WORKING PAPER

Permanent Water Entitlements and Risk Management

DR STEPHEN BEARE

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1.1 Permanent Water Entitlements and Risk Management

Water users can obtain water through holding or purchasing permanent water entitlement or through the physical water market in which current water allocations are traded. It can be argued that the expected return from either alternative should be the same if water markets are operating efficiently in the absence of any manageable risks. However, the business risks associated with holding a permanent entitlement versus purchasing water on an annual basis are not the same. As a consequence, water users that have restricted access to permanent entitlements may be economically disadvantaged.

Access to permanent water entitlements is an important risk management tool for irrigators and other water users who have significant fixed investments. Irrigated horticulture, with fixed investments in tree crops and vines, irrigation systems and delivery infrastructure, is the specific example considered here. However, the issues discussed extend to any water user with large investments in fixed infrastructure or the responsibility for the ongoing management of environmental assets.

A permanent water entitlement can be used as a hedge against adverse price movements in water allocation markets due to reduced water availability and increased water demand. Limiting financial exposure with a hedge has a number of benefits:

- Individuals will tend to prefer a more certain income stream over a more variable stream, as long as the risks are symmetric. Given an investment with the same expected return they will generally be willing to pay a premium to obtain greater certainty;
- An individual will tend to prefer a reduced probability of very low returns for a given average return. That is, they will prefer a greater probability of a slightly below average return if there is a reduction in the risk of a large loss. This can:
    - Increase the probability of being able to meet loan and other fixed payments; and
    - Reduce the probability of business failure.

The first point is reflecting that individuals tend to demand a greater return if they take on an additional level of risk. The second point highlights that the symmetry of the risks faced can be important. The last of the two points bears a direct relationship to the access to credit and cost of borrowing. Greater income certainty and the reduced risk of large losses of certainty can both reduce the cost of debt financing.

A hedge can be created through the acquisition of a financial or real asset with a value that is:

- Inversely correlated to the value of an output of a business enterprise; or
- Positively correlated to the cost of an input into a business enterprise.

In the first case the risk of a fall in the output price is expected to be offset, all or in part, by the increase in the value of asset held as a hedge. A windfall gain due to an increase in the output price will also be offset by a fall in the price of the asset. The overall result being that revenue is less variable. In the second case, a rise in the cost of an input is expected to be offset by an increase in the value of the asset held as a hedge. A decline in the input price will be offset by a fall in the price of the asset. The overall result being that costs are less variable.

A permanent water entitlement can act as a hedge if:

- The value of the allocation derived from the entitlement increases as seasonal market price increases; and
- The value of the allocation derived from the entitlement falls as seasonal market price falls.

The effectiveness of a permanent water entitlement as a hedge against an increase in the price of water in the allocation market depends on the relationship between the water prices and the value of the entitlement in a given season or year. That is, the correlation between allocation market prices and those prices times the volume of water allocated on a season-by-season basis. This will differ if the price change is due to an increase in demand or a reduction in availability.

Prices in physical markets for water allocations may change in response to short term factors such as dryer and hotter growing conditions and longer-term factors such as an increase in government purchases of water for the environment. In this case a permanent entitlement is a perfect hedge. As there is no change in the yield of the entitlement, the value of the entitlement in a given season changes by the same proportion as the price in the allocation market due to a shift in demand.

Prices in physical markets for water allocations may change in response to changes in the level of available resources, due for example to reduced inflows into upstream storages or changes to the administrative rules that govern the share of available resource made available for use by entitlement holders. In this case the hedge is unlikely to be perfect as:

- The yield of the entitlement in a given season may fall and the price of water will rise; or
- The yield of the entitlement in a given season may rise but the price of water will fall.

Whether the value of the entitlement in that season increases or declines depends on two factors:

- The response of aggregate water demand to a change in price; and
- The relative security of the entitlement. That is, the security of the entitlement held relative to the average level of security for all water entitlement holders.

If demand is price inelastic, the percentage change in prices will be greater than the percentage change in the volume of water available, therefore the value of the water entitlement with an average level of security will increase as allocation levels fall. The hedge will tend to offset price risk in the allocation market due to changes in availability. If demand is price elastic, the percentage change in prices will be less than the percentage change in volume of water available. The value of the entitlement with average security will fall as allocation levels fall. The hedge can potentially increase the risk associated with water availability although overall risk may still fall if there is enough variability in demand.

However, for more secure entitlements, the variability in allocations will be less than for the average for all entitlement holders. As a consequence, the correlation between the values of high or more secure water entitlements in a given season with prices in the allocation market will be higher. The effectiveness of the hedge will be greater. Conversely, allocations derived from entitlements with a lower than average level of security will be more variable. As a consequence, the correlation between the values of low or less secure water entitlements in a given season with prices in the allocation market will be lower. The effectiveness of the hedge will be lower and ultimately the hedge may increase as opposed to reduce risk.

The importance of being able to hedge against an increase in the price of water in the allocation market is related directly to the fixed assets that in turn shape the business enterprise's demand or willingness to pay for water. There are three key points:

- Within a season, the willingness to pay for water is constrained by the need for revenue to cover at least the variable costs of production. That is, a business is still better off earning a low rate of return on its fixed assets rather than no return.
- A business may choose to incur costs that are greater than revenue if fixed assets, such as orchards and vines, will incur an irreversible loss in value, as for example, through reduced yields into the future.
- The size or capacity of the fixed assets is likely to constrain maximum water demand and the willingness to pay for additional water may approach zero as this level is reached.

Each of these points implies that the demand for water at the enterprise level can be highly inelastic or non-responsive to price changes within a season and, importantly, over the life of the fixed assets.

This inelasticity at the enterprise level will also tend to be reflected in the aggregate demand for water in the allocation market especially at relatively low allocations and relatively high prices. In the longer term, investments in infrastructure can adjust to generate market rates of return and the demand for water will be more price responsive.

The value of being able to more effectively manage risk through a hedge will also depend on the exposure of the business to debt. Low level of equity increase the risk of business failure and fixed repayments add to the relative variability of disposable income.

Ideally, a permanent water entitlement would be held in the same market area as one would expect to trade in seasonal water allocations. That is, an entitlement that allows delivery within the same trading region that an enterprise would source water from the allocation market. This will tend to increase the likelihood that value of the entitlement in a given season will move in line with prices in the relevant physical water market.

Sourcing a permanent water entitlement from an external region can still serve to offset the risk of sourcing water in the local market. However, to the extent that conditions affecting water availably and demand vary independently between the external and local market, the hedge becomes less effective. Again, the hedge may increase as opposed to limiting the level of risk. This would occur if the value of the water entitlement in any give season tended to be negatively correlated with prices in the local allocation market. This does not mean that prices need to be negatively correlated but that value of the entitlement in season, price multiplied by the volume in the external market, is negatively correlated with the price of water in the local market.

1.2 An illustrative example

Before attempting to quantify the value of a hedge achieved by holding a permanent entitlement with enterprise and regional water market data (which we will present in the main empirical report), it may be useful to construct a simple model to illustrate how the main factors influence the effectiveness of a permanent entitlement hedge. The model calculates the distribution of key financial variables for a long term fixed investment in stylized horticultural enterprise using Monte-Carlo simulation.

1.2.1 The aggregate allocation market

Let A_{Hi} and A_{Gi} be the seasonal allocation of high and general water in year i, expressed as a percentage of the respective total nominal entitlements ET_H and ET_G. The nominal entitlement is the number of megalitres attached to the entitlement. It is assumed here that this is the maximum level that will be allocated in any given season. Allocations are assumed to be generated from a multivariate log-normal distribution according to the formula:

$$A_H = 100 - \varepsilon_{A,H}$$

$$A_G = 100 - \varepsilon_{A,G}$$

$$\varepsilon_A : \log normal\left(mu_A, sigma_A\right)$$

The terms mu_A and $sigma_A$ are the means and variance covariance matrix of the multivariate distribution. The covariance captures the tendency for high and general security entitlements to move together (the use of a distribution that is not correlated over time has the potential to understate the risks faced by perennial crop producers, as will be made more clear when we consider the enterprise structure).

For the example, the assumed distribution parameters are provided in the table below. The assumed variance covariance matrix has an expected coefficient of correlation of 0.80 between high and general security allocations. Allocations are restricted to fall between 0 and 100 percent with random values outside that range restricted to their corresponding limit. This windsorises, as opposed to trims, the distribution of allocations.

Table 1 Distributional assumptions for high and general security water allocations

	Mean	*Variance/Covariance*	
High Security	0.10	0.0500	0.0007
General Security	0.25	0.0007	0.1500

In Figure 1, a box and whisker plot of the high and general security allocations is shown. The box frames the 25^{th} to the 75 percentile with line in the box at median. The whiskers extend to approximately the 1^{st} and 99^{th} percentiles. The points extending beyond the whiskers are the extreme values. The scatter plot of the high and general security allocations, shown in Figure 2, illustrates the correlation in allocations between the two classes of entitlements.

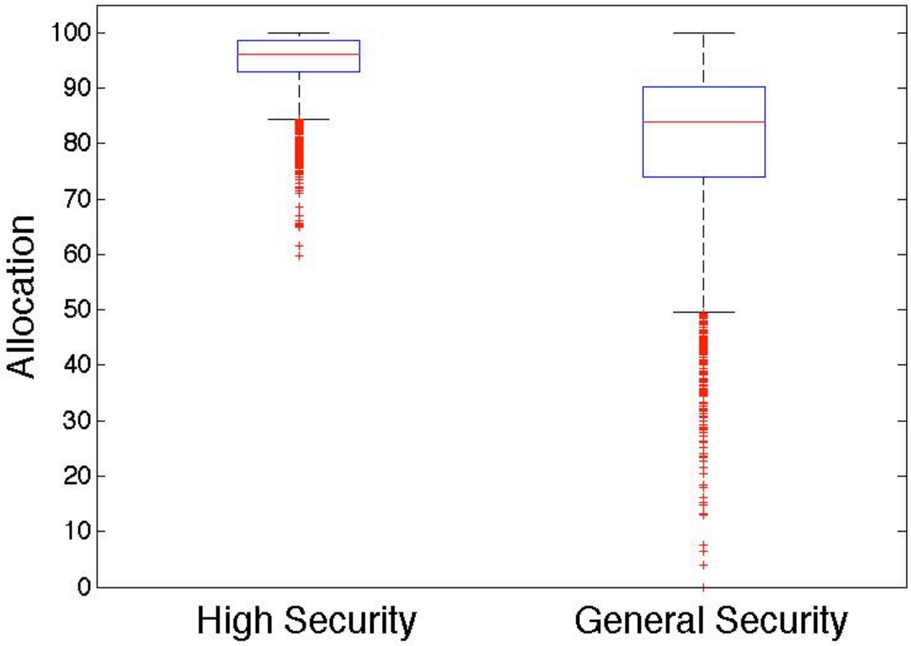

Figure 1 Distribution plots for the simulated high and general security allocations

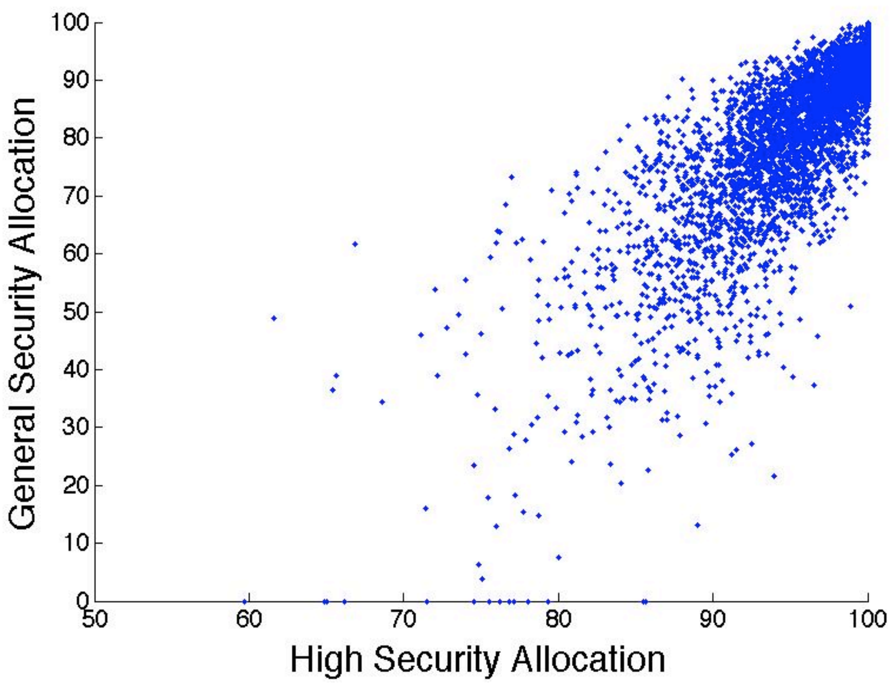

Figure 2 Scatter plot of high and general security allocations

We can express the total allocation as a percentage of the total nominal entitlement of high and general security water:

$$A_I = \frac{ET_H}{ET_H + ET_G} A_{H,i} + \left(1 - \frac{ET_H}{ET_H + ET_G}\right) A_{G,i}$$

It is clear that the security of the total allocation is less than for high security entitlements but greater than for general security entitlements.

The allocation market price is assumed to be a function of the total allocation and random normal process. The choice of a functional form for the demand relationship is important. Linear demand curves tend to be less prices responsive or elastic the greater the volume of water available. This is contrary to intuition that water demand becomes less price responsive as water becomes increasingly scarce. A multiplicative or constant elasticity formulation may provide a better approximation and will help isolate sensitivity of the model to the price responsiveness of demand:

$$P_i = \alpha_0 A_i^{\alpha_1} \varepsilon_{D,i}$$
$$\varepsilon_D : normal\left(1, \sigma^2\right)$$

The elasticity of demand, $1/\alpha_1$, has been identified as a key parameter in determining the effectiveness of a permanent entitlement as a hedge. The relative contribution of demand versus supply side variability is also important. Some alternative assumptions are explored, as set out in the following table.

Table 2 Demand characteristics assumed for modelled scenarios

Scenario	*Elasticity*	α_0	α_1	σ^2
Inelastic demand	-0.666	100	-1.500	0.0225
Very inelastic demand	-0.333	100	-3.000	0.0225
Elastic demand	-1.500	100	-0.666	0.0225
Greater variation	-0.666	100	-1.500	0.0900

Given the distributions of high and general security allocations shown in Figure 1 and assuming that high security accounts for 15 percent of the nominal entitlements, the corresponding distribution of allocation market prices is shown in Figure 3. A simple percentage bias correction was applied so that each price series has the same mean. This was done to ensure that the value of the entitlements were the same for each scenario allowing us to focus more clearly on the impact of a hedge on the variability of returns

The assumption that water availability and water demand are uncorrelated may again understate the risk associated with buying water in the allocation market.

Given that an entitlement is for a finite number of years N with a discount rate r, the value of a high and general security entitlements, V_H and V_G are:

$$V_H = \mathrm{E}(PA_H)\sum_{t=1}^{N}\frac{1}{(1+r)^t}$$

$$V_G = \mathrm{E}(PA_G)\sum_{t=1}^{N}\frac{1}{(1+r)^t}$$

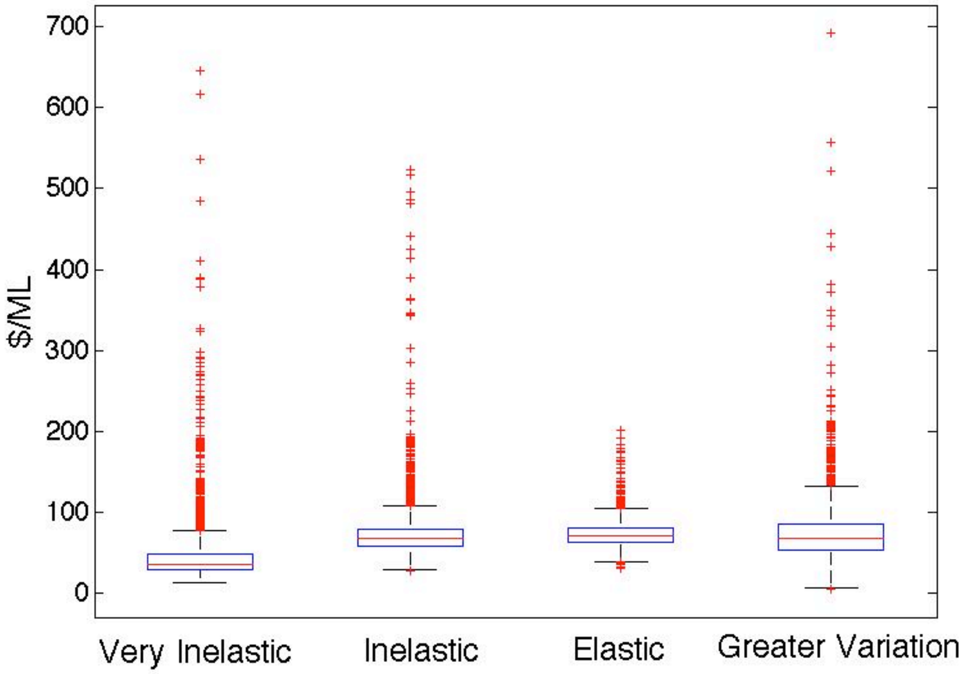

Figure 3 Price distributions for the demand scenarios

Over a limited time horizon there will be differences in the expected versus the realized value of an entitlement. The expected value of a high and general security entitlement, along with the standard deviation, is shown in the Table 8, given that the entitlement is held for a period of 40 years at a discount rate of 7 per cent.

Table 3 Expected value of high and general security entitlement

Demand Scenario	*High Security* mean	std	*General Security* mean	std
Inelastic demand	$1,436	$102	$1,161	$35
Very inelastic demand	$1,414	$239	$1,073	$66
Elastic demand	$1,446	$49	$1,203	$46
Greater variation	$1,463	$114	$1,163	$63

There is over a 20 per cent premium for high security entitlements but a greater level of variation in realized value, as indicated by the standard errors. This is due to higher average volume of high security allocations. There is also a stronger negative correlation between general security allocations and market prices as general security entitlements provide the bulk of annual allocations.

This specification ignores any market value of a hedge that can be achieved through a permanent entitlement. This point is important and examined later in this report.

1.2.2 The enterprise structure

The enterprise is intended to represent a typical investment in horticulture. The investment is assumed to have a life of N years. The capital investment in assets excluding water is K_0 dollars per hectare with a salvage value of K_{N+1} per hectare. The enterprise has the option of purchasing any combination of high and general security entitlements, A_{EH} and A_{EG}, again on a per hectare basis at prices V_H and V_G, respectively.

The enterprise returns a net output price, P:

$$P_{Output} \sim normal\left(\mu_{Output}, \sigma_{Ouptut}\right)$$

This specification subsumes all other production costs that are not correlated with the cost of water. Gross revenue per hectare is the simple product of net output price and yield per hectare, y.

The absolute maximum yield is YMAX. At any point in time there is a maximum possible yield $Ymax_t$. The realized yield is a function of total water use, W_t, and the linear coefficients β_i:

$$yield_t = \frac{Y\max_t}{1+\exp\left[\left(-(\beta_0+\beta_1 W_t\right)\right]}$$

We also allow for long-term yield damage and recovery. The loss in maximum potential yield is:

$$yieldLoss_t = \begin{cases} \dfrac{MaxYieldLoss}{1+\exp\left[\left(-(\gamma_0+\gamma_1 W_t\right)\right]} & W_t < threshold \\ 0 & otherwise \end{cases}$$

where γ_i are linear coefficients. The yield and long term yield loss functions are illustrated in Figure 4.

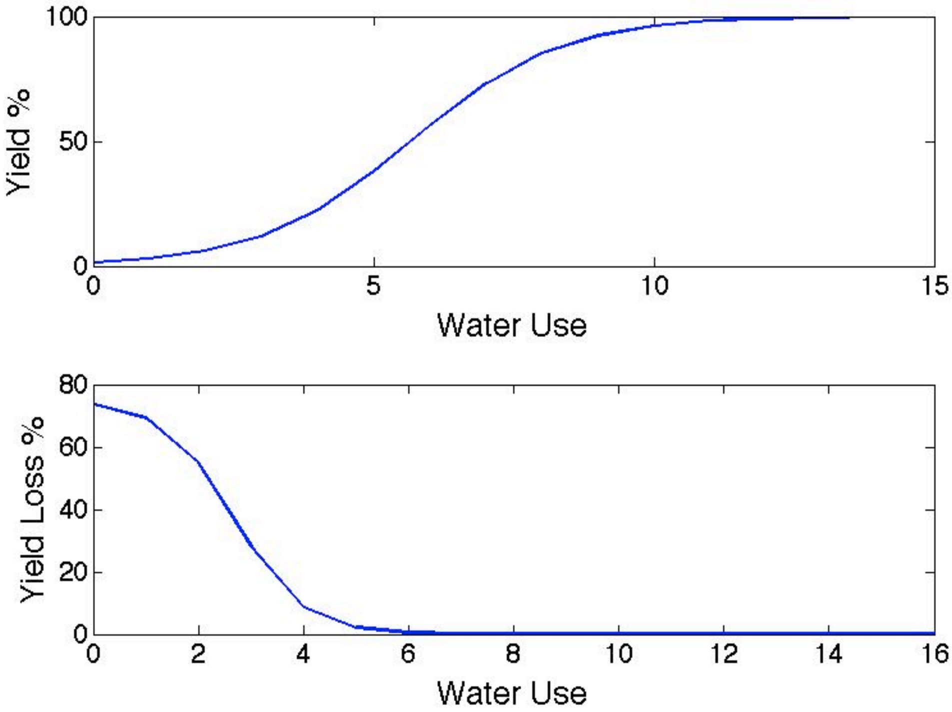

Figure 4 Logistic yield and long term yield loss functions

If water use is above the threshold then yields can partially recover at rate δ. This leads to the dynamic specification of maximum yield:

$$Y\max_t = \begin{cases} Y\max_{t-1} - yieldloss_{t-1} & if\ W_{t-1} < threshold \\ Y\max_{t-1} + \delta\left(YMAX - Y\max_{t-1}\right) & otherwise \end{cases}$$

Water use is the sum of the allocation, useful rainfall and any net purchase (less sale) of water in the allocating market, w:

$$W_t = A_{EH}A_{H,t} + A_{EG}A_{G,t} + \frac{rain_t}{100} + w_t$$

$$rain : \log normal\left(\mu_{rain}, \sigma_{rain}\right)$$

Rain is expressed in mm and converted to ML per hectare. Water purchased or sold in the allocation market is at the prevailing price.

Water use is determined by maximising the net present value of the stream of annual profit, subject to the constraint on maximum yield:

$$\underset{W}{Max}\sum_{t=1}^{N}\left(\frac{P_{Ouput,t}Y\max_t}{1+\exp\left[\left(-(\beta_0+\beta_1W\right)\right]}-P_tw_t\right)/(1+r)^t$$

$$Subject\,to:$$

$$w=\begin{cases} W-A_H-A_G-rain & if\ W>rain \\ -A_H-A_G & otherwise \end{cases}$$

$$Y\max_t=\begin{cases} Y\max_{t-1}-yieldloss_{t-1} & if\ W_{t-1}<threshold \\ Y\max_{t-1}+\delta\left(YMAX-Y\max_{t-1}\right) & otherwise \end{cases}$$

In additional there are the financial calculations associated with debt financing. Given the enterprise has an initial equity level EQ and an interest rate *i*, annual debt levels are calculated as follows:

$$Debt_t=(1+i)Debt_{t-1}-payment_{t-1}$$

$$Debt_0=EQ\left(K_0+V_HET_H+V_GET_G\right)$$

$$annuity=\frac{iDebt_0}{1-(1-i)^{-N}}$$

$$payment_t=\begin{cases} annuity & if\quad annuty<netrevenue_t \\ netrevenue_t & otherewise \end{cases}$$

Disposable income, Y, is:

$$Y_t=\begin{cases} netrevenue_t-payment & if\ \ netrevenue_t<payment \\ 0 & otherwise \end{cases}$$

The parameters used in the enterprise model are shown in Table 4.

Table 4 Parameters used to represent the irrigation enterprise

Parameter	*Value*	*Parameter*	*Value*
N	40 years	Threshold	4ML/ha
K_0	\$50,000/ha	MaxYieldLoss	75
K_{N+1}	\$1,000/ha	γ_0	4
μ_{Output}	\$100	γ_1	-1.5
σ_{Output}	\$15	μ_{Rain}	350mm
YMAX	100	σ_{Rain}	75mm
β_0	-5.0	i	0.07
β_1	7.5		

The scenarios considered are based on the permanent allocations held and the initial level of equity of the enterprise, as outlined in the following table.

Table 5 Amount of entitlement held for each scenario (ML)

Scenario	*High Security*	*General Security*
No Hedge	0	0
High	10/ha	0
General	0	10/ha

1.2.3 Results

The demand and entitlement and equity scenarios were evaluated by repeatedly solving the enterprise level water demand problem over the 40 year planning horizon. For each unique scenario the model was solved 100 times. This allowed the effect of different entitlement holds on financial performance to be explored. In particular, the impact on the variability in the net present value of the enterprise, disposable income and terminal debt levels are examined.

Table 6 Profit, disposable income, and terminal debt for modelled scenarios

Scenario/	No Hedge		High Security		General Security	
Value	Mean	Std	Mean	Std	Mean	Std
Inelastic Demand - Elasticity = -0.666						
NPV π	$8,895	$999	$8,895	$311	$8,895	$992
Income	$2,700	$1,286	$3,702	$1,256	$3,513	$1,288
Debt	$2,701	$5,865	$0	$0	$791	$3,294
Very Inelastic Demand - Elasticity = -0.333						
NPV π	$9,432	$1,653	$9,432	$1,066	$9,432	$1,154
Income	$2,743	$1,331	$3,723	$1,259	$3,487	$1,300
Debt	$6,231	$8,989	$0	$0	$884	$3,558
Elastic Demand - Elasticity = -1.500						
NPV π	$8,832	$583	$8,832	$266	$8,832	$692
Income	$3,698	$1,269	$3 529	$1.263	$2,684	$1,275
Debt	$1,106	$3,813	$0	$0	$125	$1,252
Greater Variability - Elasticity = -0.666						
NPV π	$9,027	$1,014	$9,027	$388	$9,027	$900
Income	$2,704	$1,300	$3,705	$1,268	$3,517	$1,289
Debt	$3,727	$6,785	$0	$0	$366	$2,116

Starting with profits and the inelastic demand scenario it is clear that the high security hedge reduces the variability in the net present value of profits and annual disposable income by around 69 and 29 per cent, respectively Thegeneral security hedge does not reduce the variability of either profit or income. The distribution of the net present value of profit is shown in Figure 5. The high security entitlement hedge is quite effective in reducing the variability of returns over the 40 year horizon. With the general security hedge the variability of returns is not reduced.

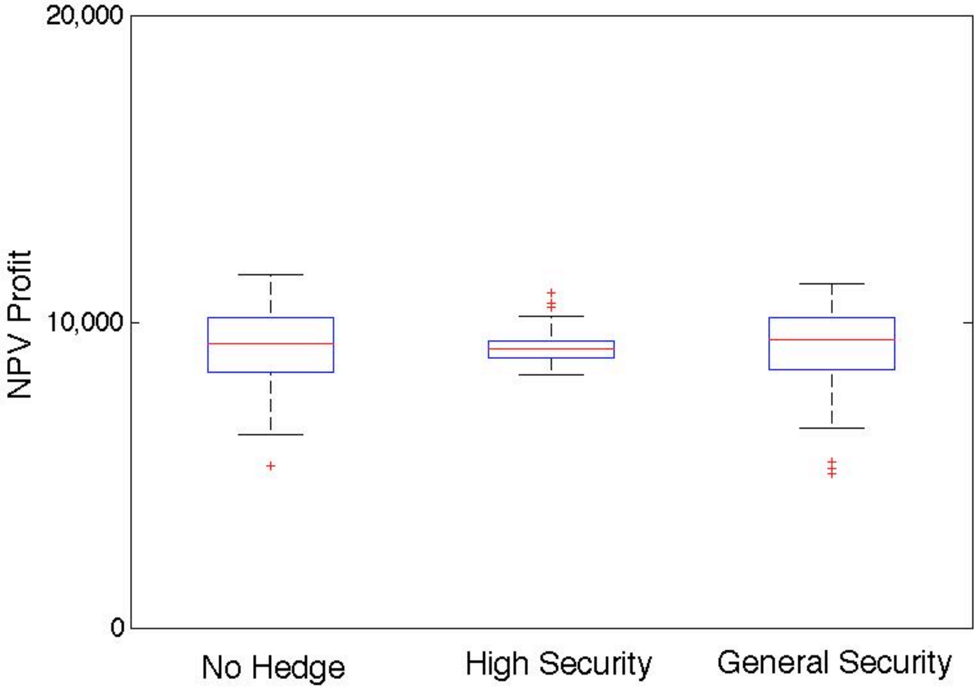

Figure 5 The distribution of profit ($) in net present value terms for the three hedge scenarios with an inelastic aggregate demand for water

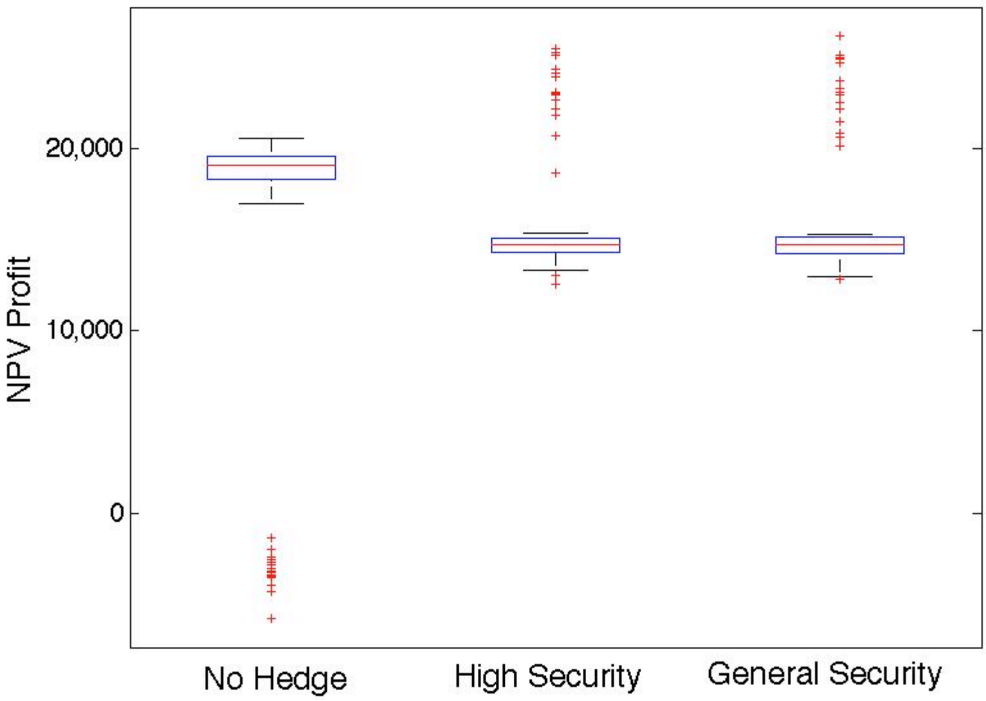

Figure 6 The distribution of profit ($) in net present value terms for the three hedge scenarios with a highly inelastic aggregate demand for water

The highly inelastic demand scenario is similar to the inelastic demand scenario. The reduction in the variability in profits is lower in percentage terms but larger in absolute terms. It is the absolute as opposed to the relative reduction in risk that will determine the value of a hedge. The effect of hedging is seen clearly in figure 6, which shows the distribution of profit for the three hedging scenarios. The highly adverse outcomes that occur without a hedge are eliminated but there is a reduction in the median profit level with the hedge. The skewness is completely reversed.

In the elastic demand scenario the variability in the net present value of profits is lowest without a hedge. Again the skewness of the distribution of annual net returns that results from either hedge reduces debt exposure. However, with an elastic demand for water in the allocation market, the overall need for risk management is reduced. As expected, an increase in the variability of demand leads to greater overall reduction in the variability of returns and reduced risk exposure with a permanent entitlement hedge.

With the high security hedge debt is fully repaid, with a fixed amortization payment in all of the 100 trials. In contrast, in the case without a hedge, the initial and average terminal debt positions are roughly the same (K_0 = $50,000 and the starting equity level was assumed to be 30 per cent). As a consequence average disposable income is higher with the hedge.

The general security hedge still reduces the probability of annual net returns that are well below average. This is reflected in the lower average terminal debt level and higher average disposable income. Without an entitlement hedge the expected debt position deteriorates significantly. The permanent entitlement hedge allows debt to be fully repaid in all 100 trials despite the greater variability in profit.

The reported variability in income is not practically meaningful because when repayments are greater than income, income is zero and the balance is added to the debt. As a consequence the distribution of income becomes increasingly asymmetric as more debt is accumulated. Variability is reduced but mean income falls.

1.3 The Hedging Value of a Permanent Water Entitlement

While it is clear from the previous analysis that owning a permanent water entitlement reduces the level of variability in returns relative to purchasing water in the seasonal allocation market, what value does this hedge have? In other words, what premium would we place on the value of a permanent entitlement, over its productive value, given it can be used to hedge risk?

One way to approach this problem is though portfolio theory using a variation on the CAPM asset-pricing model (first published by Sharpe, 1964, Lintner, 1965 and critiqued by Roll, 1977). The CAPM model prices an asset in proportion to the risk that can be diversified, in this case hedged relative to the risk that cannot be diversified.

We can think of the investment in a horticultural enterprise as being comprised of three separate assets:

- The investment in land, infrastructure and perennial crops; and
- An investment in high security water entitlement; and
- An investment in general security water entitlement

Each of these assets has an expected return, an expected level of variability and an expected level of covariance with the other assets in the portfolio. The return on the investment in land, infrastructure and perennial crops is simply the unhedged rate of return from our example. We can take this unhedged rate of return as an undiversified reference point.

The β value is the ratio of the covariance between the rate of return on an entitlement and the unhedged rates of return to the variance of the unhedged rate of return:

$$\beta = \frac{Cov\left(R_{Entitlement}, R_{Unhgedged}\right)}{Var\left(R_{Unhgedged}\right)}$$

If we have an effective hedge β will be negative. This allows the construction of an overall portfolio risk that is less than any of the individual components and reduces the overall exposure of the portfolio. If the hedge is perfect β will be equal to minus one. A perfect hedge provides a risk free investment opportunity. A β value of zero implies the risks associated with holding an entitlement are independent of risks on the investment in land, infrastructure and perennial crops. A β value of one implies the risks associated with holding an entitlement is the same as the unhedged risk. That is, the portfolio risk of purchasing a water entitlement is the same as investing in a larger enterprise. A β value greater than one implies that the portfolio risk will be greater than the unhedged enterprise risk.

A β value greater than or equal to zero and less than one allows risk to be diversified. The purchase of a permanent entitlement adds to an individual's overall exposure as the level of investment has increased. However, the portfolio risk is the linear combination of the components of the portfolio which is less than the unhedged risk on the investment in land, infrastructure and perennial crops. This gives rise to the CAPM formula.

The CAPM formula expresses the required rate of return on an asset relative to a hypothetical 'risk free' rate of rerun, typically a treasury bond rate, and the undiversified rate of return:

$$R_{Asset} = R_{RiskFree} + \beta\left(R_{Undiversified} - R_{RiskFree}\right)$$

By definition a risk free asset is independent of any other market risks. However, a β value of zero does not imply an asset is risk free. Here, we need to replace the notion of a 'risk free' asset with a diversified market rate of return.

$$R_{Entitlementt} = R_{Diversified} + \beta\left(R_{Unhedged} - R_{Diversified}\right)$$

We can take the discount rate used to determine the productive value of a permanent entitlement to be the diversified rate of return. Conversely we can use the CAPM rate of return on the entitlement to revalue to a permanent entitlement to account for value as a hedge.

$$V_H = \mathrm{E}(PA_H)\sum_{t=1}^{N}\frac{1}{(1+R_{HS\ Entitlementt})^t}$$

$$V_G = \mathrm{E}(PA_G)\sum_{t=1}^{N}\frac{1}{(1+R_{GS\ Entitlementt})^t}$$

1.3.1 Example Results

The average rates of return, along with their respective standard deviations, are shown for the alternative hedging strategies in Table 7. Average returns are highest for the unhedged position followed by the general security entitlement and high security entitlement hedges. This is because the net returns under each hedging scenario is the same but the capital investment is greater with the purchase of an entitlement.

The high security entitlement provides an effective hedge under all the demand scenarios, including the elastic demand scenario. This is because of the limited variability in the yield of a high security entitlement. The general security entitlement also provides a hedge under all the demand scenarios. However, its effectiveness is substantially reduced, especially under the elastic demand scenario. The reason for this is that a general security entitlement is a good hedge against adverse price movements due to demand shocks but does not compensate for adverse price movements due to change in the level of allocations. The performance of the high and general security entitlement under the alternative demand scenarios can be seen from the Beta values in Table 8

Table 7 Rate of return for the modelled scenarios

Demand	No Hedge		High Security		General Security	
Scenario	Mean	Std	Mean	Std	Mean	Std
Inelastic	21.1%	2.34%	15.8%	0.55%	16.6%	1.85%
Very inelastic	22.2%	3.93%	16.6%	1.93%	17.7%	2.23%
Elastic	20.1%	1.28%	15.5%	0.05%	16.2%	1.23%
Greater variation	21.2%	2.49%	15.5%	0.65%	16.7%	1.74%

Table 8 CAPM Beta values for each scenario

Demand Scenario	*High Security*	*General Security*
Inelastic	-0.052	-0.005
Very inelastic	-0.196	-0.049
Elastic	-0.015	-.0.004
Greater variation	-0.080	-0.023

The hedging or risk adjusted value of the entitlements is shown in Table 9. The risk adjustment increases the value of all entitlements under all of the demand scenarios. Of greater interest is that the risk adjustment increases the price premium for high security over general security entitlements.

Table 9 Expected value in production (VIP) and risk adjusted value (RAV) of high and general security entitlement

Demand Scenario	*High Security* VIP	RAV	*General Security* VIP	RAV
Inelastic demand	$1,436	$1,528	$1,161	$1,146
Very inelastic demand	$1,414	$1,964	$1,073	$1,227
Elastic demand	$1,446	$1,439	$1,203	$1,144
Greater variation	$1,463	$1,596	$1,163	$1,179

The premium for high security entitlements increases as demand becomes more inelastic and more variable. The premium is around 26 per cent for the inelastic demand scenario and 60 per cent for the highly inelastic demand scenario.

Currently, premiums for high security over general security entitlements in NSW are around 100 per cent. This may be a reflection of a greater expected difference in yields, especially in the near term. However, it may also reflect that the annual demand for water is more inelastic.

1.4 Summary

While the example presented here is stylized, it clearly illustrates the potential value of permanent entitlement as a hedge against adverse price movements in the allocation market. A hedge made with either a high or less secure water entitlement can help manage exposure to debt and lead to higher levels of expected income. Access to relatively more secure entitlement improves the effectiveness of this hedge.

Water users should be able to access a range of permanent entitlement with different security characteristics to create a hedge that best meets their individual needs. High security entitlements in particular provide an effective hedge for irrigators and other irrigators with large fixed investments. The results presented here indicate that a horticultural enterprise would be willing to pay a substantial premium for high security over general security water entitlement that reflects the greater risk management value of a permanent entitlement. The size of this premium, over the productive value of the water, depends on the elasticity of demand in the seasonal allocation market and the seasonal variation in both the level of water allocation and demand.

Trade restrictions that prevent or restrict water users from accessing permanent entitlements are effectively a restriction on an important financial risk management instrument. If these restrictions are binding, the consequence of this is likely to be reduced investment in higher valued water uses.

1.5 References

Lintner, John (1965). The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets, Review of Economics and Statistics, 47 (1), 13-37.

ROLL, R. (1977): "A Critique of the Asset Pricing Theory's Tests," Journal of Financial Economics, 4, 129–176.

Sharpe, William F. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk