversity of their germplasm through using LMA screening, if that results in lesser rates of genetic gain.

Breeding advancement is essentially a numbers game where large populations are required to generate gains from selection. If the size of the population from which selection can occur is reduced then the rate of advancement is liable to be less. Accordingly, in recent years where some breeding companies have been required to discard sizeable proportions of advanced lines due to LMA risk, it is possible that, at least in the near and medium term, a lesser rate of yield advancement results. Anecdotal and informal evidence from breeding companies is that some very high-yielding lines have been and are being discarded, with some sources, including wheat breeding companies, citing that breeding lines with up to 10 per cent yield advantage have been rejected.

However, the crucial comparison is the yield difference between the highest–yielding lines that pass the LMA test versus the highest–yielding lines that fail the LMA test (assuming both lines have equivalent characteristics of all other desirable traits). Such a comparison would often indicate relatively small percentage differences in yield; though as already stated these may be up to 10 per cent, with a conservative estimate being a 2 per cent yield improvement. Nonetheless even small percentages in yield difference are major sources of revenue in a large industry like Australia's wheat industry. Furthermore even small yield differences are likely to influence growers' varietal choices and thereby influence the end point royalty receipts of a wheat breeding company. Lastly, the history of varietal adoption does indicate that occasionally there are outstanding varieties and there is a risk that such 'outstanding' varieties are not made available to growers. An anecdotal example is the variety Wyalkatchem that proved to be a very high-yielding, widely grown variety that was classified as a milling wheat (Australian Premium White grade) in 2001. Apparently, under current LMA testing, the likelihood is that this variety would have been classified as a feed wheat. Hence, the variety may not have ever been released and so growers would not have enjoyed the yield advantages and milling grade prices that actually have transpired since 2001.

To-date there has been no economic assessment of the current LMA policy; nor any economic discussion of changes to that policy. This paper is a start to filling this gap in the economic literature. We use a numerical simulation of the wheat industry under alternate LMA management scenarios to identify whether there is a preferred policy for managing this defect. The simulation uses producer surplus as the proxy for net economic value, given the highly elastic demand function for exported wheat. The paper is structured as follows. The next section outlines the current policy regarding the measurement and management of the LMA risk. Then a methods section details the modelling approach to assess economic impacts of the current management policy and potential changes to that policy.

Current Management of LMA

Prior to deregulation of wheat marketing in Australia, the Australian Wheat Board undertook wheat classification, and established all wheat grades. Following deregulation, the Grains Research and Development Corporation (GRDC) assumed responsibility for the management and operation of wheat classification.

The GRDC and Grain Trade Australia established a company Wheat Quality Australia (WQA) to be responsible for wheat variety classification. WQA ensures that the quality of the classes of wheat available in Australia, now and in the future, meets the processing and end product requirements of key markets. WQA does this through two bodies: the Wheat Classification Council (Council) and the Variety Classification Panel (Panel).

The Council determines wheat classes/grades based on market requirements. A schema for the variety classification system is shown in Figure 1. The Panel assesses and classifies new wheat varieties into the grades established by the Council and the Panel is composed of technical experts. Part of the classification process is a laboratory-based LMA test. This system for LMA management was first introduced in 2004, and as such, varieties released after 2004 have been subject to the LMA test, and have low instance of LMA expression.

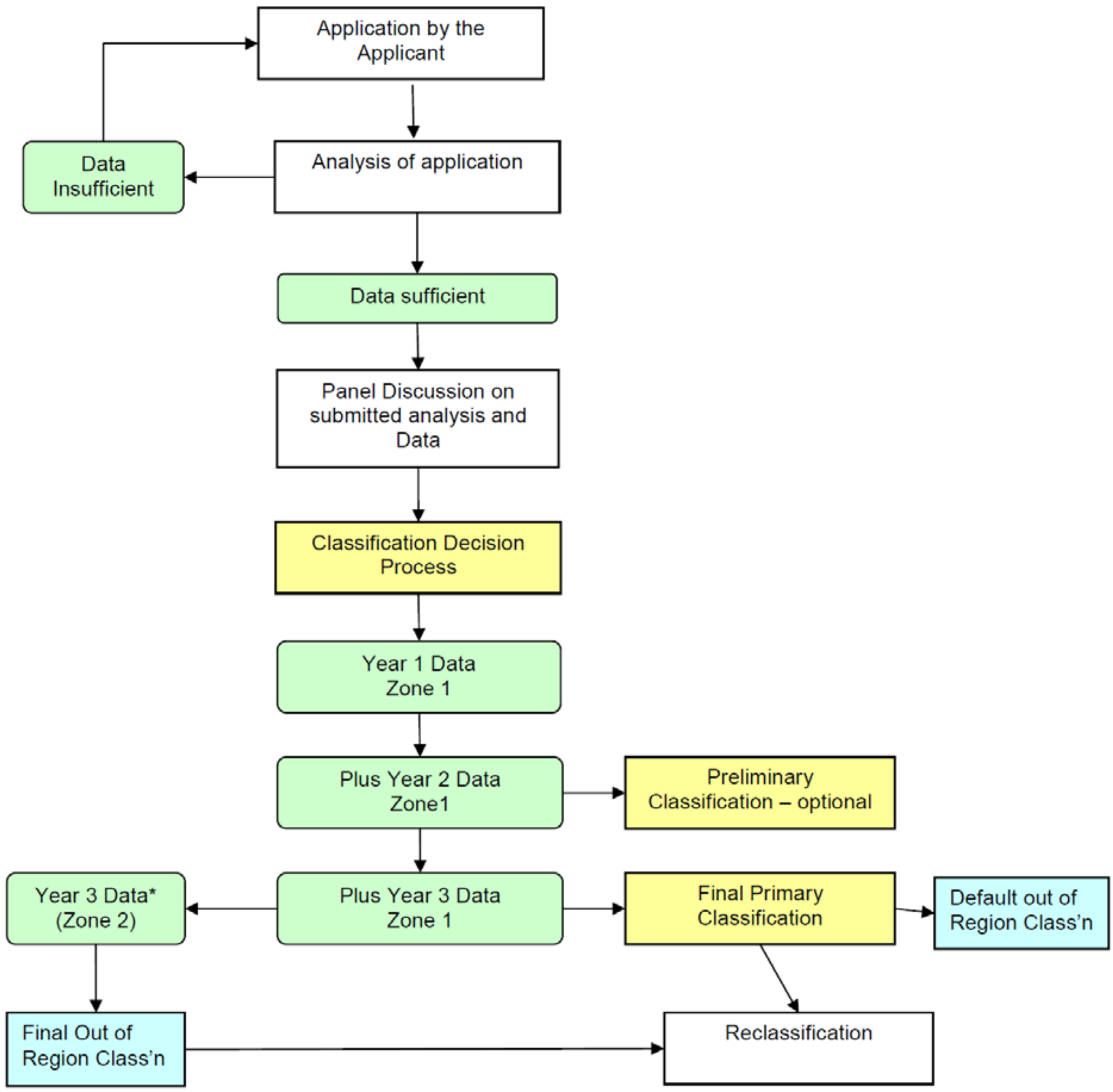
Methods

The method of assessing the impact of LMA and its management follows that espoused and applied by Edwards (1987), Brennan et al. (1989), Voon and Edwards (1992) and Alston et al. (1995). To illustrate the approach taken, consider the current situation in Western Australia (see Figure 2) whereby the majority of wheat varieties being adopted, and likely to be used in coming years, have little risk of LMA expression. A typical annual volume of wheat produced of millable quality in Western Australia is just over seven million tonnes which attracts an average FOB price of close to $275 per tonne. Under this scenario the annual value of wheat sales is around $1.95 billion.

Contrast that scenario with an alternative one that involves less stringent decision rules concerning LMA test results so that there is a greater likelihood of some higher-yielding lines becoming available, yet at some greater risk of LMA expression and consequential downgrades and price penalties for wheat grown (importantly assuming low falling number tests are more widely and frequently employed). This scenario (see Figure 2) is depicted by an increase in the wheat supply, yet accompanied by a lesser weighted price received by wheat producers. The lesser price is formed by a proportion of the wheat crop occasionally being subject to downgrade due to LMA expression and its revelation through receival point testing. In the particular scenario shown in Figure 2 wheat producers' revenues would decline due to the slight reduction in the expected price, and unchanged volume of production, in spite of the lesser unit cost of production attributable to the availability of higher yielding varieties. In this particular case, wheat producers would be no better or worse off due to less stringent decision rules surrounding LMA test results. Diagrammatically this is shown by comparing the producer surplus (shaded portions in Figure 3 and noting they are equal.

The preceding diagrammatic representation of impacts of a less stringent LMA management policy is of course a great simplification. In practice the magnitude of impacts will depend on many factors including the price differential between feed, general purpose and milling grades of wheat, the average proportion of a wheat crop that is subject to LMA expression, the likelihood that the expression of LMA will be tested for at receival points, the costs of such testing, the magnitude of greater yield advance achievable if the LMA test bar is lowered and the dynamics of industry change. Furthermore, any LMA management policy change is liable to affect different regions differently and affect key industry stakeholders (growers, wheat breeders, grain handlers and marketers) differently.

Figure 1: Variety classification system



Source: Wheat Quality Australia (2012) Wheat classification guidelines: version August 2012

Figure 2: Supply and demand scenarios associated with different LMA management policies

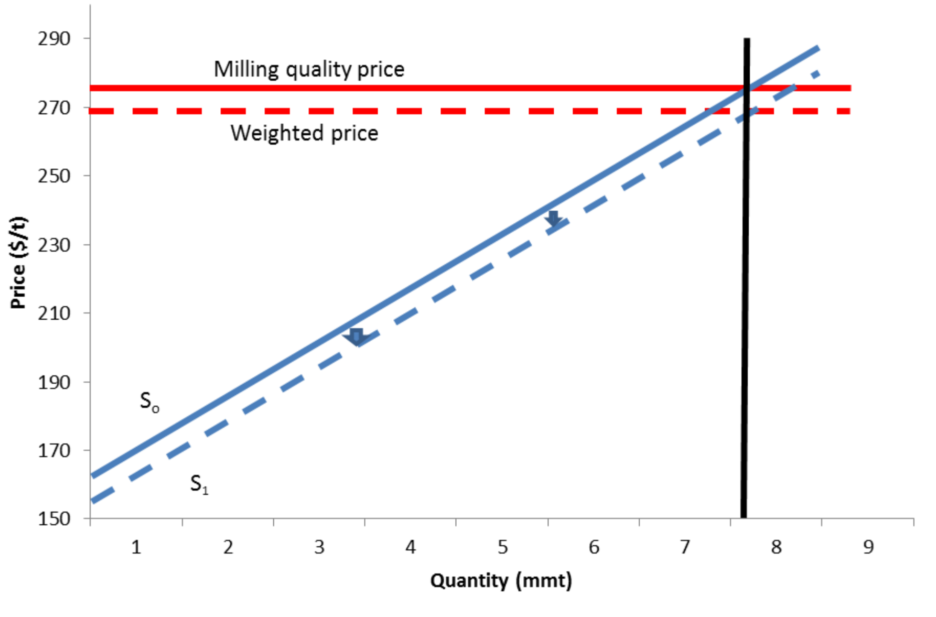
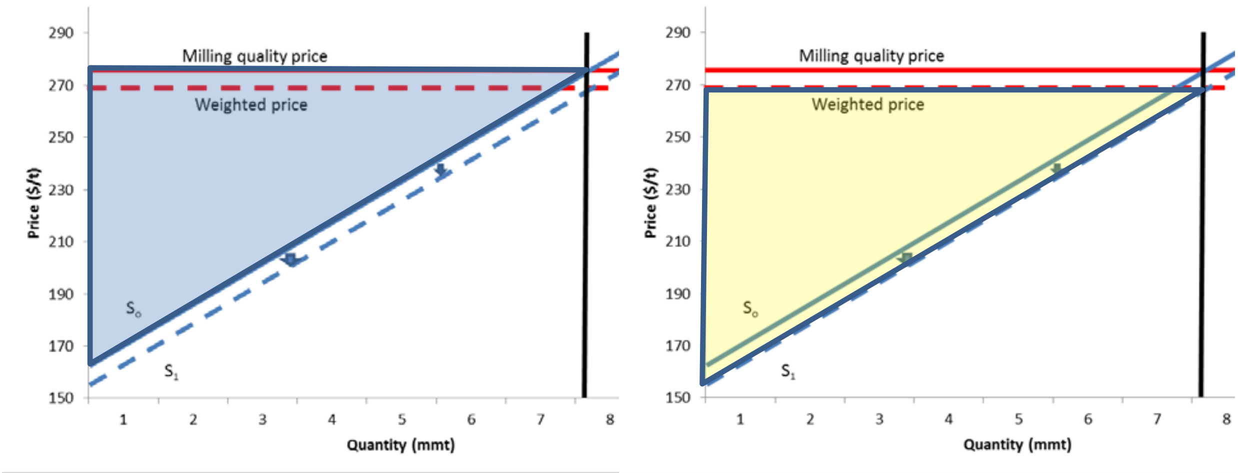


Figure 3: Producer surpluses associated with different LMA management policies



The more formal mathematical modelling approach taken, based on the preceding diagrammatic illustrations is as follows:

In spite of the WA wheat industry exporting a high proportion of its production, the exportable volume is small relative to the annually internationally traded volume. Moreover, WA wheat is substitutable by wheat from other sources in most applications. Hence, we assume a perfectly elastic export demand curve for WA wheat (Edwards and Simmons, 2004). Hence international demand for Australia's milling wheat is:

D_i=P_i

International demand for Australia's feed wheat is:

$D_f=P_f$ where $P_i>P_f$

The proportion of Australia's wheat crop that, under less stringent LMA testing, becomes on average annually downgraded to feed, is β where $0<\beta<1$.

The proportional improvement in the industry's average annual wheat yield, that flows from less stringent LMA testing, is δ where $0<\delta<0.15$. In other words, the yield improvement is less than fifteen per cent.

Australia's expected annual supply of milling wheat (Q_m) is:

$Q_m=C_m+bP$

Where C_m is the infra-marginal cost of milling wheat production, b is the slope of the supply response and P is the price of milling wheat.

The producer surplus in the absence of LMA expression (PS_1) is:

$$PS_1 = 0.5(P_i-C_m).(C_m+b_1P_i) \qquad (1)$$

The producer surplus where LMA is expressed (PS_2) is:

$$PS_2 = 0.5[((1-\beta)P_i+ \beta(P_i-P_f)-R)- C_m/(1+\delta)].[(C_m/(1+\delta))+b_2[(1-\beta)P_i+ \beta(P_i-P_f)-R]] \qquad (2)$$

where

$b_2= b_1/(1+\delta)$

and where R is an additional cost of testing grain on delivery at a receival site, that would be required with less stringent LMA varietal testing to ensure processors receive equivalent quality grain under a relaxed policy. The falling number test would hence change from a discretionary to a mandatory test, alongside protein, screenings, moisture and hectolitre weight tests.

Whether or not there is an economic case for allowing greater expression of the LMA risk or not depends on the magnitude of the difference between PS_1 and PS_2. If PS_2 exceeds PS_1 then there is economic support for the argument of lowering the LMA test bar. However, it requires noting that there are several variables in the calculation of PS_1 and PS_2 so it is highly likely that their difference will be uncertain. In practice, the difference will be variable so informed judgment will be required about the economic merit of any LMA management policy change.

To illustrate some of the uncertainties involved, consider the magnitude of the price differential P_i-P_f that features in the calculation of PS_2. Not only do these prices vary separately but so does their difference. Since mid-2007 the price for Australian Premium White (APW2) wheat, a key wheat segregation, has reached heights of over $450 per tonne and depths of around $220 per tonne. The FED1, a feed wheat segregation, price over the same period has reached a high of $410 per tonne and bottomed at around $155 per tonne. The daily differential between the two classes has been as great as $120 per tonne and as small as $30 per tonne.

The AWB pool return FOB prices of APW and Feed grade wheats from 1995/6 to 2005/6 display less volatility (Anderton and Kingwell, 2008). The difference between APW and feed grade wheats has ranged from $20 to $70 per tonne, and over the period has averaged $39 per tonne with a coefficient of variation of 41 per cent.

Another important source of uncertainty in the calculation of PS_2 is the magnitude of β, the proportion of Australia's wheat crop that, under a lower LMA bar, is on average annually downgraded to feed. Each wheat-growing region of Australia will have its unique value of β that is typically seasonally dependent (Anderton and Kingwell, 2008). It needs to be noted that β is not the proportion of

Australia's milling wheat production that on average is downgraded to feed. Rather it is the proportion of Australia's milling wheat production that on average is downgraded to feed or general purpose solely due to expression of LMA, assuming widespread testing for LMA occurs. Historical data for Western Australia shows that over the period 1989/90 to 2003/4 the proportion of the State's wheat crop that on average was classed as feed was 1.4 per cent whilst the proportion that on average was classed as general purpose was 9.9 per cent. The proportion of the crop classed as feed ranged from 0.04 per cent to 6.7 per cent and the proportion of the crop classed as general purpose ranged from 2.6 per cent to 25.8 per cent.

Mares and Mrva (2008) reported that substantial numbers of commercial cultivars and breeding lines prone to LMA were identified over the last several years. This suggests that, at least previously, a substantial proportion of wheat produced in Australia may have been at risk of LMA expression. However, it is the susceptibility multiplied by the probability of occurrence of the environmental triggers that generates the actual downgrades, not solely the prevalence of the LMA defect in the germplasm. The fact that historically a small proportion of the wheat crop was classed as feed suggests that the risk of downgrade to feed due to LMA expression is very small, perhaps on average less than one per cent (i.e. $\beta < 0.01$). However, this small proportion of feed grain also could be due to a lack of testing facilities for low falling numbers at either some receival points or in some years. Subsequently the background incidence of unidentified LMA affected grain would have been built into current milling wheat prices.

In WA, at least, the falling number test is mostly used when there is a high incidence of sprouting which can be identified visually. Also in WA, on average almost 10 per cent of the State's wheat crop is classed as general purpose. However, as indicated earlier, the percentage of general purpose wheat can range from less than three per cent to be a quarter of the State's wheat crop. Before testing for LMA became a compulsory part of variety classification it was likely that some delivered wheat would have been affected by the expression of LMA, causing low falling numbers leading to the delivered wheat being classed as general purpose. Hence, prior to the compulsory testing of advanced lines for LMA, it may have been likely that, in WA at least, on average each year around three per cent of the wheat crop would be downgraded to general purpose or feed grades due to the effects of LMA expression. However, in the absence of widespread and location-specific testing, it is not possible to be definitive about what proportions of downgraded volumes of wheat are solely due to LMA expression.

Another source of uncertainty is δ, the proportional improvement in the industry's average annual wheat yield that flows from less stringent LMA testing. As previously noted, breeding companies have indicated informally some very high-yielding lines with yields up to 10% higher than currently grower varieties, already have been and are being discarded due to failure to pass the current LMA test. However, the crucial comparison is the yield difference between the highest–yielding lines that do pass the LMA test versus the highest–yielding lines that fail the LMA test (assuming both lines have equivalent characteristics of all other desirable traits). Such a comparison would probably indicate relatively small percentage differences in yield, on average, are foregone. Nonetheless there may be cases where greatly superior lines are discarded due to their failure to pass the LMA test.

A source of further uncertainty is C_m which is the infra-marginal cost of milling wheat production. Essentially this is the cost of milling wheat production for the most cost-efficient producer; the price at which this producer would just be prepared to engage in milling wheat production. In practice such a producer might be one with ample stored soil moisture and highly fertile soils in paddocks previously prepared for wheat production. This producer's costs of wheat production would be unusually low, and given favourable yield outlooks, their costs per tonne of wheat supplied would be very low. However, identifying or imputing their actual costs of production is not without problems, causing the value of C_m to be uncertain.

To acknowledge and accommodate the inherent uncertainty in variables in equations (1) and (2) that importantly will influence findings, the following assumptions are made. Firstly, P_i, β, $(P_i\text{-}P_f)$, C_m and δ are all normally distributed variables, with their means and standard deviations set out in Table 1. The means of key variables to especially note are the $40 per tonne discount for feed wheat, the percentage of wheat crop downgraded to feed or general purpose due to LMA expression being 3.5 per cent, the additional yield improvement resulting from a less stringent LMA test being two per cent, and the infra-marginal cost of milling wheat production being $160 per tonne. Additionally the price discount for general purpose wheat is set at 40 per cent of the discount that applies for feed wheat.

The FOB milling wheat price is set at $275 per tonne. The cost for additional testing on delivery of grain at the receival site (R) is estimated as $0.5 per tonne (Lambe, *pers. comm.*).

Table 1: Means, standard deviations and coefficients of variation of key variables for impact assessment of LMA management policy change

Variable description	Symbol	Mean	Standard deviation	Coefficient of variation (%)
APW wheat price ($/t)	P_i	275	55	20
Probability of the wheat crop being downgraded to feed or general purpose due to LMA expression (%)	β	3.5	1.75	50
Price difference between APW and GP grade wheat ($/t)	$(P_i\text{-}P_f)$	40	16	40
Wheat production with no LMA (m tonnes)	$(C_m\text{+}bP_i)$	7.13	2.14	30
Infra-marginal (lowest) cost of milling wheat production ($/t)	C_m	160	32	20
Yield increase under a lower bar for LMA (%)	δ	2	0.4	20

Results

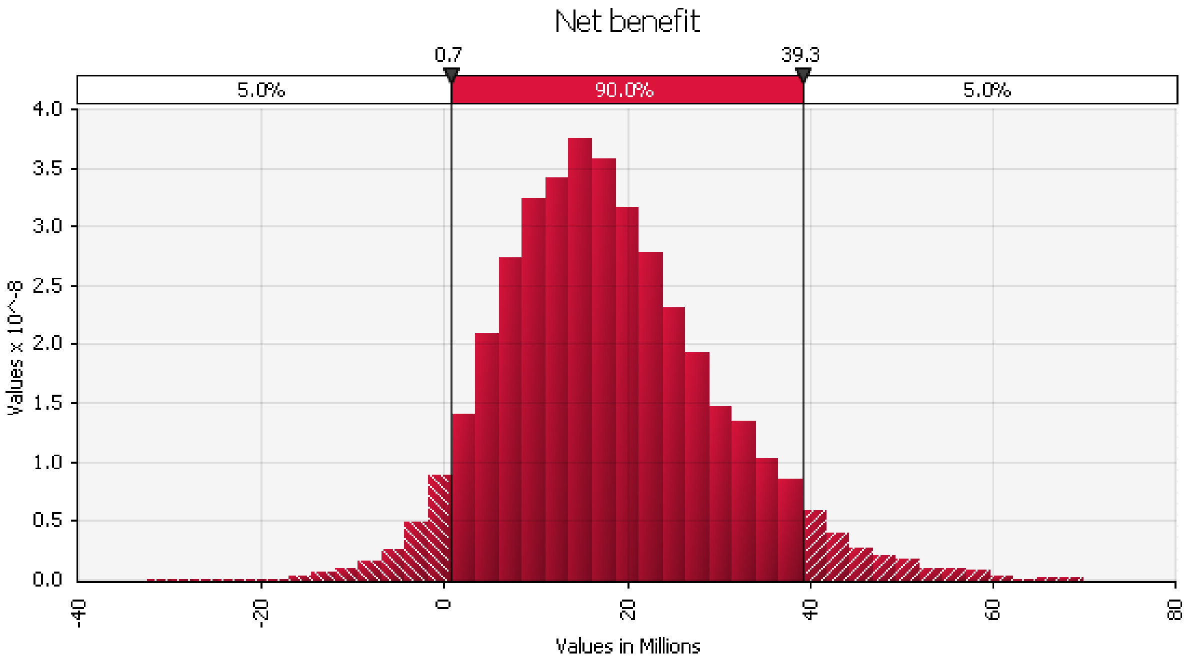
The values in Table 1 were used in a simulation of 10,000 samples from the range of assumed distributions. The simulation data was then used to calculate the differences in producer surplus. The overall mean results are listed in Table 2. These results imply an economic justification (at least in the interim) for less stringent classification decisions based on LMA tests. The industry annual benefit in Western Australia of lower acceptance bar attached to LMA tests is around $18 million, given the current set of variable specifications listed in Table 1. Moreover the distribution of possible benefits as indicated in Figure 4 displays a slight positive skew.

Table 2: Mean results of a 10,000 draw simulation

Variable description	Value
Mean of net benefit ($million)	18
Standard deviation of net benefit	11.9
Skewness	0.58
Median net benefit ($million)	16.8

There is little prospect of industry losses under the range of variable specifications listed in Table 1. As shown in Figure 4 90 per cent of net benefit values lie within the range $1 million and $39 million. Almost always, positive net benefits will be generated, provided the assumed specifications of variables apply. However, there is a marked variation in returns as indicated by the size of the net benefit standard deviation and as illustrated by the spread of values in Figure 4.

Figure 4: The distribution of annual benefits in Western Australia of a less stringent LMA test



The sensitivity of net benefits to changes in each key variable is illustrated in Figure 5. To generate the results in Figure 5 each variable was first set at its mean value. Then each variable was separately subject to fluctuation (i.e. sample draws) to gauge how the net benefit was altered by changes in each variable, whilst all others remained set at their mean values. The factor that most influenced the magnitude of industry benefits in Western Australia was shown to be the size of the yield increase associated with a relaxation of the LMA test. The possible range of yield changes resulted in the net benefit level ranging from $7.1 million to $29.8 million.

The probability of the wheat crop being downgraded to feed or general purpose due to LMA expression also was found to crucially affect the size of industry benefits. This parameter is used to weight the milling wheat and feed wheat prices, and hence the expected price of the crop. This parameter is assumed to be independent of the price differential between the two qualities of wheat.

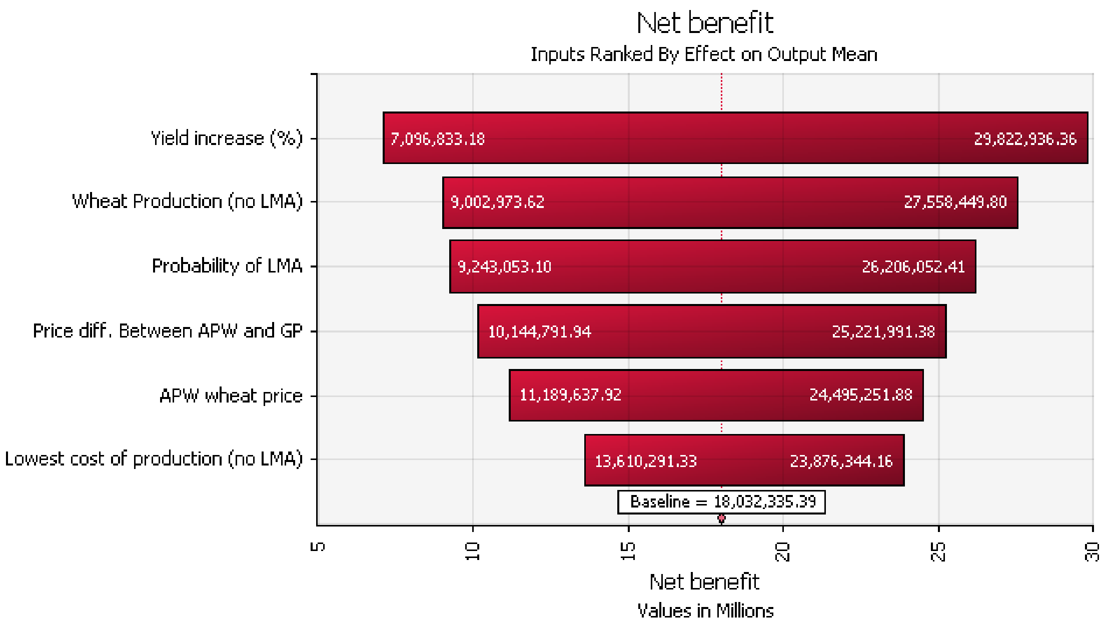
Other variables found to be important were the wheat production when LMA is absent as a defect; percentage of the wheat crop downgraded to either feed or general purpose due to LMA expression; the price differences between milling, general purpose and feed grade wheat.

Discussion

A key assumption in this analysis is that there is equal risk of exported wheat being contaminated with LMA affected grain, under each policy scenario. We know that presently and in recent years all varieties classified as milling wheats have passed a fairly stringent LMA test and thus are unlikely to be highly susceptible to LMA expression in the field. Moreover, WQA has the right to alter a variety's classification if such serious expression is found to occur. However, a proportion of growers will continue to use older varieties (like Wyalkatchem) that have an inherent higher risk of LMA expression. Given that these older varieties are purchased by processors, despite the risk of LMA affected grain, it can be safely assumed that the processors know the risk, and include the cost of that risk in their bid prices. Moreover, this would indicate that there is currently some tolerance to a background level of LMA affected grain.

Relaxing the bar on the LMA test will increase the likelihood of some varieties being classed as milling wheats that otherwise would have been classed as feed wheats. However, these varieties will have a greater likelihood of LMA expression. Consequently, in the absence of sufficient testing at grain receival points, there is *a priori* an increased risk of LMA expression and thus a higher risk of LMA-affected grain forming part of grain harvests. To combat this increased risk of LMA affected grain contaminating exported wheat, we assume that additional resources are used in testing grain at receival points to lower this risk. Specifically we impose an additional small cost on growers' costs of production sufficient to cover increased testing for LMA at receival points estimated at $0.5 per tonne, imposing an additional $3.5m cost on the industry per annum. Additional to this cost is the price penalty imposed on the older varieties when they express LMA that would not previously have been detected at receival sites. This detection is included in the modelling as a proportion of the β variable.

Figure 5: Sensitivity analysis of impacts on the annual net benefit of changes in variables



However, testing at receival points has additional drawbacks. The falling number test used to identify sprouted and LMA affected grain can take up to six minutes, not including time for preparation of the grain. Given the volume of deliveries during the harvest period, the additional time and resources required for LMA testing would result in significant delays at delivery sites. Slower turn-around times would increase growers' logistics costs at harvest and increase costs incurred by grain handlers who need to provide the staff and testing equipment and make contingencies for stack segregations. How extensive needs to be the testing for LMA-affected grain to ensure the risk of contamination is unchanged from current levels is an issue for statistical analysis and inference, and is not without its own complexities.

It may be possible to use several testing systems in combination to reduce the need for falling number tests in regions where there is a low likelihood of LMA expression. These include a more rigorous field-testing regime of pre- and post-release varieties and greater use of weather station information to assess potential for LMA expression at particular locations or in particular seasons. More rigorous field testing procedures would allow better understanding of the likelihood of LMA expression, with several benefits. One benefit would be better information on the riskiness of the variety that would allow growers to make more informed decisions regarding varietal choice. Additionally, more extensive field testing would allow collection of better information on the seasonal conditions that trigger LMA expression. Maps of these seasonal conditions could then guide LMA testing at particular receival points, thereby avoiding testing and logistics delays at sites where the risk of LMA expression is low.

Conclusion

Late maturing α-amylase (LMA) is a genetic defect in some wheat lines that when triggered by particular environmental conditions damages the grains' starch and reduces its suitability in processing. To lessen the risk of LMA expression in Australia's wheat crops, a testing regime is now part of the nation's varietal classification system. This study has used a simulation of supply and demand conditions to estimate the change in producer surplus in the wheat industry from relaxing the current testing policy for LMA expression. In the relaxed scenario there is an increased likelihood that more higher-yielding wheat varieties would be classed as milling wheats but that they would contain a higher risk of LMA expression.

We assume additional testing for LMA occurs at receival points in order to identify this increased risk with the result that affected loads are downgraded to feed. These downgrades alter the farmer's expected price of wheat produced, with the farmer's supply response being based on an expected price. The expected price is determined using the probability of wheat being downgraded and the differential between the two grades, milling versus feed grade.

The model of change in producer surplus includes several uncertain variables including: the wheat price, wheat grade price differentials, the probability of downgrade, wheat production, potential yield improvement following a lower bar on the LMA test and the infra marginal cost of production for wheat. Model simulations based on 10,000 random draws from the distributions of the uncertain variables generate the finding that the mean net benefit from a more relaxed LMA policy is $18 million per annum, with a standard deviation of 11.9. This result is based on data and assumptions for the Western Australian wheat industry that is the source of almost half of Australia's wheat exports.

This paper does discuss the practical issue of greater testing for LMA expression at receival points. Such testing is required if there is to be no change in the underlying risk of LMA contamination of millable wheat sales, in order to preserve the market reputation of Australian milling wheat. To manage both the risk of LMA contamination and the increased cost of testing, there may be a role for weather forecasting and observation systems to inform the spatial allocation of falling number test sites. If the grain testing systems could be targeted to high risk areas through use of forecasting and observation data, the total cost of implementing the test procedures would be reduced, with little increase in risk. Targeted allocation of test sites would also reduce the temporal impact from increasing the test times at the receival sites. The weather information could even be extended to assisting growers to decide which varieties would be more or less likely to exhibit LMA, given their location. This study points to the desirability of a lower bar for the LMA test; albeit the nature and extent of LMA testing at receival points, and possible use of existing data and systems to create optimal testing procedures, warrants further study and policy decision-making.

The current LMA policy, with its cliff face evaluation may exclude some higher yielding varieties, and especially disadvantage wheat growers in regions that rarely have seasonal conditions likely to trigger LMA. Further analysis of the regional implications would be beneficial to broaden industry discussion, as would expanding the current analysis from assessing the impact of LMA policy in Western Australia to other wheat-growing regions of Australia.

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