РАЗДЕЛ 1
НАУЧНЫЕ ИССЛЕДОВАНИЯ И КОНЦЕПЦИИ

SECTION 1
ACADEMIC INVESTIGATIONS & CONCEPTS

CAPITAL MARKETS, CORPORATE GOVERNANCE AND CAPITAL BUDGETING: IMPLICATIONS FOR FIRM VALUE

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Abstract

The conventional discounting capital budgeting techniques have been widely criticised for being inappropriate in incorporating multi-criteria interactions and for focussing on one-off single objective of maximizing net present value. This paper modifies a Multiple Objective Linear Programming (MOLP) optimization model of Levary and Seitz (1990). It adds to the objective function the mitigation of agency costs as a proxy of good corporate governance principles and capital market interactions. The goal of the study is to examine the impact of agency costs on the present value of a long term capital project and investment appraisal decision making in the airline industry to support better capital investment decision making in the future. Recent collapses of high profile companies in airline industry and other industries such as Flyglobespan Airline (in the year 2009) in Scotland, Ansett Airline (in the year 2001)in Australia, Enron(in the year 2001)and Lehman Brothers (in 2008)in the U.S whose impact is still being experienced today provide us with evidence of how important the minimization of agency costs is for the survival and success of organisations and the huge amounts involved as a result of poor corporate governance. The results reveal that debt financing which is often provided by capital markets plays an influential role in shaping the investment appraisal decisions through interest rates and debt covenants embedded in the debt contracts. The results show that mitigation of agency costs improves the firm's cash flow, financial management and corporate governance. It discourages illegal earnings management practices, enhances investment decisions, investors' confidence and reliability in the firm's investment decisions and hence enhances the firm value.

Keywords: Corporate Governance, Capital Markets, Cash Flow, Agency Costs, MOLP, Firm Value and Capital Budgeting

JEL Classification: G29; G31; G32; M14

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1 Introduction

Financial managers are required to make both operational and strategic decisions to maximise firm value. However, decision making for nonrecurring long term investments in the modern economy that relies on constantly changing information technology (IT) is complicated. It requires integrating multi-disciplinary interactions and impact on the investment decisions and the firm value (Schniederjans, Hamaker & Schniederjans 2010). This paper focuses on the investment appraisal decisions integrating the impact of minimising agency costs[1] of debt financing. Agency costs significantly affect the firm's efficiency, performance and long term investment decisions (Brealey, Cooper & Habib 1997 and Ross et al., 2011). According to Byrd (2010) agency costs are inversely related to financial leverage until the tax benefits and added discipline are exceeded by bankruptcy costs, agency costs and loss of future financing flexibility. The minimization of agency costs helps to lessen the self-interest behaviour of management (Wang 2010). Agency costs of debt financing increase the cost of equity because shareholders demand higher returns to compensate for the increased financial risk undertaken (Chen, Chen & Wei 2011) thus reducing firm value. Furthermore, Ruiz-Porras (2011) finds that agency costs of debt financing influence long term investment decisions because of debt covenants inserted in debt agreements by capital markets or debt provider. The study of the impact of agency costs on investment appraisal decisions is important today because of the large sums of money involved in capital investment of modern economy in general and the high debt financing the airline industry experiences in particular. For example, the Congressional Budget Office (CBO) of the US predicts the final bill to bail out Fannie Mae and Freddie Mac to be about $389 billion Appelbaum (2010) because of high agency costs the companies incurred as a result of poor corporate governance. In this case, the major shareholders of the two companies were local financial institutions owned by the US government which are assumed to have higher degree of moral hazard (Patibandia 2001) because of laxity supervision. According to Berrone (2008) one of the main causes of most company collapses is poor corporate governance and, Fulghieri & Suominen (2005)find that one of the main measures of poor corporate governance practices is high agency costs. This paper focuses on the minimisation of agency costs as a mechanism of mitigating agency costs and improving long term investment appraisal decisions.

The traditional discounted cash flow (DCF) techniques commonly used in capital budgeting decision making are found to be inadequate in incorporating the impact of multiple objectives and agency costs in the investment appraisal decisions (Schniederjans and Hamaker & Schniederjans 2010). Traditionally, there are two main sources of capital funds, debt and equity. According to Tadesse (2004) capital markets provide the larger proportion of capital in the form of debt. It is also acknowledged that capital markets facilitate good corporate governance practices through issuing debt covenants, demanding access to firm information and special purpose reports, and monitoring firm performance. Literature on capital markets asserts that loans from financial institutions discipline managers in strategic decision making to protect their assets (Nowak 2001). This action results into mitigating agency costs, increasing cash flow and enhancing firm value. Conventionally, agency costs are incurred to improve efficient financial management, good corporate governance and maximize firm value (Jensen & Meckling 1976, Renz 2007 and Psaros 2009).The mitigation of agency costs due to debt capital reduces the probability of management misappropriating cash flow which constitutes one of the main firm's current assets that managers can easily manipulate and misappropriate to maximize their self-interests.

The modified investment appraisal approach develops a multiple objective optimization model by incorporating agency costs in the objective function. The developed model is able to determine the optimum level of present value (PV) and debt capital amount that results into optimum firm value. This modelis applied to a hypothetical airline company in the US called World Airways Ltd. The goal of the company is maximizing the PV of the firm by maximising the PV of future net cash flows received from multiple flight routes, purchase of new airplanes, borrowing, lending and minimizing agency costs.

The use of optimization models in the airline industry has become the norm in the modern economy (Ragsdale 2007 and Papadakos 2009).The optimization models in airline operations can be used for scheduling crews to provide efficient and effective service without overworking the crew, selecting flight routes and scheduling arrival slot allocations that maximize firm value(Papadakos 2009). The developed optimization model in this study uses Microsoft Excel Solverto implement. The Solver is selected because it is user-friendly and its ability to handle quite easily multiple goals and constraints covered in this study. Solver permits editing and incorporatingrisk by changing coefficients of decision variables and constraints using sensitivity analysis. In fact, according to Fylstra et al. (1998) and Ragsdale (2007)it can be

[1] Banks (2004) defines agency costs as costs arising from the separation of ownership and control, which lead ultimately to a reduction in enterprise value.

used commercially under different economic conditions so it is robust.

Optimization Model: Airline industry

Traditionally, academics advocate for the use of net present value (NPV) technique in the investment appraisal process (Ragsdale 2007). The application of NPV technique helps managers to identify the project that adds most value to the firm. However, it ignores the impact of other internal and external economic factors, such as agency costs, multiple objectives, financial flexibility and the impact of capital markets interactions. Therefore, the failure for NPV technique to consider these significant economic factors provides a justification for this study that attempts to cover that gap. It develops a new integrated capital budgeting approach which considers NPV, multiple objectives and agency costs applied to an airline industry.

The main objective of this paper is threefold. One, it attempts to highlight the limitations of NPV in the face of increasing use and reliability of IT to gather data; two, the importance of multiple objectives in investment appraisal decision making; and three, the impact of capital markets in capital budgeting decision making. The airline industry is selected for this paper because the study modifies the multiple objective linear programming (MOLP) model used in Ragsdale (2007) which was based on an airline company. The modern airline industry faces an inherent risk, global uncertainty, severe competition and conflicting multiple objectives. The model incorporates the maximization of decision variables and minimization of agency costs in the objective function. Considering recent experiences in the airline industry such the Ansett pilot strike in Australia in 2009 (Weller 2009), the September 11 bombing of the World Trade Centre in the U.S (Kaddy 2007), the Ireland volcano eruption in 2010 (Michaels, Dalton & Pasztor 2010), global high fuel prices (Morrell 2011) and the Chile volcano eruption (Vergara 2011), a new investment appraisal approach in the industry to maximize firm value is justified and long over due. Since the initial capital investment in the airline industry such as purchasing the first airplane requires a huge sum of money, it is fitting that the investment appraisal approach in this industry considers various significant economic factors before such huge sum of money is committed. It is recognized that investment decisions made that are not optimum negatively affect the firm's financial performance and position for a long time in the future because long term investment decisions are not easily reversible (Ross et al., 2011).

2 Background and Literature Review

Modern economy which relies on IT to collect data used to make strategic decisions needs access to developed capital markets[2]for debt capital to be competitive and respond to capital market changes promptly (Faleye 2004 and Gatchev, Pulvino, & Tarhan 2010).There is overwhelming evidence that countries with developed economy such as the US, Japan, Australia, Canada, Germany, UK and France have developed capital markets (Dietl, 2001). Agency costs due to mainly poor corporate governance limit prompt access to debt capital from capital markets thus limiting a firm's capital investments (DeMarzo & Fishman 2007). The literature on capital markets suggests that through the issuance of debt covenants (both positive and negative) checks on management self interest behaviour, strengthens corporate governance and mitigates agency costs which in turn improves capital investment decisions (Nowak 2001 and Chava & Roberts 2008).

The strict internal and external regulatory regime on capital markets including elements such as debt covenants, operation interactions, accounting practices, corporate governance, interest rates and default risk influence the banks' lending decisions. Capital markets lend funds to corporations after thoroughly analysing their default risk and corporate governance. The level of default risk is used to determine the level of interest rate charged and the debt covenants stipulated in the debt agreement (Chen, Chen & Wei 2003; Schauten & Blom 2006; Piot & Missonier-Piera 2007). The interest rate charges translate into firm's cost of capital which impact on the net cash inflows and the discount rate applied to calculate the NPV of the capital investment. The higher the interest rate charged the higher the cost of capital and the lower the NPV. The managers use NPV calculated to make decisions whether to proceed with the project or to reject it which, in turn impact on the firm's present value and shareholder wealth (Ross et al, 2011).

Corporate Governance

Corporate governance[3]policies are formulated with the aim of achievingoverall sound financial management to maximize firm value (Banks 2004). According to Wang (2010) developing and implementing the correct optimal investment policy increases corporate value and good corporate

[2] Viney (2009) describes capital markets as markets which offer long term funds in the form of equity, corporate debt and government debt.

[3] Banks (2004, p.3) defines corporate governance as '…the structure and function of a corporation in relation to its stakeholders generally, and its shareholders specifically…'

governance helps in achieving this goal. Capital budgeting principles too are developed with the same objective in mind of maximizing the firm value (Seitz & Ellison 1999 and Ross et al, 2011). Therefore, good corporate governance results into capital budgeting policies that aim at maximizing firm value (Allen, Carletti & Marquez 2009 and Ross et al., 2011). Thus the principles of both capital budgeting and corporate governance are interrelated and complement each other in their effort to maximize firm value. Therefore, an investment appraisal model that does not integrate the principles of both capital budgeting and corporate governance ignore an important factor required to maximize firm value. The findings of Cremers and Nair (2005) support the study results of Gompers, Ishii, and Metrick (2003) that good corporate governance improves investment decision making and earnings. Also, according to Shleifer and Vishny (1997) and Salacuse (2002) effective corporate governance practices impose discipline on firm managers to maximize returns to the firm and reduce agency costs within a firm thus enhancing the firm value.

Agency Costs

Agency costs[4] arise as a result of the agency relationship between managers (agents) and shareholders (principals). Decisions to finance long term projects with debt capital require managers employing the debt capital prudently and achieving financial efficiency measured in return on capital (Palepu 1990, Kaplan 1989, Smith 1990 and Denis & Denis 1993). The impact of agency costs on firm survival and success has become significant topic of discussion in theory and practice lately after the demise of high profile firms such as government-sponsored entities Fannie Mae and Freddie Mac, Lehman Brothers, HIH Insurance, Enron Corporation and WorldCom due to poor corporate governance. Puzzanghera (2010) of the Los Angeles Times reports that the financial bailout of Fannie Mae and Freddie Mac could cost the US taxpayer a huge sums of money ranging from $221 to $363 billion by the end of 2013. Appelbaum (2010) cites the Congressional Budget Office (CBO) the bailout for Fannie Mae and Freddie Mac to be about US$389 billion. According to Hirth & Uhrig-Homburg (2010) and Byrd (2010) one of the ways of reducing agency costs is debt financing. Increasing debt as a source of capital increases the debt equity ratio which in turn increases cash outflow in the form of interest charges paid out but also reduces tax payable (tax shield). This in turn decreases free cash flow available to the managers thus imposing financial discipline on the managers, reducing agency costs and increasing firm value. As documented by Stulz (1990; Rasiah & Kim 2011) shareholders mitigate agency costs by limiting managers' access to free cash flow which in turn improves corporate governance and enhances firm value. This paper focuses on minimizing agency costs using the debt equity ratio as the proxy for agency costs and good corporate governance(Jensen 1986; Cui & Mak 2002). High agency costs limit the extent of borrowing and consequently limit firm's investment potential (DeMarzo & Fishman 2007). The minimization of agency costs is a good indicator of prudent and efficient financial management and, good corporate governance (Tsuji 2011). Therefore mitigating agency costs in investment appraisal process improves the firm value.

Capital Budgeting

Capital budgeting[5]decisions involve investing in long term projects (Ross 2011). They are decisions that form an integral part of a company's operational and strategic decision making, sound financial management and corporate governance. They are often influenced by a number of factors such as capital market interest rates, corporate governance, financial management, earnings management and agency costs. Therefore, capital budgeting decisions should consider the interactions of various economic factors rather than being based on simple projected net cash flows that result into a one-off NPV.

These decisions are some of the most important decisions management makes because they have long term implications on the firm's survival; require large sums of funds; are not easily reversible and are difficult to make. A wrong decision can be disastrous for the long term continued existence of the firm. Therefore investment decisions in capital budgeting need very careful planning, implementation and performance follow-up.

The risk of making negative net cash inflows in the early years of the investment is a normal occurrence but the situation is exacerbated if a firm invests in sectors which have inherent high business risk, such as the airline industry. At the same time the traditional capital budgeting techniques including NPV and internal rate of return (IRR) that are commonly advocated for by both academics and practitioners (Bennouna et al., 2010), are not capable of handling such inherent high business risk. Therefore, capital investments in the airline industry need capital budgeting models that can factor in multiple flight routes (multiple objectives),

[4] Renz (2007) defines agency costs as costs incurred by a firm to encourage managers to maximize the firm's value, rather than making decisions which maximize their own interests.

[5] Ross (2011) defines capital budgeting as the process of planning and managing a firm's investment in non-current assets.

risk and corporate governance principles. This paper develops an optimisation model that considers multiple objectives and agency costs thus improving on the NPV traditional capital budgeting models.

3 Data Sources and Multiple objective linear programming (MOLP) – Base Model

While the capital budgeting literature asserts that the main objective of capital investments is to maximize shareholder wealth using NPV metric, in the modern economy, this goal can only be achieved when the interactions of multi-disciplinary impacts are considered.

The paper uses multiple objective linear programming (MOLP) model[6] rather than NPV because MOLP model allows multiple objectives (Hallerbach & Spronk 2002)such as multiple flight routes, mitigation of agency costs and multiple constraints in the case of an airline industry. Programming models are tools that help decision makers choose suitable decisions to achieve their planned objectives. The models are not intended to replace rational human judgement. In executing the MOLP model, decision variables and constraints are defined and ranked by assigning them coefficients based on financial managers' past experience, current estimation and future expectation. Then an objective function and constraint equations are formulated. Next the figures are put in a solver program and after that the model is run to find the optimum value of the objective function. This paper analyses the generated sensitivity report using shadow prices and reduced costs. The model can incorporate risk analysis by changing the coefficients of decision variables and constraints by one unit at a time and examine the impact on the optimum value - PV. This model modifies Levary and Seitz's objective function by adding the agency costs and the results analysed. Following Levary and Seitz (1990) the general mathematical equation for MOLP for an investment appraisal problem when borrowing and lending are allowed can be written as:

MAX: $$\sum_{i=1}^{M} \hat{f}_i x_i + \xi_N - \delta_N$$

Subject to:

$$-\sum_{i=1}^{M} f_{i1} x_i + \xi_1 - \delta_1 \le b_1$$

$$-\sum_{i=1}^{M} f_{it} x_i - (1+r)\xi_{t-1} + \xi_t + (1+r)\delta_{t-1} - \delta_t \le b_t$$

for t=2,3,…,N

$$\delta_t \le C_t \qquad \textit{for } t=1,2,\dots,N$$

$$\xi_t, \delta_t \ge 0 \qquad \textit{for } t=1,2,\dots,N$$

$$0 \le x_i \le 1 \qquad \textit{for } t=1,2,\dots,M$$

Whereb_t is the available budget for year t, $C_t$is the limit on borrowing during year t (the firm's credit), $\sum_{i=1}^{M} \hat{f}_i x_i$ represents PV of cash flows at year Mandξ_N – $\delta_N$equals the amount lent less the amount borrowed during year N.

The objective junction represents the PV of all net cash flows from the flight routes, purchase of airplanes, borrowing, lending and mitigation of agency costs at the end of year N. Data used in this study is Levary and Seitz (1990) and on World Airways Ltd, a hypothetical international airline company.

- World Airways purchases a new aircraft on January 1 for $28 million;
- The airplane flies East Coast commuter routes and generates revenues of $18,980,000 a year;
- Operating expense excluding depreciation is $12,509,280 a year;
- Depreciation is $741,680 in the first year;
- World Airways faces a 34% corporation tax rate;
- At the time of acquisition, World Airways must pay $28 million plus $2,847,000 to increase working capital, for a total of $30,847,000;
- World Airways also considers purchasing wide-body airplanes for use on European routes;
- Each wide-body airplane costs $146 million.

Note: Adopted from Levary & Seitz 1990, pp.21-22 and p.143.

The previous year, World Airways considered replacing its last obsolete narrow-body airplane.

- The old airplane costs $28,570,000 per annum to operate;
- The new airplane costs $16,325,720 per annum to operate, excluding depreciation and taxes;
- The new airplane requires a working capital of $2,487,000;
- The old airplane requires a working capital of $1,814,000;
- A feasibility study to determine the costs and benefits has already cost $15,000;
- The old airplane could be sold for $12 million;
- The old airplane has a written down value (cost less accumulated depreciation) of $9 million;
- The depreciation for year 1 for the new airplane is $1,112,520;

[6]MOLP is concerned with structuring, solving decision and planning problems involving multiple objectives where all relationships are assumed to be linear.

- The depreciation for the old airplane is $613,000 for year 1 if the old airplane was kept;
- The estimated required rate of return earned for the planning horizon of five years is 14%;
- World Airways accepts capital rationing during the entire five-year period;
- World Airways evaluates the purchase of the new airplane using the NPV method.

Note: Adopted from Levary & Seitz 1990, pp. 24-25.

The company assumes a number of economic conditions as shown in Table 1. Also the company estimates cost of capital of 14% per annum and limits the amount of external capital that can be raised at this cost at $1 billion. If World Airways tries to raise capital faster than this, the marginal cost of capital would increase to 20%. The company also decides that any unusual funds raised can be temporarily invested at an interest rate of 10% a year. The estimated cash flows and calculated coefficients for the constraints are shown in Table 1.

Table 1. Flight Route Assumptions and Calculation Summary of Coefficient Variables

1	All flight routes have equal risk or cash flows are identified
2	All costs and benefits are measured in cash flows
3	The capital structure is the best possible (lowest possible cost of capital)
4	Funds that can be raised or invested externally at a given discount rate is unlimited
5	The discount rate is the same from year to year
6	If more than one source of capital is used, each source each source remains of the same proportion of the present value of the remaining cash flows throughout the life of the asset.

		Year 1		Years 2-5		Year 1	Years 2-5
	Flight Routes	Cash Flow Per Flight	Flight Days	Cash Flow Per Flight	Flight Days	Coefficient Variables	
						Sums divided by 1,000,000	Sums divided by 1,000,000
R_1	Europe Summer	49,924	182.5	49,924	182.5	9,111	9,111
R_2	Europe Winter	49,924	182.5	49,924	182.5	9,111	9,111
R_3	Transcontinental	33,611	365	33,611	365	12,268	12,268
R_4	Short flights	2,049	365	2,049	365	0.748	0.748
R_5	Intermediate	2,566	365	2,566	365	0.9367	0.9367
R_6	Caribbean Summer	18,763	182.5	37,142	182.5	3.424	6.778
R_7	Caribbean Winter	18,763	182.5	37,142	182.5	3.424	3.4246.778
R_8	Commuter	1,549	365	1,549	365	0.565	0.565
R_W	Wide-body plane purchase price	146,000,000 in Year 1					
R_N	Narrow-body plane purchase price	28,000,000 in Year 1					
ξ_{1-5}	Lending interest	10%					
δ_{1-5}	Borrowing interest	14%					

Note: The assumptions and calculations given here are based on the information given on page 49 and in Table 5.2, p.143 respectively of Levary and Seitz (1990).

It is company policy to maintain the debt to equity ratio at a limit 40% per annum. The debt capital must be less than or equal to $1,000,000,000. Hence the equity value is estimated to be equal or less than $2,500,000,000 maximum.

Two additional constraints include state that the trans-Atlantic revenue must be limited to at most 30% of the revenue for summer and winter seasons combined. The revenue for the first year is estimated to be lower than that expected for the following years, because it will take time for World Airways to develop the Caribbean routes. Therefore, two additional constraints on trans-Atlantic revenue are needed, one for the first year and another one for the subsequent years. These constraints are formulated below:

Defining the Decision and Constraint Variables

The maximisation of the present value (PV) of World Airways is achieved through optimal allocation of available capital resources based on the given constraints. Below we define the following decision variables:

R_1: Wide-bodied airplanes: average number of trans-Atlantic flights per day in summer.

R_2: Wide-bodied airplanes: average number of trans-Atlantic flights per day in winter.

R_3: Wide-bodied airplanes: average number of transcontinental flights per day.
R_4: Narrow-bodied airplanes: average number of short flights per day.
R_5: Narrow-bodied airplanes: average number of intermediate flights per day.
R_6: Wide-bodied airplanes: average number of Caribbean flights per day in summer.
R_7: Wide-bodied airplanes: average number of Caribbean flights per day inwinter.
R_8: Narrow-bodied airplanes: average number of commuter flights per day.

P_w: Wide-bodied airplanes purchased at the beginning of the first year.
P_N: Narrow-bodied airplanes purchased at the beginning of the first year.
$\xi_{t:}$ The amount lent in year t (t = 1, 2, …, 5.
δ_t*:* The amount borrowed in year t (t = 1, 2, …, 5).

The formulation of the capital budgeting problem: In the base model of Levary and Seitz (1990), management estimates expected PVs from each route, calculated at the 5-year time period. They are shown in Table 2.

Table 2. Estimated Present Values (PV)

Routes	**Present value at the horizon of total cash flows (millions of dollars).**
Summer trans-Atlantic routes *(R_1)*	11.11
Winter trans-Atlantic routes *(R_2)*	0.00
Transcontinental routes *(R_3)*	0.00
Short routes *(R_4)*	0.25
Intermediate routes *(R_5)*	0.25
Summer Caribbean routes *(R_6)*	0.00
Winter Caribbean routes *(R_7)*	2.15
Commuter routes *(R_8)*	0.00

Note: The present values for different routes given here are based on the information given on page 146 Levary and Seitz (1990).

The objective function aims at maximizing the present value of the company and the full model is formulated as follows:

Maximize present values (PV): $\xi_5 + 11.11_{R1} + 0.25_{R4} + 0.25_{R5} + 2.15_{R7} + 100_{Pw} + 20_{PN} - \delta_{5;}$

subject to:

$\xi_1 - 9.111_{R1} - 9.111_{R2} - 12.268_{R3} - 0.748_{R4} - 0.9367_{R5} - 3.424_{R6} - 3.424_{R7} - 0.565_{R8} + 146_{Pw} + 28_{PN} - \delta_{1;} \leq 0;$

$1.14\xi_1 - \xi_2 - 9.111_{R1} - 9.111_{R2} - 12.268_{R3} - 0.748_{R4} - 0.9367_{R5} - 6.778_{R6} - 6.778_{R7} - 0.565_{R8} - 1.1\delta_1 + \delta_2 \leq 0;$

$1.14\xi_2 - \xi_3 - 9.111_{R1} - 9.111_{R2} - 12.268_{R3} - 0.748_{R4} - 0.9367_{R5} - 6.778_{R6} - 6.778_{R7} - 0.565_{R8} - 1.1\delta_2 + \delta_3 \leq 0;$

$1.14\xi_3 - \xi_4 - 9.111_{R1} - 9.111_{R2} - 12.268_{R3} - 0.748_{R4} - 0.9367_{R5} - 6.778_{R6} - 6.778_{R7} - 0.565_{R8} - 1.1\delta_3 + \delta_4 \leq 0;$

$1.14\xi_4 - \xi_5 - 9.111_{R1} - 9.111_{R2} - 12.268_{R3} - 0.748_{R4} - 0.9367_{R5} - 6.778_{R6} - 6.778_{R7} - 0.565_{R8\,-}\ 1.1\delta_4 + \delta_5 \leq 0;$

$15.587_{R1} + 15.587_{R2} - 9.451_{R3} - 0.931_{R4} - 1.281_{R5} - 3.203_{R6} - 3.203_{R7} - 0.721_{R8} \leq 0;$

$15.587_{R1} + 15.587_{R2} - 9.451_{R3} - 0.931_{R4} - 1.281_{R5} - 5.018_{R6} - 5.018_{R7} - 0.721_{R8} \leq 0;$

$2_{R1} - 3_{R2} = 0;$

$2_{R6} - {}_{R7} = 0;$

$1.277_{R1} + {}_{R3} + {}_{R6} - 2.3_{Rw} \leq 98.9;$

$1.277_{R2} + {}_{R3} + {}_{R7} - 2.3_{Rw} = \leq 98.9;$

${}_{R4} + {}_{R5} + {}_{R8} + 8_{PN} = \leq 1000;$

${}_{R4} - 0.1_{R5} \leq 0;$

${}_{R4} - 0.3_{R5} \leq 0;$

$\delta_1 + \delta_2 + \delta_3 + \delta_4 + \delta_5 \leq 1000;$

${}_{Ri} \leq 0$ for i = 1, 2, …, 8;

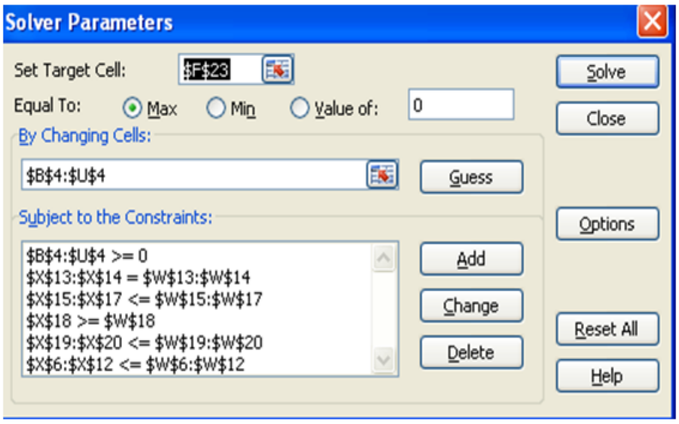
${}_{Rw} \leq 0,\ {}_{PN} \leq 0;$

$\xi_j \leq 0,\ \delta_j \leq 0$ for j = 1, 2, …, 5.

Implementing the model

In Figure 1, the set target cell F23 holds the expected PV after running the model. In this problem the PV is $16,511. The objective of this model is to maximize the PV for airplane investment appraisal. The figure in the target cell is the sum-product of the PV for each decision variable (different flight routes, purchases of airplanes, lending and borrowings) at the 5-year time horizon of the total cash flows (in millions of dollars). The changing cells hold the maximum PV for each decision variable. The Solver is used to run the model and it places values into these cells until it finds the values that give the optimum results in total.

Figure 1. Solver Parameter Dialog Box



The constraints for the study are added to the problem in the 'subject to' window after the objective function equation. One of the options' icons in the Solver Parameter's dialog box allows the user to customise the problem. For example, there is an option which defines whether the problem is linear or non-linear. When the user defines the problem as linear, the sensitivity report produced contains different terms such as shadow prices[7] to describe marginal value of PV and reduced costs[8] to describe the cash flow at which routes not used in the itinerary would be included in the schedule to achieve the optimum PV. When the problem is not defined as linear, the Solver assumes the problem is non-linear and the sensitivity report generated uses the terms such as the Lagrange multiplier instead of shadow price to describe marginal value of PV. The Solver results dialog box is presented in Figure 1.

4 Base Model Results

Technically, when Solver returns a solution, it means that it has found a feasible and optimum answer and all the constraints are satisfied (Fylstra et al. 1998). The most important report of the three reports generated is the sensitivity one that contains the shadow prices and reduced costs. The analysis of the report involves ranking the shadow prices to identify the constraint that impacts on the optimal value most. The rankings of shadow prices in this study are shown in Table 3.

As indicated in Table 3, based on the rankings of the shadow prices, the availability of wide-bodied airplanes in summer impacts most on PV of the World Airways, followed by the availability of wide-bodied airplanes in winter. The third most significant constraint that impacts on maximizing PV is the availability of narrow-bodied airplanes all the times. Therefore, the results show that the availability of both wide-bodied and narrow-bodied airplanes impacts most on the PV.

The paper selected the top three constraints with the highest values of shadow prices and separately increased their constraints by one unit ($1million); then ran the model after each change and analysed the results. Table 4 shows the final values for both decision variables and constraints for the model, after modifying the base model with the three top shadow prices. For the purpose of useful analysis of the results, the final values only for the decision variables are discussed in the paper. The goal of the model is to maximize the PV of World Airways therefore all decision variables with zero values are excluded in the analysis because they do not add anything to the optimal PV. Further, based on the management estimation of PV values for each decision variable (see Table 2), some decision variables are estimated to contribute zero PV, therefore these too are excluded in the analysis because they also do not add any value to the total PV.

Shadow prices

Table 4clearly shows that when the three constraints with higher values of shadow prices are increased by one unit (1 million), the optimal value as well as the values of some decision variables changes. The constraint with the largest shadow price value, the availability of wide-bodied airplanes in summer, causes the greatest increase on the optimal value and final values of some decision variables, followed by the availability of wide-bodied airplanes in winter, and third is the availability of narrow-bodied airplanes all times.

After excluding decision variables with zero final values and decision variables with zero

[7] Ragsdale (2004) defines shadow price as the amount by which the objective function value changes given a unit increase in the RHS value of the constraint, assuming all other coefficients remain constant.

[8] Ragsdale (2004) defines reduced cost as the amount by which the objective function would be reduced (or improved) if this variable were allowed to increase by one unit.

coefficient values, the results for the horizon of five years show that the two decision variables which contributed most to the optimal PV, are the PV of the interest earned on money lent (ξ_5) and PV from wide-bodied airplanes purchased (P_W). Both decision variables contributed a total of 93% of the optimal PV (see Table 7); interest on money lent contributed 77%; and wide-bodied airplanes purchased contributed 16%. When the constraint of an decision variable with the highest shadow price – the availability of wide-bodied airplanes in summer, is increased by one unit ($1 million), the optimal value increases from $16,510.64 million to $16,561.3 million (an increase of 50.66 units – $50.66 million). When the constraint of the decision variable with the second highest shadow price – the availability of wide-bodied airplanes in winter is increased by one unit ($1 million), the optimal value increases from $16,510.64 million to $16,548.3 million (an increase of $37.66 million). Lastly, when the constraint of the decision variable with the third highest shadow price – the availability of narrow-bodied airplanes all times is increased by one unit ($1 million), the optimal value increases from $16,510.64 million to $16,517.9 million (an increase of $7.26 million). In absolute dollars, these are significant increases. In modifying the base model, the agency costs of 0.48 (-1.2*0.4) are incorporated in the objective function; -1.20 is the estimated debt capital and 0.4 is the estimated debt equity ratio. Based on the results, World Airways should operate 72 trans-Atlantic flights per day during the summer season, 91 short flights per day, 910 flights intermediate flights per day, 61 Caribbean flights per day during winter season, purchase 25 new wide body airplanes and lend $12753.16 million per year. The decision to operate the above flight routes, the purchase of the wide body airplanes and the lending out excess cash flow, maximizes the PV of the future cash flow to $16,517.9 million which maximizes World Airways PV.

Reduced cost

Two of the ways reduced cost can validly be interpreted are; the amount by which one unit of that variable's coefficient value would change the optimal value or the amount of penalty (cost) the company would pay for introducing one unit of that variable into the solution.

Since this paper is about maximizing PV the negative reduced costs for non-basic variables in the sensitivity report indicate that the variable or resource marginal cost is more than the marginal revenue. Therefore, the activity should not be undertaken. If the reduced cost is positive, increasing the reduced cost of that particular activity makes it attractive and improves the optimal value (Bradley, Jarrell & Kim 1984).

The paper analyses the reduced costs to establish their impact on the PV of World Airways. The results of the base model (see Table 5) show that out of the twenty variables analysed, seven variables have negative reduced costs therefore money should not be spent on these resources.

Table 3. Base Model: Shadow Prices Rankings

Names	Shadow Price	Ranking
Total value in Year 1	2.08	4
Total value in Year 2	1.33	5
Total value in Year 3	1.21	6
Total value in Year 4	1.10	7
Total value in Year 5	1.00	8
AC1 – Trans–AtlanticRevenueY1	0.63	9
AC2 – Trans–AtlanticRevenueY2-5	0.00	11
AC3 – Trans–AtlanticFlightsWinter	-1.09	12
AC4 – CaribbeanFlightsSummer	-5.04	14
AC5 – AvailabilityWidebodyAirplanesSummer	50.67	1
AC6 – AvailabilityWidebodyAirplanesWinter	37.69	2
AC7 – AvailabilityNarrowbodyAirplanesAlltimes	7.21	3
AC8 – ShortFlightRoutesMoreThanTenPercent	-1.35	13
AC9 – ShortFlightRoutesLessThanThirtyPercent IntermediateFlights	0.00	11
AC10 – ExternalCapitalLimit	0.56	10

Table 4. Summary: Impact of Final Values by Increasing the Top Three High ranked Constraints Using Shadow Prices by One Unit ($1 million)

		Final values (millions)			
		Base model	Shadow price 1¤	Shadow price 2*	Shadow price 3#
	Optimal present value (objective value)	16510.64	16561.3	16548.3	16517.9
	Changing variables				
1	Flights Europe – Summer	72.26	72.57	72.25	72.29
2	Flights Europe – Winter	48.17	48.38	48.17	48.20
3	Flights - USA	35.17	36.91	34.14	35.12
4	Short flights Narrow – bodied airplanes	90.91	90.91	90.91	91.00
5	Intermediate Flights	909.09	909.09	909.09	910.00
6	Flights Caribbean – Summer	30.76	29.89	31.75	30.77
7	Flights Caribbean – Winter	61.51	59.78	63.51	61.55
8	Commuter flights	0.00	0.00	0.00	0.00
9	Wide-bodied airplanes purchased	25.78	25.90	25.77	25.79
10	Narrow-bodied airplanes purchased	0.00	0.00	0.00	0.00
11	Amount lent Year 1	0.00	0.00	0.00	0.00
12	Amount lent Year 2	1933.64	1942.08	1941.21	1934.88
13	Amount lent Year 3	5200.64	5218.37	5216.55	5203.24
14	Amount lent Year 4	8794.35	8822.28	8819.41	8798.44
15	Amount lent Year 5	12747.42	12786.59	12782.57	12753.16
16	Money borrowed Year 1	1000.00	100.00	1000.00	1000.00
17	Money borrowed Year 2	0.00	0.00	0.00	0.00
18	Money borrowed Year 3	0.00	0.00	0.00	0.00
19	Money borrowed Year 4	0.00	0.00	0.00	0.00
20	Money borrowed Year 5	0.00	0.00	0.00	0.00
	Constraints				
1	Total value Year 1	0.00	0.00	0.00	0.00
2	Total value Year 2	0.00	0.00	0.00	0.00
3	Total value Year 3	0.00	0.00	0.00	0.00
4	Total value Year 4	0.00	0.00	0.00	0.00
5	Total value Year 5	0.00	0.00	0.00	0.00
6	AC1 – Trans-Atlantic revenue Year 1	0.00	0.00	0.00	0.00
7	AC2 – Trans-Atlantic revenue Year 2-5	-167.47	-162.75	-172.91	-167.56
8	AC3 – Trans-Atlantic flights – Winter	0.00	0.00	0.00	0.00
9	AC4 – Caribbean flights – Summer	0.00	0.00	0.00	0.00
10	AC5 – Availability wide-bodied Airplanes – Summer	98.90	99.90	89.90	98.90
11	AC6 – Availability wide-bodied Airplanes – Winter	98.90	98.90	99.90	98.90
12	AC7-Availability narrow-bodied Airplanes – All-times	1000.00	1000.00	1000.00	1001.00
13	Short flight routes more than 10% of Intermediate flights	0.00	0.00	0.00	0.00
14	Short flight routes less than 30% of Intermediate flights	-181.82	-182.82	-182.82	-182.00
15	External capital limit	1000.00	1000.00	1000.00	1000.00

Notes:
Shadow price 1¤: Availability of wide-bodied airplanes – Summer
Shadow price 2*: Availability of wide-bodied airplanes – Winter
Shadow price 3#: Availability of narrow-bodied airplanes – All times

Table 5

Microsoft Excel 12.0 Sensitivity Report
Worksheet: [World_Airways_2010_UNMODIFIED6.xlsx]Sheet1
Report Created: 1/10/2010 2:25:30 PM

Adjustable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B6	Flights_Europe_Summer	72.26	0.00	11.11	6848.29	24.03
C6	Flights_Europe_Winter	48.17	0.00	0	10272.43	36.05
D6	Flights_USA	35.17	0.00	0	13.90	29.13
E6	Short_Flights_Narrow_Body_Airplanes	90.91	0.00	0.25	1.49	32.66
F6	Intermediate_Flights	909.09	0.00	0.25	1E+30	1.49
G6	Flights_Caribbean_Summer	30.76	0.00	0	58.43	37.78
H6	Flights_Caribbean_Winter	61.51	0.00	2.15	29.21	18.89
I6	Commuter_Flights	0.00	-2.97	0	2.97	1E+30
J6	WidebodyAirplanesPurchased	25.78	0.00	100	2126.86	66.33
K6	Narrow_bodied_Airplanes	0.00	-95.85	20	95.85	1E+30
L6	Amount_Lent_Year1	0.00	-0.61	0	0.61	1E+30
M6	Amount_Lent_Year2	1933.64	0.00	0	0.32	1.331
N6	Amount_Lent_Year3	5200.64	0.00	0	0.35	1.21
O6	MoneyLentYear4	8794.35	0.00	0	0.39	1.1
P6	MoneyLentYear5	12747.42	0.00	1	0.42	1
Q6	MoneyBorrowedYear1	1000.00	0.00	0	1E+30	0.56
R6	MoneyBorrowedYear2	0.00	-0.61	0	0.61	1E+30
S6	MoneyBorrowedYear3	0.00	-0.60	0	0.60	1E+30
T6	MoneyBorrowedYear4	0.00	-0.60	0	0.60	1E+30
U6	MoneyBorrowedYear5	0.00	-0.56	-1	0.56	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
X8	TotalValueYear1	0.00	2.08	0	1E+30	3056.32
X9	TotalValueYear2	0.00	1.33	0	1E+30	1933.64
X10	TotalValueYear3	0.00	1.21	0	1E+30	5200.64
X11	TotalValueYear4	0.00	1.10	0	1E+30	8794.35
X12	TotalValueYear5	0	1	0	1E+30	12747.42
X13	AC1_TransAtlanticReveueYear1	0.00	0.63	0	178.28	2762.06
X14	AC2_TransAtlanticRevenueYear2_5	-167.47	0.00	0	1E+30	167.47
X15	AC3_TransAtlanticFlights_Winter	0.00	-1.09	0	49.74	64.58
X16	AC4_CaribbeanFlights_Summer	0.00	-5.04	0	38.11	32.21
X17	AC5_Availability_widebody_Airplanes_Summer	98.90	50.67	98.9	35.47	20.22
X18	AC6_Availability_widebody_Airplanes_winter	98.90	37.69	98.9	34.16	30.83
X19	AC7_Availability_Narrowbody_airplanes_alltimes	1000.00	7.21	1000	761.08	1000.00
X20	AC8_Short_Flight_routes_more_than_tenpercent	0.00	-1.35	0	153.85	100.00
X21	AC9_Short_Flight_routes_Less_than_thirtypecentage_intermediate_Flig	181.82	0.00	0	1E+30	181.82
X22	AC10_External_Capital_Limit	1000.00	0.56	1000	2178.20	1000.00

The variables which have negative reduced costs include commuter flights route which has a negative of 2.97 units (-2.97 million). This means that the estimated coefficient variable (PV) for this route has to increase by at least 2.97 units from its original estimated PV of zero to positive 2.97 units in order to contribute positively to PV. Next is the narrow-bodied airplanes purchased which has a negative reduced cost of 95.85 units (-95.85 million). Similarly, this means that the estimated PV for the purchase of narrow-bodied airplanes has to be increased by 95.85 units from its original estimated PV of 20 units to 115.85 units, in order to contribute positively to PV. The other decision variables that have negative reduced costs include amount lent in the first year (-0.61 million), amount borrowed in the second year (-0.61 million); amount borrowed for both the third and fourth year (-0.60 million), and amount borrowed for the fifth year (-0.56 million). These variables need to be increased by their negative respective amounts in order to contribute positively to PV.

5 Modified Model Results

Agency costs

The objective function of the base model of Levary and Seitz (1990) is modified by including agency costs as a proxy for good corporate governance and the constraints are modified by adding equity capital, debt capital, debt equity ratio and agency costs. The modified model is discussed below.

The objective function of the modified model incorporate agency costs of 0.48. The constraints' section include limits of debt capital of $2,500 million, debt equity ratio of 40% and agency costs of 1.2 of the debt equity ratio. The modified model aims at maximizing the PV and minimising agency costs of the company. The model defines all cash components to be in units of millions of dollars.

The mathematical equations of the modified model are shown below.
Maximize (PV): $\xi_5 + 11.11_{R1} + 0.25_{R4} + 0.25_{R5} + 2.15_{R7} + 100_{Pw} + 20_{PN} - \delta_5 - 0.48_{AC5}$
Subject to:
(Showing only constraints added to the original mathematical equations after table 2)

$T_E = E_1 + E_2 + E_3 + E_4 + E_5 \leq 2500$
$DER = T_\delta / T_E$
$DER \geq 0.40$
$AC \leq -1.2DER$

Shadow prices

The study uses shadow prices to identify and analyse sensitive decision variables that impact the PV most. The higher the shadow price value is the higher the impact of that resource is on the PV. The results show three decision variables that have significant impact; the availability of wide-bodied airplanes in summer, availability of wide-bodied airplanes in winter and availability of narrow-bodied airplanes at all times. In the order of sensitivity, the study finds that the availability of wide-bodied airplanes in summer impacts the PV most (53%), next is the availability of wide-bodied airplanes in winter (39%) and number three is the availability of narrow-bodied airplanes at all times (1%).

Table 6 ranks the shadow prices of the modified model according to their values from the highest to the lowest. In the paper, the sensitivity report for World Airways under the constraint section, it shows that the availability of wide bodied airplanes during summer season has the highest value of shadow price therefore, it impacts the PV most. It has a shadow price of 50.67; final value of 98.90; right side constraint of 98.90; allowable increase of 35.47; and allowable decrease of 20.22. This means that the right hand side constraint of 98.90 can be increased by any figure between zero and 35.47 to impact the PV. In other words, when the constraint is increased by one unit ($1 million), the optimum value will increase by 50.67 units (50.67 million). Similarly, the constraint can be decreased by any amount between zero and 20.22 to impact the PV. When the constraint is decreased by one unit ($1 million), the PV will decrease by 50.67 units (50.67 million). When the constraint variable is changed with any values that lie outside the allowable increase and decrease values, the PV will not change – no impact. Therefore, the PV increases from $18,375.8 million to $18,426.5 million, an increase of $50.70 million.

Table 6. Modified Model: Shadow Prices Rankings

Name	Shadow prices	Rankings
Total value Year 1	2.08	4
Total value Year 2	1.33	6
Total value Year 3	1.21	7
Total value Year 4	1.10	8
Total value Year 5	1.00	9
Trans-Atlantic Year 1	0.63	11
Trans-Atlantic Year 2 - 5	0.00	13
Trans-Atlantic flights – Winter	-1.09	14
Caribbean flights – Summer	-5.04	16
Availability wide bodied Airplanes – Summer	50.67	1
Availability wide bodied Airplanes – Winter	37.69	2
Availability narrow bodied Airplanes – All times	7.21	3
Short flight routes more than 10% of intermediate flights	-1.35	15
Short flight routes less than 30% of intermediate flights	0.00	13
External capital limit	0.56	12
Equity	0.75	10
Debt/equity ratio	1.40	5
Agency costs	0.00	13

The decision variable, the availability of wide-bodied airplanes in winter, has the second highest value of the shadow price of 37.69, final value of 98.90; right hand side constraint of 98.90; an allowable increase of 34.16, and an allowable decrease of 30.83. This means that the right hand side constraint of 98.90 can be increased by any figure between zero and 3416 to impact the PV. For example, if the constraint is increased by one unit ($1 million), the PV increases by 37.69 units ($37.69 million). Similarly, the constraint can be decreased by any amount between zero and 30.83 to impact the PV. If the constraint is decreased by one unit ($1 million), the PV decreases by 37.69 units ($37.69 million). If the constraint variable is changed with any values that lie outside the allowable increase and decrease, the PV will not be impacted. This means by increasing the availability of wide-bodied airplanes in winter by one unit ($1 million), the PV increases from $18,375.8 to $18,413.5 million; an increase of $37.70 million.

The decision variable, the availability of narrow-bodied airplanes all times has the third highest value of the shadow price of 7.21; a final value of 1000.00; the right hand side constraint of 1000.00; an allowable increase of 761.08, and an allowable decrease of 1000.00. This means that the right hand side constraint of 1000.00 can be increased by any figure between zero and 761.08. If the constraint variable is increased by one unit ($1 million), the PV increases by 7.21 units ($7.21 million). Similarly too, the constraint variable can be decreased by any amount between zero and 1000.00. If the constraint variable is decreased by one unit ($1 million), the PV decreases by 7.21 units ($7.21 million). If the constraint variable is changed with any values that lie outside the allowable increase and decrease, the PV does not change. Lastly, if the availability of narrow-body airplanes at all times, is increased by one unit ($1 million), the PV increases from $18,375.8 million to $18,383.0 million; an increase of $7.20 million.

In summary, among the three decision variables with the highest shadow price values, the availability of wide-bodied airplanes in summer is the most sensitive constraint variable if changed by one unit, followed by the availability of wide-body airplanes in winter, and the availability of narrow-bodied airplanes at all times is the least sensitive among these three decision variables as indicated in Table 6. Therefore, management should pay special attention to these three decision variables when making investment decisions.

Table 7 shows the impact on the final values of various decision variables after incorporating different shadow prices in the modified model. The results show that some decision variables are not affected at all; some others are slightly changed while others are significantly impacted. Those which are significantly affected impact the PV most i.e., they are very sensitive to any change in the decision variable. The results show that the two decision variables that contribute most to the PV are the interest earned on money lent and the wide-bodied airplanes purchased. Both decision variables contribute a total of 93% of the PV. The interest on money lent contributes 67% and the wide-bodied airplanes purchased contribute 26%. The study finds that the total percentage of contribution to PV for the two top decision variables before and after considering agency costs remain the same at 93%. However, the individual percentage contribution for each decision variables change from 77% and 16%, to 67% and 26%, before and after agency costs respectively.

Table 7. Summary of the Impact on Optimal Value after Increasing the Constraints with the Top Three High Shadow Prices by One Unit (1 Million), and After Excluding Objective Variables with Zero Values

CG_CAP_BUD_MOLP								
Base model after incorporating agency costs and before modifying it with shadow price								
	R1	R4	R5	R7	Pw	α5	DER5	Optimal value
MAX: PV	11.11	0.25	0.25	2.15	100.00	1.00	1.00	
Changing cells	84.33	90.91	909.09	71.79	46.87	12347.10	0.40	
Contribution/Variable	936.91	22.73	227.27	154.35	4687.00	12347.10	0.40	18375.75
Percentage contribution/variable	5.10%	0.12%	1.24%	0.84%	25.51%	67.19%	0.00%	100.00%
Base model after incorporating agency costs and after modifying it with shadow price #1								
	R1	R4	R5	R7	Pw	α5	DER5	Optimal value
MAX: PV	11.11	0.25	0.25	2.15	100.00	1.00	1.00	
Changing cells	84.64	90.91	909.09	70.06	46.99	12386.28	0.40	
Contribution/Variable	940.35	22.73	227.27	150.63	4699.00	12386.28	0.40	18426.66
Percentage contribution/variable	5.10%	0.12%	1.23%	0.82%	25.50%	67.22%	0.00%	100.00%
Base model after incorporating agency costs and after modifying it with shadow price #2								
	R1	R4	R5	R7	Pw	α5	DER5	Optimal value
MAX: PV	11.11	0.25	0.25	2.15	100.00	1.00	1.00	
Changing cells	84.32	90.91	909.09	73.79	46.85	12382.25	0.40	
Contribution/Variable	936.80	22.73	227.27	158.65	4685.00	12382.25	0.40	18413.09
Percentage contribution/variable	5.09%	0.12%	1.23%	0.86%	25.44%	67.25%	0.00%	100.00%
Base model after incorporating agency costs and after modifying it with shadow price #3								
	R1	R4	R5	R7	Pw	α5	DER5	Optimal value
MAX: PV	11.11	0.25	0.25	2.15	100.00	1.00	1.00	
Changing cells	84.36	90.91	909.09	71.82	46.88	12352.85	0.40	
Contribution/Variable	937.24	22.73	227.27	154.41	4688.00	12352.85	0.40	18382.90
Percentage contribution/variable	5.10%	0.12%	1.24%	0.84%	25.50%	67.20%	0.00%	100.00%

Reduced cost

We now turn to analyse the reduced costs of the modified model to establish their impact on the PV of World Airways. The results of the modified model (see Table 8) show that out of the thirty five variables analysed, fifteen variables have negative reduced costs therefore money should not be spent on these resources.

Table 8

Microsoft Excel 12.0 Sensitivity Report
Worksheet: [6_World_Airways_MODIFIED_Agency_Costs.xlsx]Sheet1
Report Created: 29/10/2010 11:13:53 AM

Adjustable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B6	Flights_Europe_Summer	84.33	0.00	11.11	570.46	24.03
C6	Flights_Europe_Winter	56.22	0.00	0	855.68	36.05
D6	Transcontinental_Flights_Wide_body_airplanes	63.12	0.00	0	13.90	29.13
E6	Short_Flights_Narrow_Body_Airplanes	90.91	0.00	0.25	1.49	32.66
F6	Intermediate_Flights	909.09	0.00	0.25	1E+30	1.49
G6	Flights_Caribbean_Summer	35.90	0.00	0	58.43	37.78
H6	Flights_Caribbean_Winter	71.79	0.00	2.15	29.21	18.89
I6	Commuter_Flights	0.00	-2.97	0	2.97	1E+30
J6	WidebodyAirplanesPurchased	46.87	0.00	100	326.49	66.33
K6	Narrow_bodied_Airplanes	0.00	-95.85	20	95.85	1E+30
L6	Amount_Lent_Year1	0.00	-0.61	0	0.61	1E+30
M6	Amount_Lent_Year2	64.33	0.00	0	0.32	1.331
N6	Amount_Lent_Year3	3775.09	0.00	0	0.35	1.21
O6	MoneyLentYear4	7856.92	0.00	0	0.39	1.1
P6	MoneyLentYear5	12347.10	0.00	1	0.42	1
Q6	MoneyBorrowedYear1	1000.00	0.00	0	1E+30	0.56
R6	MoneyBorrowedYear2	0.00	-0.61	0	0.61	1E+30
S6	MoneyBorrowedYear3	0.00	-0.60	0	0.60	1E+30
T6	MoneyBorrowedYear4	0.00	-0.60	0	0.60	1E+30
U6	MoneyBorrowedYear5	0.00	-0.56	-1	0.56	1E+30
V6	Equity_Year1	2500.00	0.00	0	1E+30	0.62
W6	Equity_Year2	0.00	-0.62	0	0.62	1E+30
X6	Equity_Year3	0.00	-0.64	0	0.64	1E+30
Y6	Equity_Year4	0.00	-0.65	0	0.65	1E+30
Z6	Equity_Year5	0.00	-0.75	-1	0.75	1E+30
AA6	Debt_Equity_Ratio_Year1	0.00	-1.10	0	1.10	1E+30
AB6	Debt_Equity_Ratio_Year2	0.00	-1.35	0	1.35	1E+30
AC6	Debt_Equity_Ratio_Year3	0.00	-1.36	0	1.36	1E+30
AD6	DEbt_Equity_Ratio_Year4	0.00	-1.36	0	1.36	1E+30
AE6	Debt_Equity_Ratio_Year5	0.40	0.00	1	1E+30	1.10
AF6	Agency_Costs_Year1	0.00	0.00	0	0	1E+30
AG6	Agency_Costs_Year2	0.00	0.00	0	0	1E+30
AH6	Agency_Costs_Year3	0.00	0.00	0	0	1E+30
AI6	Agency_Costs_Year4	0.00	0.00	0	0	1E+30
AJ6	Agency_Costs_Year5	0.00	0.00	0	0	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
AM8	TotalValueYear1	0.00	2.08	0	1E+30	254.99
AM9	TotalValueYear2	0.00	1.33	0	1E+30	64.33
AM10	TotalValueYear3	0.00	1.21	0	1E+30	3775.09
AM11	TotalValueYear4	0.00	1.10	0	1E+30	7856.92
AM12	TotalValueYear5	0.00	1.00	0	1E+30	12347.10
AM13	TransAtlanticReveueYear1	0.00	0.63	0	208.06	933.77
AM14	TransAtlanticRevenueYear2_5	-195.45	0.00	0	1E+30	195.45
AM15	TransAtlanticFlights_Winter	0.00	-1.09	0	89.27	75.36
AM16	CaribbeanFlights_Summer	0.00	-5.04	0	68.40	37.59
AM17	Availability_widebody_Airplanes_Summer	98.90	50.67	98.9	41.39	7.62
AM18	Availability_widebody_Airplanes_winter	98.90	37.69	98.9	61.32	8.49
AM19	Availability_Narrowbody_airplanes_alltimes	1000.00	7.21	1000	1366.02	51.98
AM20	Short_Flight_routes_less_than_tenpercent	0.00	-1.35	0	153.85	100.00
AM21	Short_Flight_routes_Less_than_thirtypecentage_intermediate_Flifgts	-181.82	0.00	0	1E+30	181.82
AM22	External_Capital_Limit	1000.00	0.56	1000	72.46	1000.00
AM23	Equity	2500.00	0.75	2500	86.03	2500.00
AM24	Debt_Equity_Ratio	0.40	1.40	0.4	1E+30	0.40
AM25	Agency_Costs	0.48	0.00	0.48	0	1E+30

The variables which have negative reduced costs include commuter flights route which has a negative of 2.97 units (-2.97 million). This means that the estimated coefficient variable (PV) for this route has to increase by at least 2.97 units from its original estimated PV of zero to positive 2.97 units in order to contribute positively to PV. Next is the narrow-bodied airplanes purchased which has a negative reduced cost of 95.85 units (-95.85 million). Similarly, this means that the estimated PV for the purchase of narrow-bodied airplanes has to be increased by 95.85 units from its original estimated PV of 20 units to 115.85 units, in order to contribute positively to PV. The other decision variables that have negative reduced costs include amount lent in the first year (-0.61 million), amount borrowed in the second year (-0.61 million); amount borrowed for both the third and fourth year (-0.60 million), and amount borrowed for the fifth year (-0.56 million), equity in year 2 (-0.62), equity in year 3 (-0.64), equity in year 4 (-0.65), equity in year 5 (-0.75), debt equity ratio in year 1 (-1.10), debt equity ratio in year 2 (-1.35), debt equity ratio in years 3 and 4 (-1.36), . These variables need to be increased by their negative respective amounts in order to contribute positively to PV.

Robustness and Validation of the Model and the Results

The results show that the developed model is effective and meets the overall intended World Airways' objectives of maximizing PV and minimizing agency costs. The model allows the optimization process to be implemented and the optimum solutions found by running the model several times under different input conditions which impact the decision making.

The objective function in the developed model maximizes the PV and mitigates the agency costs subject to twenty one limited financial resources. Analytical validation that entails the practicability and robustness of the model and the results is carried out in the study. It involved changing various coefficients of decision variables and constraints and finding the results that can be interpreted rationally within the parameters used and as expected. The paper finds the developed model to be operational and can be used in the real life investment appraisal process. The results of this model achieve the intended objective and support the decision criteria consideration in capital budgeting such as maximizing PV and minimising agency costs to maximize firm value.

Plausibility of Results

The accuracy and acceptability of the results in this study are verified by comparing the generated optimal solutions and the expected results after considering the PV of cash flow and mitigating agency costs.

After examining the optimal solutions generated by both the base and modified model, they revealed that there was a significant increase in the PV after the inclusion of mitigation of agency costs in the objective function as expected. The model identified four flight routes, purchase of wide-bodied airplanes, lending free cash flow in year 5 and mitigation of agency costs as the business transactions that contribute to the firm value of World Airways. The generated results are found to be in agreement with the theory regarding the maximisation of the PV of cash flows after considering uncertainty and risk in the DCF capital budgeting techniques. The PV of World Airways increased as expected. The paper finds it difficult to compare the current results with past findings in other similar studies because the inclusion of minimisation of agency costs in the objective function has not been the normal practice in the investment appraisal process. By including the mitigation of agency costs the model captures the impact of good corporate governance on management behaviour when making long term investment decisions such as selecting flight routes, purchasing new aircrafts, borrowing and lending money. The results show that by including good corporate governance in the form of agency costs in investment appraisal decisions maximizes firm value as expected. The new integrated approach extends the theory by incorporating mitigation of agency costs in the current MOLP model. Based on the improved firm value generated the modified model should become a standard in any investment appraisal decision-making because it considers an economic factor that is faced by the majority of companies in the modern economy that relies on IT to collect data and use it to make investment decisions.

6 Conclusion and Future Research

The study modifies MOLP optimization model by adding minimization of agency costs in the objective function using debt equity ratio as a proxy of good corporate governance and capital market interactions. The results of the modified model show that NPV techniques are incapable of handling long term capital investments having multiple objectives and limited in their application and therefore do not produce optimum firm values. The results also confirm that capital markets influence investment appraisal decisions through determining interest rates and debt covenants. The developed model is tested using different levels of risk, various coefficients of decision variables and constraints that produces plausible results. The PV of the cash flows for the modified model increased and agency costs mitigated. Therefore, this model is operational and valid. It can be applied to any investment appraisal problems such as investment in manufacturing, hospital, government and non-profit organizations that have multiple objectives and high level of risk including firms in airline industry and e-commerce sector hence it is robust.

The results show that the three decision variables which impact most on PV of World Airways, in their order of impact on the optimum value, are trans-Atlantic flights during summer season using wide-body airplanes, short flights using narrow-body airplanes and intermediate flights using narrow body airplanes. When the PV for the base model is subjected to different economic assumptions it is impacted in all situations. The summary of results for World Airways is shown in Table 9 below.

Table 9. The impact of agency costs on present value and the three significant decision variables

	1			2			3			Objective function		
	Wide body Airplanes in Summer			Wide body Airplanes in Winter			Narrow body Airplanes – All times			Optimal value – Present value		
Adjusting constraints with shadow prices	BM*	MM&	Impact	BM	MM	Impact	BM	MM	Impact	BM	MM	Impact
Not adjusted with shadow prices	72.26	84.33	12.07	48.17	56.22	8.05	90.91	90.91	0.00	16510.64	18375.75	1865.11
Adjusted: shadow price #1	72.57	84.64	12.07	48.38	56.43	8.05	90.91	90.91	0.00	16561.31	18426.66	1865.35
Adjusted: shadow price #2	72.25	84.32	12.07	48.17	56.21	8.04	90.91	90.91	0.00	16548.33	18413.09	1864.76
Adjusted: shadow price #3	72.29	84.36	12.07	48.20	56.24	8.04	91.00	91.00	0.00	16517.85	18382.90	1865.50

Source: Tables 5&8.
Key: BM* = Base Model
MM& = Modified Model

The PV for the base model before considering agency costs ranges from $16,510.64 to $16,561.31 million. However, the PV for the modified model ranges from $18,375.75 to $18,426.66 million. The difference between the highest PV of the modified model - $18,426.66 and the highest PV of $16,561.31 of the base model is $1,865.35 million (18,426.66 – 16,561.31). This is a significant sum of money. These results provide evidence that mitigating agency costs improves firm value.

The increase of 12.07 (Table 9, column 4) in the average number of trans-Atlantic flights per day during summer using wide body airplanes increases the PV of World Airways because it was allocated a coefficient variable (contribution per unit) towards PV of the firm initially. However, management did not allocate any coefficient variable to the next significant variable – the average number of trans-Atlantic flights per day during the winter season using wide body airplanes. Thus, even if the modified model shows clearly that the consideration of agency costs would increase the average number of flights of this decision variable it did not add value to the PV.

This revelation confirms that management did not get it right when making estimates for decision variable coefficients. However, using the modified model it is now possible for management to make new estimates for second decision variable and run the model to find its impact on the PV.

Clearly, based on these results in particular the PV after considering agency costs, the evidence is that by integrating agency costs, the results reveal that NPV techniques are incapable of incorporating multiple objectives into capital investment decision making. Also capital market interactions such as interest rates debt covenants strengthen capital budgeting decision making and enhance corporate governance by influencing management behaviour in undertaking financially viable investments. The new approach is multi-criteria. It considers multiple objectives such as different flight routes, cash flows, agency costs and multiple constraints. It generates higher net cash inflows, PV and maximizes firm value. It enhances the airline's capital resource allocation and flight routes scheduling. Therefore; this model is robust, operational and can be used to make investment appraisal decisions in the real world situation in many industries.

A limitation of this research is that it uses one case study, World Airways, a company in the US. It is a hypothetical one discussed in Levary and Seitz (1990).The study also uses debt equity ratio as a proxy for good corporate governance and agency costs to modify the objective function of MOLP model. Future research can be carried out on existing Airline Company and other companies that experience relentless global competition and rapid technological changes in IT. It may not be easy to find a firm that is willing to allow you access its actual capital investment information but it would be a worthwhile undertaking. Also more agency costs proxies such as the ratio of total sales to total assets (asset turnover); the ratio of selling, general and administration expenses to total sales; the ratio of operating expenses to total sales; the ratio of independent directors to total number of directors and the ratio of value of shares owned by institutions to total value of shares could be used to modify the MOLP model. Also most textbooks in finance focus on the maximizing shareholder wealth ignoring the interests of other stakeholders. Future research in investment appraisal could develop an inclusive "Social Welfare Maximization model" rather than an exclusive "Shareholder Wealth Maximization Model". The new MOLP model increases our understanding of the impact of capital markets interactions on investment appraisal decision making that has either been ignored or taken for granted by financial decision makers.

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