EVALUATING POTENTIAL INVESTMENTS IN THE PINK LADY APPLE CULTIVAR UNDER UNCERTAINTY AND IRREVERSIBILITY

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Abstract

Many South African (SA) apple producers are currently considering whether or not to invest in the Pink Lady apple cultivar in response to the changing tastes of international fresh apple consumers. Given uncertainty about Pink Lady apple yields, costs and prices, and that orchard investment costs are irreversible (cannot be fully recovered in the short term), an ex ante *version of the Dixit-Pindyck investment model is used to assess the viability of such an investment under uncertainty and irreversibility. This model accounts for uncertainty and irreversibility by raising the orthodox hurdle rate that must be met to justify the orchard investment by an amount that reflects the value of the option to postpone the investment. The results suggest that SA apple producers should only invest in a Pink Lady apple orchard with a 35-year lifespan if the expected annual real rate-of-return is above 10.75%, which is more than double the orthodox real rate of five per cent that is commonly used in capital budgeting analyses. Differences of this level between orthodox and modified hurdle rates have also been reported in recent studies of the adoption of dairy housing technology, and investment in grapefruit orchards, in the United States.*

1.   INTRODUCTION

Making appropriate capital investments can help firms to create and exploit opportunities that improve their competitive position. For example, purchasing a new item of farm equipment (e.g. a larger tractor or a combine-harvester) can help producers increase their production capacity and drive down per unit costs. Adopting new biotechnologies (e.g. high-amoloyze soybeans or high-protein wheat) can also help them to become more effective at meeting the needs of their customers (Boehlje & Lins, 1998). Determining *which* investment opportunity is the best alternative given limited capital resources, and deciding *when* to invest, are critical components of the investment-making process. Furthermore, making an optimal investment

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decision is a challenge due to uncertainty about the future income, costs and performance of the new capital investment. A "wrong" or a regrettable choice is usually costly since most investment expenditures are partially or completely irreversible (Dixit & Pindyck, 1995). Irreversibility means that the start-up investment costs are sunk costs once the investment expenditure occurs, and cannot be fully recovered in the short-term.

The expected Net Present Value (NPV) and the Internal Rate-of-Return (IRR) approaches to capital budgeting are commonly used to assess the desirability of an investment opportunity. These methods involve (1) estimating the expected net cash flows for each period of the investment's productive life, and then (2) discounting these cash flows at a discount rate that reflects the weighted average cost of capital required to finance the project. Although the orthodox decision rules are to accept the investment with the greatest positive NPV and IRR, Collins & Hanf (1998) suggest that these NPV and IRR estimates have significant bias because they ignore the possibility that investment expenditure can be delayed. Typically, NPV evaluations assume that investors face a dichotomous "now" or "never" decision with no possibility to postpone the investment until a later time when more information might be available. In most cases, however, investment expenditure can be delayed, and the possibility to benefit from "hindsight" can profoundly affect *if* and *when* a manager might make the investment, especially when expected net returns from the investment are uncertain (Purvis *et al,* 1995; Dixit & Pindyck, 1995). Thus, given uncertainty and irreversibility, *an option to postpone* a capital investment has value. Investing now would mean that managers would give up the opportunity to use the option, implying that the value of the lost option is an opportunity cost that must be added to the direct cost of the investment. Incorporating this value into orthodox NPV and IRR evaluations would raise the costs or required rates of return that must be "hurdled" in order to justify investing now, and so help managers to make more appropriate capital investment decisions.

To the best of the authors' knowledge, no previous published research on evaluating agricultural investments in SA has attempted to incorporate the value of postponing a capital investment when making NPV and IRR evaluations. The aim of this paper, therefore, is to show how to modify these evaluations to account for uncertainty, irreversibility, and the value of the option to postpone an investment, using the case of a potential investment in a Pink Lady apple orchard (Pink Lady is the trade mark for the Cripps-pink apple cultivar). Many SA producers of fresh apples for export are currently considering whether or not to invest in the Pink Lady apple cultivar that has recently been introduced into SA, in order to meet the changing tastes of

international apple consumers. The next section discusses why the Pink Lady apple cultivar might play a role in improving the competitiveness of the SA fresh apple export value chain. Section 3 then explains how the option to postpone concept can be applied to capital budgeting using a model proposed by Dixit & Pindyck (1994). Research methodology and data sources are described in section 4. The last two sections summarize the results and discuss some implications for managers wishing to use the modified NPV and IRR approaches to make capital budgeting decisions.

2.   THE FUTURE ROLE OF THE PINK LADY APPLE CULTIVAR

Gala, Braeburn, Cameo, Fuji and Pink Lady are expected to be the most popular apple cultivars for the future (World Apple Report, 2001). Interviews with key industry players (Dall, 2001; Finn, 2001; Jensen, 2001; Rabe, 2001) at all levels in the SA fresh apple export value chain during March 2001 indicated that the failure by SA apple producers to adopt these new apple cultivars to meet changing consumer tastes was a serious threat to the future competitiveness of the SA fresh apple export value chain. To counteract this threat, it has been suggested that a systematic approach of introducing emerging apple cultivars into the current SA apple basket is required by replanting apple orchards at the end of their lifespan with these cultivars rather than with the original cultivars (Dall, 2001; Rabe, 2001). The Pink Lady apple cultivar, in particular, has been central to the debate about which new cultivars should be grown in SA, and it is considered a promising cultivar that could improve the competitiveness of the SA fresh apple export value chain (Dall, 2001). An investment in a new Pink Lady apple orchard is, however, irreversible, as the estimated real (2 000 = 100) initial costs of establishing an orchard (preparation and planting, tree royalties (R6 per tree = R10 000 per hectare), irrigation infrastructure, etc.) of R97 313 per hectare cannot be completely recovered if an apple producer elects to disinvest soon after initiating the investment.

Furthermore, the future competitive performance of the SA fresh apple export industry is uncertain due to potential changes in government labour policy and real interest rates, and increased rivalry from other fresh apple exporting countries like Chile and France (Hardman *et al*, 2002). South African fresh apple producers, packers and exporters interviewed in March 2001 all ranked variable climatic conditions as one of the most important sources of risk that prevent the SA fresh apple export chain from becoming more competitive internationally (Hardman *et al*, 2002). Poor climatic conditions restrict the growth and colouring of Pink Lady apples, leading to lower volumes of top quality apples. Postponing a Pink Lady apple orchard investment will give

South African apple producers more time to acquire new information about expected Pink Lady price premiums (currently the price is about 18% higher than that for Golden Delicious apples), costs and production techniques. The question is whether SA apple producers should invest in a new Pink Lady apple orchard now, and capitalize on the expected price premium, or wait another period and only invest if the real Pink Lady apple price remains favourable, and when more knowledge about how to improve this cultivar's performance is available.

3.   THE OPTION TO POSTPONE AN INVESTMENT

A financial option confers upon the holder the right, but not the obligation, to buy (call option) or sell (put option) an asset, subject to certain conditions, within a specified period of time (Black & Scholes, 1973). How much an option contract is worth is jointly determined by the current price of an underlying asset and by the degree of uncertainty about that price over the term of the option contract. McDonald & Siegel (1986) and later Dixit & Pindyck (1994) have used this options-pricing concept to analyze managers' capital investment behaviour under uncertainty and irreversibility. Analogously, investment opportunities through time are viewed as a series of choices (options) of whether to invest (exercise the option) or not. Investors are assumed to weigh up the value of investing now against the value of waiting to invest.

The value of investing now (V) depends on the expected annual net returns from the investment (R), the variance of the expected annual net returns (σ^2), the sunk cost of initiating the investment (K), and the real discount rate (ρ). In orthodox NPV analysis, an investment would be acceptable if the present value of the discounted R over the life of the project (R/ρ) is greater than or equal to K. The point of indifference between investing now or not investing, ignoring the option to postpone the investment, is called the Marshallian trigger (M), and occurs where $M = \rho K$ (the annuity that yields a required real rate of return equal to ρ on the sunk cost over the life of the investment). If, however, an investor values the option to wait to invest, M must be modified and adjusted upward to reflect the value of the foregone opportunity to postpone the investment. If the present value of the discounted expected returns then exceeds the modified investment trigger, the investment is acceptable, as the expected returns cover the full cost (direct cost plus opportunity cost) of making the investment. The gains from waiting in the case of the Pink Lady apple orchard investment result from being able to avoid downside risk such as lower real apple prices and adverse climatic

conditions. Dixit & Pindyck (1994:142) derive the modified (optimal) investment trigger (H) as

$$H = \frac{B}{B-1}\rho K \tag{1}$$

The H in equation (1) is greater than M by the factor $B/(B-1)$ which is the "option value multiple". At H, the discounted expected returns from investing now are sufficiently high to cover both K and the opportunity cost of not waiting. The parameter B is a component of the function that Dixit & Pindyck (1994) derive to calculate the value of waiting, and it is jointly determined by ρ and σ^2 as

$$B = \frac{1}{2}\left[1 + \sqrt{1 + \frac{8\rho}{\sigma^2}}\right] \tag{2}$$

A lower real discount rate, ρ, and/or greater uncertainty about the expected returns from investing, σ^2, reduces B and *increases B/(B-1)*. This *increases* the H, implying that the opportunity cost of exercising the option to invest has risen. A lower real discount rate increases the present value of later expected net returns and so encourages waiting, while greater uncertainty also increases the expected gains from waiting.

In addition to the modified H associated with the NPV method, Dixit (1992) proposes using the modified hurdle rate (ρ') to evaluate the desirability of making an investment now. The ρ' factors in the value of waiting by raising ρ (the equivalent of the required rate of return, RRR, in the IRR method) by the value of the option value multiple *B/(B-1)* as

$$\rho' = \frac{B}{B-1}\rho \tag{3}$$

where B is again estimated from equation (2). Elmer *et al* (2001) estimated ρ' values ranging from 19 to 29% when they applied real discount rates of between three and nine per cent to analyze the orchard investment decisions of Texas grapefruit farmers in the United States (US). Summers (1987) found that the managers of US companies were applying hurdle rates ranging from eight to 30% (with a median of 15% and mean of 17%) in their investment decisions when nominal interest rates were about four per cent. The *a priori* expectation, therefore, is that South African fresh apple farmers who value the option of waiting for more information about the future performance of the Pink Lady apple cultivar under South African conditions, will also apply

hurdle rates higher than the current real discount rate ($\rho' > \rho$) before deciding to invest in a Pink Lady apple orchard.

4.   RESEARCH METHODOLOGY AND DATA SOURCES

Equation (2) shows that the parameter B is jointly determined by the applied real discount rate, ρ, and the variance of the investment's expected net returns, σ^2. The researcher can set a range of plausible ρ levels based on previous work such as Elmer *et al* (2001) and recommendations made in financial texts like Barry *et al* (1995). Two different approaches can be used to estimate σ^2: The *ex post* approach involves collecting cross-sectional time-series data from investments similar to the capital investment under consideration, and then deriving σ^2 by averaging the variance of expected net returns in the observed cases. The implicit assumption is that expected net returns are homoscedastic, and that past estimates of the variance of expected net returns are the best measure of future expected variance. However, there is little reason to believe that the variance of expected annual net returns for the Pink Lady apple orchard investment will remain stable over time, especially given increasing competition from rival fresh apple exporters and the recent volatility of the Rand exchange rate. The *ex post* approach is also ineffective when a new unproven opportunity to invest arises, having no predecessor from which to obtain the necessary time-series data. To overcome these factors, an *ex ante* approach to the Dixit-Pindyck model for calculating H or ρ' was developed by Purvis *et al* (1995), and their approach will be used in this paper.

First, define the natural log difference between the value of the opportunity to invest in a Pink Lady apple orchard now, V_t, and the potential value of that opportunity one period later, V_{t+1}, as $\Delta ln V_j \equiv ln V_t - ln V_{t+1}$. The present value of this investment with expected annual net returns of R_t, at time t, and an instant later, at t + 1, are then defined, respectively, as

$$PV_t = \sum_{i=0}^{n} \frac{R_t}{(1+\rho)^i} \qquad (4)$$

and

$$PV_{t+1} = \sum_{i=1}^{n+1} \frac{R_{t+i}}{(1+\rho)^{i-1}} \qquad (5)$$

Following Dixit & Pindyck (1994:175-212), the present value of the investment can be converted to the value of the equivalent opportunity to invest in perpetuity as

$$V_t = \frac{\left[\dfrac{\rho}{1-\left(\dfrac{1}{(1+\rho)^{n-t}}\right)} PV_t\right]}{\rho} \qquad (6)$$

Similarly, V_{t+1} is given by:

$$V_{t+1} = \frac{\left[\dfrac{\rho}{1-\left(\dfrac{1}{(1+\rho)^{n-t-1}}\right)} PV_{t+1}\right]}{\rho} \qquad (7)$$

The numerator of equations (6) and (7) gives the annuity required to generate a stream of benefits equivalent to the present value of the Pink Lady apple orchard investment. Dividing this annuity by the discount rate, ρ, converts the stream of benefits to its present value (Purvis, *et al*, 1995).

The difference between the natural logarithms of V_t and V_{t+1}, or $\Delta ln V_j$, gives a discrete estimate of the change in the value of the apple orchard investment opportunity, where j is the size of the sample over which the difference is calculated. Simulated over a large number of iterations, the expected R_t from investing that are used to estimate V_t and V_{t+1} are assumed to follow a geometric Brownian motion process, which characteristically provides a discrete approximation of a geometric Brownian motion variate in the limit (Cox *et al*, 1979, cited by Purvis *et al*, 1995). Thus, the time path of this random process, with trend u_v and variance σ^2_v, is estimated by measuring the movements that occur in infinitesimally small, discrete intervals over N iterations. The trend variable, u_v, is estimated by

$$u_v \approx \frac{1}{N} \sum_{j=1}^{N} \left[\Delta \ln V_j\right] \qquad (8)$$

and it is applied to estimate the variance of the value of the opportunity to invest, σ^2_v, as

$$\sigma_v^2 \approx \frac{1}{N} \sum_{j=1}^{N} \left[\Delta \ln V_j - u_v\right]^2 \qquad (9)$$

where $E[(\ln V_j - u_v)^2] \gg 0$. The estimated σ^2_v is then substituted into equation (2) to estimate B. Given that the Pink Lady apple cultivar has only recently been introduced into South Africa, and that there is a lack of reliable production or economic performance data, the *ex ante* approach for estimating B was adopted in this study. The trend and variance of the difference between investing now and one period later were estimated in a Monte Carlo simulation model using 5 000 iterations.

Three real discount rates were used to generate three different scenarios for the Pink Lady apple orchard investment. First, projected real annual net returns (2 000 = 100) over a 35-year orchard lifespan for a typical Pink Lady apple orchard investment in the Western Cape and Langkloof East regions of SA were discounted at a *five* per cent discount rate (the estimated average rental rate of return to farm land in SA (Nieuwoudt, 1980)), to estimate the investment's present value in the current period (PV_t) and one time period later (PV_{t+1}). Real discount rates of three, and seven per cent were then used as alternative scenarios that describe the current situation faced by South African fresh apple producers. An MSExcel spreadsheet model was constructed to proxy the real annual net returns over the 35 years using expected annual net economic profit per hectare (accounting profit less estimated management costs and less the opportunity cost of capital). The simulation model under the three scenarios was then run using @RISK software integrated with this MSExcel application (Palisade Corporation, 2002). Projected real apple prices and quality estimates were based on a three-year data series for 1999-2001, but annual yield estimates were drawn from information submitted to the Deciduous Fruit Producers' Trust (DFPT) by its members in 2001. Variable costs were based on real cost series data adjusted to reflect an orchard bearing 45 tons of apples per hectare per annum (the estimated industry average) (Dall, 2001). Four apple exporters, two apple packers and two different apple producers, selected from the Western Cape and Langkloof East regions between July 2001 and January 2002, provided three-year apple quality and price data, and apple production cost data for the Pink Lady apple cultivar. Where possible, data were evaluated for deviations from the DFPT's industrial averages.

5. RESULTS

The estimated real (2 000 = 100) initial costs of establishing a Pink Lady apple orchard, *K,* are R97 313 per hectare (see section 2 above). Assuming a 31% Class I and 36% Class II quality distribution, a seven-and-a-half per cent exporter commission, a R120 per bin packing charge, a 120-day storage period for apples in controlled atmosphere storage, and a real apple price ranging

from R2 436 per ton for Class I apples to R403 per ton for processed apples, the estimated PV_t for this Pink Lady apple orchard when ρ = five per cent was R205 000 per hectare. Using sensitivity analysis to vary these key parameters by plausible amounts – for example, Class I pack-out ranges from 25% to 45%, and 10% increases or decreases in the real apple price range - a triangular distribution was estimated for PV_t with minimum and maximum values of R120 000 and R290 000 per hectare, respectively. Figure 1 shows the distribution of PV_t per hectare values for a Pink Lady apple orchard investment in SA generated by the Monte Carlo simulation.
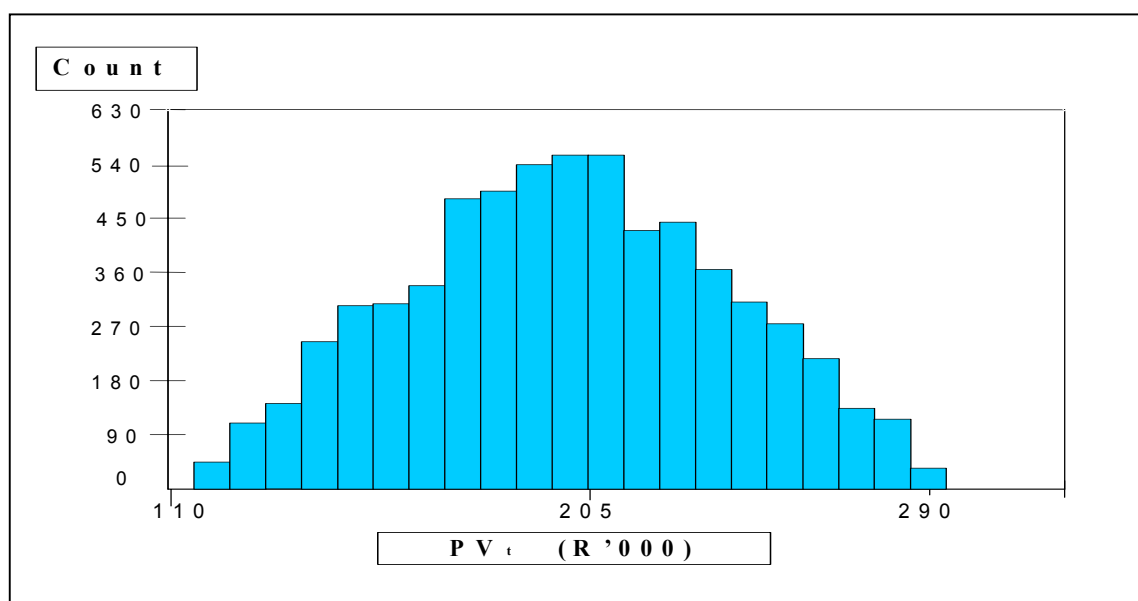
Figure 1:   Distribution of the present value of expected annual net returns per hectare generated by Monte Carlo simulation for a Pink Lady apple orchard investment in the Western Cape and Langkloof East regions, 2001

Using this PV_t range and the @RISK simulation models to estimate equations (4) through (9), and equation (2), the estimated option value multiple, $B/(B-1)$, was 2.15 for ρ = five per cent. Orthodox NPV analysis of the Pink Lady orchard investment would estimate a Marshallian investment trigger, M, of R5 943 per hectare (this annuity would yield a real required rate of return of five per cent on the sunk cost, K, of R97 313, over 35 years). Substituting 2.15 for $B/(B-1)$, and R5 943 for M in equation (1), implies a modified investment trigger, H, of R12 778 per hectare in the first scenario where ρ = five per cent. Similarly, substituting 2.15 for B/(B-1), and ρ = five per cent into equation (3) gives an estimated modified hurdle rate, ρ', of 10.75%. These results imply that SA apple producers that value the option to postpone a Pink Lady apple orchard investment in the Western Cape and Langkloof East regions of SA

must have an expected real IRR greater than 10.75%, or equivalently, have an expected present value of real annual net returns above R12 778 per hectare, to trigger investment expenditure. These results and the modified H and ρ' hurdle rates for the other two scenarios where ρ = three per cent and seven per cent, respectively, are summarized in Table 1. For all values of ρ, the estimated H and ρ' are between two and three times higher than M and ρ, which is consistent with the findings of Summers (1987), Elmer *et al* (2001), and the Purvis *et al* (1995) study of dairy housing technology adoption in the US.

Table 1: Estimated modified optimal investment triggers per hectare, and real hurdle rates for a Pink Lady apple orchard investment in the Western Cape and Langkloof East, 2001

Real Discount Rate	$\rho = 3\%$	$\rho = 5\%$	$\rho = 7\%$
Option value multiple, $B/(B\text{-}1)$	2.26	2.15	2.99
Marshallian investment trigger, M	R 4 535	R 5 943	R 7 516
Modified investment trigger, H	R10 250	R12 778	R22 473
Modified hurdle rate, ρ'	6.78%	10.75%	20.93%

6.   DISCUSSION AND CONCLUSIONS

Uncertainty about the future annual net returns from a capital investment, and the irreversible nature of such investment, mean that investors may postpone capital expenditure, or seek higher returns to compensate them for uncertainty and irreversibility. Fresh apple producers in SA should, therefore, explore ways to reduce the uncertainty of expected annual net returns from investing in new cultivars like the Pink Lady. For example, by adopting management and product quality assurance standards, such as Nature's Choice, Hazard Analysis and Critical Control Point (HACCP) and ISO 9000, managers can improve the consistency of their quality pack-outs. These systems also encourage the capturing and monitoring of key production information, such as yields per hectare and the percentage pack-out of Class I fruit, that can be used to more accurately estimate how expected annual net returns may vary. Research institutions, such as universities and Hortec (Pty) Ltd (a subsidiary of the Deciduous Fruit Producers Trust (DFPT)) can help to collect, analyze and disseminate regional information on the current performance of different apple cultivars. The DFPT can also play a key role in assisting producers to make better apple orchard investment decisions by providing key industrial statistics, and technical help.

The growing and marketing of inappropriate apple cultivars have been identified as a serious threat to the competitiveness of the SA fresh apple

export value chain. To monitor changes in consumer needs, SA apple producers must work more closely with their packers and exporters, and transfer information about factors such as current apple prices, changing trends in consumer consumption, and current and expected production and marketing of apples by international rivals, more effectively along the value chain. Working more closely with up- and down-stream players in the SA fresh apple export value chain will help SA apple producers to reduce the likelihood of making a "wrong", irreversible investment decision.

Since about 58% of SA apple farm-level gross income is derived from sales of apples for export, the volatile performance of the Rand against the US Dollar, the British Pound and the Euro, has caused major variability in SA fresh apple farm profits. Furthermore, export freight, fuel, chemical spray and other specialized input costs shift with changes in the value of the US Dollar, which adds to the complexity of forecasting the future net returns from a Pink Lady apple orchard investment. In the short-term, managers can try to reduce the impact of unfavourable exchange rate changes by exploring the use of forward exchange rate contracts, freight forwarding, or minimum price contracts with packers, exporters and import receivers.

This paper has highlighted the need for modified NPV and IRR analyses that explicitly account for uncertainty and irreversibility when assessing the potential profitability of Pink Lady orchard investments. Given uncertainty and irreversibility, the option to postpone such investments has value, and adds to the costs that must be hurdled in order to justify investing now rather than waiting. The value of waiting to invest is the result of an opportunity to avoid downside risk, and is estimated from two parameters - the real discount rate, ρ, and the variance of expected real annual net returns, σ^2. Decision makers that apply lower real discount rates and that are more uncertain about future annual net returns from Pink Lady orchard investments will have relatively higher hurdle rates to justify investing now. Using an *ex ante* approach to estimate σ^2, the results show that SA apple producers that account for uncertainty and irreversibility should only invest in a Pink Lady apple orchard if the expected annual real rate-of-return is greater than 10.75% – more than double the orthodox rate, ρ, of five per cent. Differences of this level between orthodox and modified hurdle rates have also been reported in recent studies of the adoption of dairy housing technology, and investment in grapefruit orchards, in the United States. An area for future research would be to extend the Dixit-Pindyck methodology to incorporate the foregone net income from an existing orchard that could be earned during the waiting period if the Pink lady apple orchard investment is postponed.

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