Labor Cost and Value of Citrus Operations with Alternative Technology:

Enterprise DCF Approach

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Abstract

The prospect of immigration policy reform has renewed growers' concerns of serious labor shortages and cost increases given that a large portion of the workforce is unauthorized for U.S. employment. This concern of labor shortages and cost increases is more serious for specialty crop agriculture which is highly labor intensive. Specialty crop growers may address the problem in various ways, but likely options include adoption of mechanical harvesting. In the current paper we study the citrus industry case and estimate the value for two operational modes (hand and mechanical harvesting) using the enterprise discounted cash flow (DCF) approach. Further we implement a simulation to forecast how the value for each operational mode would change with a change in cost scenario.

Introduction

The prospect of immigration policy reform has renewed growers' concerns of serious labor shortages and cost increases given that a large portion of the agricultural workforce is unauthorized for U.S. employment. According to the National Agricultural Workers Survey (NAWS) data, at least 53% of agricultural workers were unauthorized for U.S. employment for the years 2001-02 (Office of Assistant Secretary for Policy 2005). This concern of labor cost increase is more serious for specialty crop agriculture which is highly labor intensive. Sarig, et al. (2000) report that "…at least 20-25% of the U.S. vegetable acreage and 40-45% of the U.S. fruit acreage is totally dependent on hand harvesting." Given that immigration policy reform may lead to much higher ratio of legal workers, the concern over labor cost increases is legitimate since existing literature suggests that a significant wage gap exists between legal and illegal workers in U.S. agriculture (Taylor, 1992; Ise and Perloff, 1995).

Agricultural employers may address the increased labor cost in various ways, but likely options include (a) adoption of a technology which uses less labor and (b) termination of current crop production if an alternative technology is not available (Emerson 2007). Mechanical harvesting is a typical example of the former, whereas the latter may involve changes to the cropping mix such that less labor is required. If we focus on adoption of mechanical harvesting, the most imminent effect of immigration policy reform might be on crops for which labor intensive technology is currently used, but an alternative less-labor-intensive technology is already developed. In the current paper we study the citrus industry case and estimate the value of operation for two operational modes (hand and mechanical harvesting) using the enterprise discounted cash flow (DCF) approach. Further we implement the simulation to forecast how the value for each operational mode would change with the change in cost structure scenario.

The Florida citrus industry has been pursuing mechanical harvesting with an increased intensity over the past few years. Although there have been efforts to develop viable mechanical harvesters for citrus since the 1960s, the recent thrust has resulted in a significant level of utilization of mechanical harvesters.[1] Most of Florida oranges are utilized for juice processing rather than for fresh market consumption, an obvious advantage for mechanical harvesting. At the same time that there are continuing concerns about labor availability for harvest, the Florida citrus industry has faced difficulties from recent hurricanes to new diseases (citrus canker and citrus greening) to urban encroachment. The U.S. and Florida citrus industries are also facing increased international competition for citrus products. For example, the U.S. production of oranges fell by 29% between the 1980-81 and 2006-07 seasons while the Brazilian production of oranges doubled (USDA, 1986, 2008). In addition, China has become a major citrus producing nation. They are second only to Brazil in total citrus production although over half of China's citrus production is tangerines and mandarin oranges.

As a result of all of these factors Florida citrus producers are searching for ways to better compete in the global marketplace. Mechanical harvesting has arisen as one of the possible ways that may improve their competitive position, particularly in light of potential labor disruptions due to labor availability and

[1] Machine design has not changed since 1999. The next big innovation will be incorporation of an abscission agent that should substantially enhance cost efficiencies of the equipment.

cost uncertainties. The estimated cost of mechanical harvesting of Florida oranges for juice processing ranges between 10 and 30 cents per 90-lb box less than hand harvesting (Roka). This is a significant cost difference because harvest cost savings translate to an increase in grower net returns by as much as a $150 per acre. While an economic advantage appears to be present, the adoption of mechanical harvesting systems remains relatively low at about 7.5% of the Florida orange acreage in 2006-07 (UF). The hesitation by growers to adopt the new technology is not uncharacteristic of the experience in other commodities such as cotton, tomatoes, and sugar cane where mechanization has taken place in the past. The important point is that the value of each operational mode cannot be measured by the cost advantage for a single year. We use the enterprise discounted cash flow (DCF) approach to overcome this problem.

Among the many ways to value an operation, we use the enterprise DCF approach, the most widely used tool for the valuation, which discounts the forecasted free cash flow (FCF) at the opportunity cost of capital that is consistent with riskiness of the cash flow. The approach uses the cash flow in and out of the enterprise, rather than accounting-based earnings or cash flow attributable only to stockholders (Koller et al., 2005), so that it is simpler but better eliminates the possibility of artificial manipulation of the value. The most challenging tasks in the approach are forecasting the future FCF and estimating the appropriate risk-adjusted discount rate. For the former, we start with modeling and estimating the stochastic process of citrus yield, price, production costs and harvesting costs using the past time series data collected by UF-IFAS extension centers. Then a Monte Carlo simulation is run to generate sample paths for future FCF. Mean of the sample paths will yield the expected future FCF for each year.

The discount rate we use is the weighted average cost of capital (WACC), which is the time value of money used to convert the expected FCF into a present value for all investors. Since enterprise FCF is available for payment to both debt and equity sources of capital, the discount rate must comprise a weighted average of the marginal costs of both sources of capital. For estimation of the opportunity cost of equity capital, we use the standard method: capital asset pricing model (CAPM). In the formula we use the relevered equity beta for citrus operations converted from the unlevered equity beta of agriculture.

Data

The most important source of data is the archive of "Budgeting Costs and Returns for Southwest Florida Citrus Production" which is available from 1993-4 season to 2004-5 season.[2] In the report costs and returns of growing processed-market Hamlin orange and fresh-market seedless grapefruit in the Southwest area of Florida (Charlotte, Collier, Glades, Hendry and Lee counties) are presented for the twelve consecutive years. The southwest area of Florida has become a major citrus production area representing 169,386 acres, over 22.6% of total Florida citrus acreage in 2004 (Muraro et al. 2005). Furthermore, more than 90% of the mechanically harvested acreage is in southwest Florida. The budget cost items in the report have been revised to reflect the most current grove practices (e.g., chemical mowing, different spray materials and rates of fertilization, microsprinkler irrigation, more reset trees, etc.) being used by growers for the respective seasons (Muraro et al. 2005).

As illustration, the estimated annual per acre cost for a mature, Hamlin grove in southwest Florida producing oranges for juice processing is shown in Table 1 from 2001-2 season to 2004-5 season. The average mature Hamlin orange grove is composed of 3% of 3 year old, 3% of 4 year old, 33% of 5-15 year old, 49% of over 15 year old trees, and 3% of trees producing 50% of expected yield.[3] In the budget below, beyond average management and cultural practices, the following specifics are assumed:

1. A mature (10+ years old), low volume irrigated grove;
2. Annual tree loss is 4.4% per acre;
3. Trees are pulled and replaced when production falls below 50% of expected yields;
4. Tree density is 145 trees per acre.

[2] Although the archive includes data from 1986-7 season to 1992-3 season, the important information such as harvesting and assessment costs, interest payments, property tax and water management district tax has been omitted. So we focus on the data from 1993-4 season to 2004-5 season.

[3] This adds up to 91 percent as 9 percent of the trees were non-bearing (pulled and reset, or 1 and 2 year old trees).

Table 1. Cost for growing and harvesting Hamlin orange for a model farm ($ per acre).

Season	2001-2	2002-3	2003-4	2004-5
Production/Cultural Costs				
Weed control	184.79	183.13	165.52	172.96
Spray program	136.43	137.18	131.69	141.19
Fertilizer	114.00	124.05	135.33	159.39
Dolomite	10.66	12.04	12.01	14.56
Pruning	40.97	28.03	27.51	28.38
Tree replacement and care	280.48	286.60	296.15	316.55
Total Production/Cultural Costs	**767.33**	**771.03**	**768.21**	**833.03**
Management	48.00	48.00	48.00	48.00
Interest on operating cost	38.37	38.55	38.41	41.65
Property tax and water management district tax	61.00	61.00	61.00	61.00
Canker decontamination costs	27.72	4.54	4.54	4.54
Capital expenditure	367.85	378.50	321.22	321.22
Total Grower Costs	**1,310.27**	**1,301.62**	**1,241.38**	**1,309.44**
Pick/spot pick, roadside and haul	1,088.64	1,120.39	1,143.97	1,187.93
DOC assessment	83.16	83.16	77.40	83.16
Total delivered-in cost	**2,482.07**	**2,505.17**	**2,462.75**	**2,580.52**

Source: Muraro et al. (2002, 2003, 2004, 2005).

Next, we combine cost items above with revenue to calculate free cash flow (FCF) which is equal to the after-tax operating earnings of the farm, plus non-cash charges, less investments in operating working capital, property, and other assets (Copeland and Antikarov 2003). Unlike “cash flow from operations” reported in financial statement, FCF is independent of financing and nonoperating items. It can be thought of as the after-tax cash flow as if the company held only core operating assets and financed the business entirely with equity.[4] This is the correct cash flow for the enterprise DCF model since it reflects the cash flow that is generated by a farm’s operation and available to all capital providers, both debt and equity (Koller et al., 2005).

We illustrate the calculation of the FCF per acre for the model Hamlin orange grower from 2001-2 season to 2004-5 season. First, we calculate operating cash flow which is revenue[5] minus production costs, management, overhead taxes and regulatory costs, and harvesting costs. Second, we subtract depreciation

[4] Instead, FCF is discounted by the risk-adjusted cost of capital (WACC) which reflects the capital structure of the company. We will elaborate the calculation of the WACC later.

[5] Here the revenue represents average returns to the grower before the costs of picking and hauling have been removed. This means that the harvesting activities are parts of operation integrated by the grower. This assumption may not be exactly true for some operations. However, we do not have enough information to calculate FCF for non-integrated operation.

from operating cash flow to have earnings before interest and taxes (EBIT). The FCF equals the EBIT minus taxes on EBIT, plus depreciation (since there is no actual cash outflow with depreciation), minus capital expenditures.[6] The problem here is the operating tax rate on EBIT. Corporate tax data for 2004 indicates that agricultural production firms had net income of $5.756 billion, income subject to tax was $2.151 billion, and income tax prior to credits of $0.646 billion, with credits of $0.020 billion (Internal Revenue Service, 2007). This implies an average tax rate of 29% relative to taxable income. So we use 29% as operating tax rate on EBIT. The calculation result for FCF for each season for the model farm is given as Table 2.

Table 2. Historical FCF for growing and harvesting Hamlin orange for a model farm ($ per acre).

Season	2001-2	2002-3	2003-4	2004-5
Revenue	2,577.96	2,539.15	2,310.13	2,259.91
Production/Cultural Costs	767.33	771.03	768.21	833.03
Management	48.00	48.00	48.00	48.00
Overhead taxes and regulatory costs	88.72	65.54	65.54	65.54
Harvesting and assessment costs	1,171.80	1,203.55	1,221.37	1,271.09
Operating cash flow	502.11	451.03	207.01	42.25
Depreciation	367.85	378.50	321.22	321.22
EBIT	134.26	72.53	-114.21	-278.97
Tax on EBIT (29% if positive)	38.94	21.03	0.00	0.00
Capital expenditure	367.85	378.50	321.22	321.22
FCF	95.32	51.50	-114.21	-278.97

Source: Authors calculated from Muraro et al. (2002, 2003, 2004, 2005).

FCF Forecast

Next task is forecasting the future FCF for growing and harvesting processed-market Hamlin orange, which is usually done in the following steps. First we model and estimate the stochastic factors in the operation (citrus yield, price, production costs, and harvesting costs) using data from the archive of "Budgeting Costs and Returns for Southwest Florida Citrus Production" available from 1993-4 season to 2004-5 season. Second, the Monte Carlo simulation is run to generate sample paths for future FCF based

[6] Exact record for the depreciation is not available for the model orange grower. Assuming the perpetuity condition following Copeland and Antikarov (2003), we set it equal to capital expenditure. This is a reasonable assumption for the current study, since the latter is constant for most of the observed periods. We also assume net change in operating working capital is negligible, which equals operating current assets minus noninterest bearing current liabilities. Operating current assets include all current assets necessary for the operations of the business, including operating cash, accounts receivables, and inventories.

on the estimation results. Simply taking average of the sample paths will yield the expected future FCF for each year.

We start modeling and estimating the stochastic process for time series following the approach suggested by Brockwell and Davis (1991, 2002). The first step suggested is creating a stationary process by transforming the time series of interest. We have four variables from 1993-4 season to 2004-5 season for the average Hamlin orange operation: yield, delivered-in price, production costs, and harvesting costs. Further using USDA (2008) we extend the yield data up to 2006-7 season, and price data from 1987-8 season to 2006-7 season.[7] On the other hand, we omit the last observation of the production cost in the estimation, since that observation alone changes both growth rate and volatility significantly.[8] First, since all these variables are strictly positive we take the logarithm of these, and test the stationarity of these transformed series. Considering the possibility of drift and correlation between disturbance terms, we estimate the following formula using OLS for each variable for the Dickey-Fuller test:

$$\Delta y_t = c + \gamma y_{t-1}.$$

With this estimation we test $\gamma = 0$. Also note that we do not use Δy_{t-p} only for $p>0$ on the right hand side since none of difference lagged is statistically significant for any series. Table 3 shows the estimates and standard errors for the four series. We also show MacKinnon approximate p-value.

Table 3. Estimated coefficients, standard errors, and p-values

	Yield	Price	Production costs	Harvesting costs
c	5.07 (2.16)	0.37 (0.24)	4.80 (2.06)	0.90 (0.98)
γ	-0.83 (0.35)	-0.27 (0.18)	-0.72 (0.31)	-0.12 (0.14)
Observations	13	19	10	11
MacKinnon approximate p-value	0.15	0.51	0.16	0.80

[7] We use the longer sample period for price because its growth rate and volatility are affected too much by the final few seasons in the sample. Although both price and yield data in USDA (2008) are for early, midseason oranges, Hamlins dominate the early and midseason oranges. For Southwest Florida, Hamlins represent 76% of acreage of early & midseason oranges (USDA, 2007). Also note that, for estimation of time series, we use both yield and price data from USDA (2008) for all seasons.

[8] Only one observation changes growth rate to 1.19% from 0.50% and volatility to 3.53% from 2.83%. Note that there is no other source of data to extend the production cost series.

Using p-values above, we cannot reject the null hypothesis of a unit root for the log of any time series. Then we take the first difference of each series and repeat the same test procedure for the transformed data. The test results in Table 4 show that the first difference is enough to produce the stationary processes for all series. The final results are shown in Table 4.

Table 4. Estimated coefficients, standard errors, and p-values after taking the first difference

	Yield	Price	Production costs	Harvesting costs
c	-0.03 (0.04)	0.01 (0.07)	0.00 (0.01)	0.05 (0.02)
γ	-1.65 (0.24)	-0.93 (0.27)	-1.11 (0.36)	-1.42 (0.30)
Observations	12	18	9	10
MacKinnon approximate p-value	0.00	0.01	0.03	0.00

The next step is to model the transformed series obtained by differencing the logarithm of the original series. If there is no dependence among these residuals, we can regard them as observations of independent random variables. However, if there is significant dependence among the transformed series, we need to look for a more complex stationary time series model to account for the dependence. This will be to our advantage since dependence means that past observations of the sequence can assist in predicting future values. Here we implement some tests for the hypothesis that the transformed series are observations of independent and identically distributed (iid) random variables. In Table 5, we show the test results from the following five tests of randomness: Ljung-Box, McLeod-Li, Turning point, Difference-sign, and Rank test. Since the randomness is rejected at the 5% level of significance by only one (Ljung-Box test for yield series) out of twenty tests, we do not need to use the theory of stationary processes to find a more appropriate model. We also run Shapiro-Wilk test and Jarque-Bera test for normality, which show that normality assumption is rejected at the 5% level of significance by only one (Shapiro-Wilk test for production costs series) out of eight tests.

Table 5. Tests of randomness and normality for the transformed series

Variable	Test	Test statistics	Test distribution[9]	p-value
Yield (transformed to Δln(Yield), for which sample mean=-0.019, sample variance=0.027)				
	Ljung – Box	19.94	Chi-Square (10)	0.03
	McLeod – Li	6.01	Chi-Square (10)	0.81
	Turning point	10	AN(7.33, 1.41)	0.06
	Difference-sign	6	AN(6.00, 1.08)	1.00
	Rank	36	AN(39.00, 8.20)	0.71
	Shapiro-Wilk	0.94	W statistic	0.46
	Jarque-Bera	1.55	Chi-Square (2)	0.46
Price (transformed to Δln(Price), for which sample mean=0.0058, sample variance=0.072)				
	Ljung - Box	10.88	Chi-Square (16)	0.82
	McLeod - Li	25.31	Chi-Square (9)	0.06
	Turning points	12	AN(11.33, 1.75)	0.70
	Difference-sign	9	AN(9.00, 1.29)	1.00
	Rank	103	AN(85.50, 14.29)	0.22
	Shapiro-Wilk	0.94	W statistic	0.32
	Jarque-Bera	0.47	Chi-Square (2)	0.79
Production costs (transformed to Δln(Production costs), for which sample mean=0.0050, sample variance=0.00080)				
	Ljung - Box	3.62	Chi-Square (7)	0.82
	McLeod - Li	3.13	Chi-Square (7)	0.87
	Turning points	5	AN(5.33, 1.21)	0.78
	Difference-sign	4	AN(4.50, 0.96)	0.60
	Rank	13	AN(22.50, 5.59)	0.09
	Shapiro-Wilk	0.82	W statistic	0.03
	Jarque-Bera	5.72	Chi-Square (2)	0.06
Harvesting costs (transformed to Δln(Harvesting costs), for which sample mean=0.039, sample variance=0.0031)				
	Ljung - Box	4.22	Chi-Square (8)	0.84
	McLeod - Li	4.45	Chi-Square (8)	0.81
	Turning points	7	AN(6.00, 1.28)	0.43
	Difference-sign	5	AN(5.00, 1.00)	1.00
	Rank	24	AN(27.50, 6.42)	0.59
	Shapiro-Wilk	0.94	W statistic	0.51
	Jarque-Bera	0.85	Chi-Square (2)	0.66

Further consideration is often tested about the potential interdependence between the series. That is, multivariate time series $\{\boldsymbol{X}_t\}$ may have not only serial dependence within each component series but also interdependence between the different component series $\{X_{ti}\}$ and $\{X_{sj}\}$, $t \neq s$, $i \neq j$. In the current study, however, since each transformed series has unique number of observations (see Table 4), the interdependence is not tested between any series.

[9] AN(·) stands for approximately normal distribution.

Using these results we can generate sample future path for each variable. For example, for the first year after the observed period, which we call t+1, ln(Yield$_{t+1}$) is estimated as ln(Yield$_t$)+ε_{t+1} where ε_{t+1} ~N(-0.019, 0.027). Note that we used the test results for Δln(Yield) from Table 5. In the same way we can generate a sample for ln(Yield$_{t+2}$) using the generated sample of t+1 and newly generated white noise ε_{t+2}. We can generate a sample of the original series by taking exponential.

The problem here is how many periods of future sample paths should be generated. In other words, how many periods should the DCF approach forecast explicitly? Suggestion is that explicit forecast period should be long enough to reach a steady state financial performance before calculating a continuing value, typically 10 years or more (Koller et al., 2005; Damodaran, 2002). We generate future sample paths for 10 years. Growing FCF perpetuity formula, shown later, will be used for the continuing value after the explicit forecast period. Repetition of the above steps 10 times for each series will yield one sample of future ten-year path for each variable. We generate 100,000 sets of the future path for four variables with which we calculate 100,000 sets of ten-year future FCF path.[10] The average of generated FCF for each year is given as Table 6.

Table 6. Forecasted FCF for growing and harvesting Hamlin orange for a model farm ($ per acre)

Season	2007-8	2008-9	2009-2010	2010-2011	2011-2012
FCF	906.43	880.15	848.62	823.36	796.63
Season	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
FCF	760.40	738.35	702.41	660.78	630.19

Estimation of Weighted Average Cost of Capital

Now that we have estimated future free cash flow, the next step is to discount the FCF by the appropriate discount rate. The discount rate we use is the weighted average cost of capital (WACC) which is the time value of money used to convert the expected FCF into a present value for all investors. Since enterprise cash flows are available for payment to both sources of capital, debt and equity, the discount rate must

[10] We simply assume that historical trend will continue for other items. That is, there is no change in management cost, overhead taxes and regulatory costs decreases by 0.078% annually, and capital expenditure decreases by 1.89% annually.

comprise a weighted average of the marginal costs of both sources of capital. In our application WACC is given by

$$WACC = k_d(1-T)\frac{D}{D+E} + k_e\frac{E}{D+E}, \quad (1)$$

where k_d is the pretax market expected yield to maturity on debt, for which we take k_d=7.69% from Florida Department of Citrus (2005),[11] T is the operational tax rate for the enterprise, which is 29% in our application, and k_e is the market-determined opportunity cost of equity capital. D is the market value of interest-bearing debt, and E is the market value of equity, but the important point is that we need to use the long term target level of debt equity ratio (Koller et al., 2005). For this we use the average debt equity ratio of 18.67% for 1994-2003 for all Florida farms including citrus farms (Economic Research Service). Many farms were actually farming multiple crops, but financing is done for the farm unit basis not for individual crop basis. In this case the cost of capital should reflect the risk structure of the farm unit rather than that of the specific crop (Suzuki, 2004). Since D/E=18.67%, so that $D/(D+E)$=0.1573.

Finally we estimate k_e, the market-determined opportunity cost of equity capital. Here we use the most widely used estimation method: capital asset pricing model (CAPM). The equation for the cost of equity from the CAPM is given as

$$k_e = r_f + [E(r_m) - r_f]\beta_e, \quad (2)$$

where r_f is the risk-free rate of return, $E(r_m)$ is the expected rate of return on the overall market portfolio, so that $[E(r_m)-r_f]$ is the market risk premium. β_e is the systematic risk of the equity (levered equity beta) which is defined as $COV(r_j, r_m)/VAR(r_m)$ where r_j is the rate of return from the equity to be evaluated. We use the annual yield on U.S. Treasury bond at 10-year constant maturity for 2005 as the risk-free rate of return (r_f=2.87%).[12] Suggestions for the market risk premium from Koller et al. (2005) is to calculate arithmetic average of the market premium relative to long-term government bonds for longest period

[11] Florida Department of Citrus (2005) indicates that the typical interest rate for citrus operation is 1.50% over prime rate. We take the average majority prime rate of 6.19% for 2005 from Federal Reserve Statistical Release (http://www.federalreserve.gov/releases/h15/data/Annual/H15_PRIME_NA.txt).

[12] Data is provided by Damodaran (2002). Updated data is available at http://pages.stern.nyu.edu/~adamodar/pc/datasets/histretSP.xls.

possible with longer-dated intervals (such as 5 years). We calculated arithmetic average of the S&P 500 premium relative to 10-year government bond for 1936-2005 with 10-year intervals, so that $\frac{1}{7}\sum_{t=1945,1955\ldots}^{2005}\frac{1+r_m(t)}{1+r_f(t)}=1.8526$ which is annualized as $1.8526^{1/10}-1=0.0636$. We use 6.36% as our market risk premium.[13]

The estimation of beta is not available for the Florida citrus operation. The only indicator we have is industry asset (unlevered equity) beta of 1.00 for agriculture from Mullins (1982). To convert it to the levered beta for citrus operation, we make the standard assumption: interest tax shields have the same risk as the debt for the operation. Also, we observe that the level of debt is almost constant, because the interest payments are almost constant in the sample period. However, the debt of the operation cannot be regarded riskless, because the typical interest rate (7.69%) is much higher than the riskless rate (2.87%). Under these conditions, the levered beta is expressed as the following formula from (Koller et al., 2005):

$$\beta_e = \beta_u + (1-T)\frac{D}{E}(\beta_u - \beta_d), \qquad (3)$$

where β_u is unlevered equity beta and β_d is beta for debt. Substituting k_d =7.69%, r_f =2.87%, $E(r_m)-r_f$ =6.36% into CAPM ($k_d = r_f + [E(r_m)-r_f]\beta_d$) yields β_d =0.7579. Substituting β_u =1.00, T=0.29, D/E=0.1867, β_d =0.7579 into the equation (3), we have levered equity beta of 1.0321. Subtituting these results in equation (2) and (1) yields k_e = 0.0943 and WACC = 0.0881.

Present Value Calculation

PV for year t is given as $PV_t = \sum_{\tau=t+1}^{2016}\frac{E(FCF_\tau)}{(1+WACC)^{\tau-t}} + \frac{(1+g)FCF_{2016}}{(1+WACC)^{2016-t}(WACC-g)}$ for t<2016. $PV_{2016} = \frac{(1+g)FCF_{2016}}{(WACC-g)}$. The latter is continuing value after the explicit forecast period estimated using

[13] We calculated r_m and r_f for each interval from dataset provided by Damodaran (2002) which is available at http://pages.stern.nyu.edu/~adamodar/pc/datasets/histretSP.xls.

growing FCF perpetuity formula in which *g* is the expected growth rate in FCF in perpetuity (-0.1512 from historical FCF).[14] NPV for year *t* simply adds FCF of that year to PV: $NPV_t = FCT_t + PV_t$ ($-I_t$ if the investment is made in that year). In Table 7 we show sample mean of these figures from the generated 100,000 samples.

Table 7. PV and NPV from growing and harvesting Hamlin orange for a model farm ($ per acre)

Season	2007-8	2008-9	2009-2010	2010-2011	2011-2012
PV	7,407.52	7,179.97	6,963.91	6,754.07	6,552.47
NPV	**8,313.95**	8,060.12	7,812.53	7,577.43	7,349.10
Season	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
PV	6,369.34	6,192.13	6,035.25	5,906.18	5,796.32
NPV	7,129.74	6,930.48	6,737.66	6,566.96	6,426.51

Next, we repeat the same procedures for mechanical harvesting operation. According to Roka the adoption of mechanical harvesting technology typically has the following impacts on citrus operation in subsequent seasons:

1. Harvest recovery rate becomes 98%.
2. Harvest cost decreases by $0.25 per box. That is, harvesting cost reduction of $0.25 for 98% of fruit, zero harvesting cost for 2% of fruit.
3. There is cost increase of $10/acre for skirting.

In addition to these annual impacts, the grower incurs the following costs in the initial season:

1. Cost increases by $20/acre for skirting, $40/acre for pruning and $40/acre for irrigation.
2. Yield reduces by 2% due to skirting.

In summary, this typical scenario will lead to 4% decrease in fruit harvest but $0.25 harvesting cost decrease for 96% of fruit, and zero harvesting cost for 4% of fruit in the initial season. In subsequent seasons, fruit harvest decreases by 2%, but harvesting cost decreases by $0.25 for 98% of fruit, and harvesting cost becomes zero for 2% of fruit. Other effects include $10/acre cost for each season, and

[14] Since *g* is negative, the continuing value is set to zero for a sample path for which the FCF is negative in 2016. It is not plausible that an agent continues to hold an asset with negative value which will continuously lose value.

$100/acre cost for the initial season. In Table 8 we show sample mean of FCF, PV and NPV from the generated 100,000 samples with the mechanical harvesting operation.

Table 8. FCF, PV and NPV from growing and harvesting Hamlin orange with mechanical harvesting ($ per acre)

Season	2007-8	2008-9	2009-2010	2010-2011	2011-2012
FCF	811.93	900.90	870.06	845.23	818.86
PV	7,531.60	7,294.24	7,066.81	6,844.16	6,628.26
NPV	**8,343.54**	8,195.14	7,936.86	7,689.39	7,447.13
Season	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
FCF	783.07	761.21	725.64	684.49	654.22
PV	6,429.15	6,234.35	6,057.95	5,907.16	5,773.37
NPV	7,212.21	6,995.56	6,783.59	6,591.65	6,427.58

In an alternative mechanical-harvesting scenario (lower recovery, higher cost reduction case) also presented by Roka, the harvest recovery rate becomes 90% from 98%, and per box harvest cost reduction becomes $0.51 from $0.25. Compared to the manual harvesting case, this alternative scenario will lead to 12% decrease in fruit harvest, but $0.51 harvesting cost decrease for 88% of fruit, and zero harvesting cost for 12% of fruit in the initial season. In subsequent seasons, fruit harvest decreases by 10%, but harvesting cost decreases by $0.51 for 90% of fruit, and harvesting cost becomes zero for 10% of fruit. Other effects include $10/acre cost for each season, and $100/acre cost for the initial season. In Table 9 we show sample mean of FCF, PV and NPV from the generated 100,000 samples with the mechanical harvesting operation with lower fruit recovery and higher cost reduction scenario.

Table 9. FCF, PV and NPV from growing and harvesting Hamlin orange with mechanical harvesting (lower fruit recovery, higher cost reduction scenario) ($ per acre)

Season	2007-8	2008-9	2009-2010	2010-2011	2011-2012
FCF	717.76	808.75	779.03	755.15	729.98
PV	6,789.43	6,578.82	6,379.38	6,186.26	6,001.29
NPV	**7,507.19**	7,387.57	7,158.41	6,941.40	6,731.27
Season	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
FCF	696.17	675.34	641.85	603.29	574.80
PV	5,833.83	5,672.45	5,530.35	5,414.28	5,316.48
NPV	6,530.00	6,347.79	6,172.19	6,017.57	5,891.28

Comparing the NPVs for 2007-8 season in Tables 7, 8 and 9, we find that the mechanical harvesting with standard scenario has the highest NPV of $8,343.54 followed by the manual harvesting operation with NPV of $8,313.95. The alternative mechanical harvesting scenario (the lower fruit recovery, higher cost reduction scenario) has the lowest NPV of $7,507.19. However, the NPV difference between the first two scenarios is very little (only 0.36%). Further, note that we need to subtract the investment cost for mechanical harvesting equipment from NPV of mechanical operation. Considering the investment cost, the enterprise DCF approach using the current data available for the Hamlin orange operation in Southwest Florida shows that the NPV of the manual harvesting operation is at least as high as that of mechanical harvesting operations.

Concluding Remarks

Value of the citrus operation has been estimated using the enterprise discounted cash flow (DCF) approach, the most widely used tool for the valuation, which discounts the forecasted free cash flow (FCF) at the opportunity cost of capital that is consistent with riskiness of the cash flow. Specifically, we applied the enterprise DCF approach to processed-market Hamlin orange operation in Southwest Florida, and compared the value of operation for the hand harvesting and that for the mechanical harvesting.

The standard scenario of the mechanical harvesting operation assumes that mechanization decreases harvesting costs by 25 cents per 90-lb box less than hand harvesting, but the fruit recovery rate also decreases by 2%. The alternative (lower recovery, higher cost reduction) scenario of the mechanical harvesting operation assumes that mechanization decreases harvesting costs by 51 cents per 90-lb box less than hand harvesting, but the fruit recovery rate decreases by 10%.

NPVs calculated using the enterprise DCF approach show that mechanical harvesting with standard scenario has the highest NPV of $8,343.54 followed by the hand harvesting operation with NPV of $8,313.95. The alternative mechanical harvesting (lower recovery, higher cost reduction) scenario has the lowest NPV of $7,507.19. Although the NPV difference between the first two scenarios is very small (only 0.36%), the NPV from the third scenario is almost 10% lower than the other two, due to large fruit losses.

Considering the investment cost for mechanical harvesting equipment which should be subtracted from NPV of the mechanical operations, the enterprise DCF approach applied for the Hamlin orange operation in Southwest Florida shows that the NPV of the hand harvesting operation is at least as high as that of mechanical harvesting operations.

This result might suggest one explanation for the relatively low adoption rate of mechanical harvesting systems (about 7.5% of the Florida orange acreage in 2006-07). However, further consideration is needed about the option value for the investment opportunity since the grower has the option (not the obligation) to invest or wait, called "investment flexibility". Hence the grower does not invest until the NPV less investment cost is greater than the NPV for the current operation by the margin of the option value of investment opportunity. The consideration for the option value often suggests further delay of the investment decision until a higher cash flow is more likely.

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