A Note on Capital Budgeting: Treating a Replacement Project as Two Mutually Exclusive Projects

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ABSTRACT

This note, with a numerical example, demonstrates that evaluating a replacement project is equivalent to assessing two mutually exclusive projects. This unconventional view requires no more knowledge on the part of students than what is required to evaluate a single expansion project. Textbooks typically use separate sections of a chapter to explain how to evaluate expansion projects and replacement projects, leading students to believe that there are two entirely different methodologies. We show that there is really only one methodology. Conceptually, this is much easier for students to understand. Moreover, this alternative view allows decision makers to avoid a potential pitfall associated with the NPV when the two assets involved in the replacement project do not have the same remaining useful life. This note further revises the MIRR and modifies the PI to reconcile possible ranking conflicts between the two rules and the NPV when dealing with mutually exclusive projects.

INTRODUCTION

Businesses are formed in order to create value for their owners. For corporations, this value creation goal is transformed into stockholder wealth maximization. To fulfill this goal financial managers have certain responsibilities. One of them is to make wise capital budgeting/investment decisions. Several decision rules have been developed to guide the decision making process. The most widely suggested rule is the Net Present Value (NPV). Arguably, the NPV is the best decision rule on theoretical grounds because it readily captures the dollar benefit of the project to stockholders. According to this rule, only projects with NPV ≥ 0 are worth taking.

Projects faced by corporations, depending on their nature, involve different risks with maintenance, replacement, expansion, and research and development projects spanning across the risk spectrum. While replacement projects are less risky than expansion projects, conveying the evaluation of replacement projects has required much more effort from academia. This has a lot to do with the typical way the topic is covered in corporate finance textbooks. Generally, capital budgeting is introduced with expansion projects, and then a separate section is used to explain the methodology for replacement projects. In the replacement section, the concept of incremental cash flows is emphasized and implemented. The incremental analysis approach dictates an item-by-item comparison between the new and existing assets. This practice results in quite a lot of confusion for students because they have to deal with both assets simultaneously, and it leaves the false impression that there is a different methodology for evaluating replacement projects.

One puzzling piece for the majority of the students is the appearance of double counting the depreciation of the existing asset: once at time zero when its after-tax resale value needs to be determined; and later annually for its remaining life in order to figure out the foregone deprecation tax shield. Another common struggle arises when accounting for the lost terminal salvage value from the asset to be replaced. Students wrongly deem it unnecessary since the salvage value has already been "taken care of" at time zero. This is particularly problematic when the straight-line depreciation method is used, which requires the explicit recognition of the estimated terminal salvage value at both time zero and the end of the useful life of the existing asset.

This note, in recognizing the difficulty experienced by students, presents an alternative way of handling replacement projects. In the example presented, it is shown that evaluating a replacement project is equivalent to assessing two mutually exclusive projects: the existing project and the new project. After all, either the new or the old asset will be in place after the decision is made. The two cannot coexist. This unconventional approach, while leading to the same accept/reject decision as the incremental cash flow approach, allows the student to handle the assets one at a time. Furthermore, it eliminates the false distinction between methodologies and thus is conceptually easier.

The process of forecasting the annual after-tax cash flows of the existing project is fundamentally the same as for the new project. However, instead of asking how much the firm stands to gain, we ask how much the firm would lose each year if the existing project was eliminated without replacement. These annual after-tax cash flow "losses" are the cash flows provided by the existing project. The "cost" of the existing project is the amount for which it could be sold at time period 0. In other words, the cash flows for the existing project are all opportunity costs.

Several textbooks hint at the possibility of using our suggested methodology, but none actually demonstrate it. For example, Brigham and Daves (2007) provide an example of a replacement project with a table listing the cash flows for both the new and old machine. However, they only calculate the NPV and IRR for the new machine as a stand-alone project and of the incremental cash flows. They don't show that the NPVs of the new and old machines can be directly compared. Brigham and Daves specifically state that "If a project involves replacing existing assets with new ones, then we must estimate cash flows on an incremental basis." (p.441). They then conclude that their example "demonstrates the fundamentals of a replacement analysis and the importance of focusing on incremental cash flows" (p.442). Gitman (2009) explains that expansion decisions can be treated as replacement decisions with cash flows associated with the asset to be replaced equal to zero. As a result, he focuses his capital budgeting discussions on replacement decisions. Sharing the same view as Brigham and Daves (2007), Gitman contends that incremental cash flows must be determined for the evaluation purpose of capital expenditure alternatives.

Block and Hirt (2008) mention that our methodology is an alternative (they refer to it as "a total analysis"), but they don't elaborate and they proceed to cover only the incremental cash flow approach. Brealey, Myers, and Marcus (2004) do provide an example where they briefly compare a new project's cash flows to those of an existing project. However, their simplified example, with a focus on the optimal timing for replacement, simply compares the annual operating costs of the new machine with that of the current one without factoring in the resale value of the old machine at the time of replacement. Furthermore, they don't point out the advantages of our proposed methodology. Many other textbooks don't mention this alternative at all.

AN EXAMPLE

Suppose that a firm is considering replacing an inefficient machine with a new, more efficient one. The new machine will cost $200,000 and is expected to last for six years. The current one, obtained two years ago at an original cost of $120,000, could be sold for $36,000 today if it is replaced. Otherwise, it will be kept for six more years. Both machines are classified into five-year MACRS life. The new machine would allow the firm to save $45,000 in operating costs each year, thus the operating income on a before-tax basis, excluding depreciation, will increase from $20,000 to $65,000. Given 40% as the tax rate and 10% as the cost of capital, the firm needs to determine if it should proceed with the replacement.

Table 1: Project Comparison

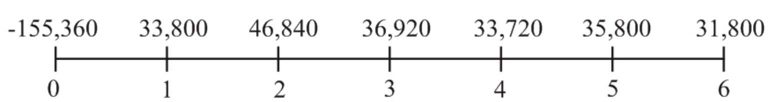
	Existing Machine	*New Machine*
Initial Cost	$120,000	$200,000
Current Value	$36,000	$200,000
Remaining Life	6 years	6 years
MACRS Class	5 years	5 years
Annual Pre-tax Operating Cash Flows, before depreciation	$20,000	$65,000

The Replacement Approach

Typically, the incremental approach, new vs. old, is followed for the analysis of replacement projects. It requires an item-by-item comparison at every time period between the two machines. For time point zero, the additional cost associated with acquiring the new machine needs to be calculated. This involves subtracting the after-tax salvage value from disposing of the old machine, $44,640,[1] from the cost of the new machine, $200,000. Thus, the net cost of replacing the old machine with the new one is $155,360 today.

The benefit of this spending is present value of the yearly incremental after-tax operating cash flow from the annual after-tax operating cost savings ($27,000), and the depreciation tax shield for each of the six years ($6,880, $19,840, $9,920, $6,720, $8,800, and $4,800). The incremental cash flows for the replacement project are shown in Figure 1.

Figure 1: Incremental Cash Flows as Replacement Project



[1] This number is derived by first figuring out the book value of the old machine, $57,600, which is the difference between the original cost of $120,000 and the accumulated depreciation at time zero for the old machine after it has been put into place for two years, $62,400. Given the tax rate of 40% and current resale value of the old machine, $36,000, which is $21,600 lower than the book value and represents a capital loss, selling the old machine would yield 8,640 in tax savings. This, in turn, is added to the resale value and results in an after-tax salvage value of $44,640.

With 10% as the cost of capital, Figure 1 further reveals that the project has a positive NPV ($5,099.75), both its IRR and MIRR are greater than the cost of capital (11.15% and 10.59%, respectively), and the PI exceeds one (1.03). Thus, all of the discounted cash flow (DCF) based decision rules point to the same decision: the current machine should be replaced.

The Mutually Exclusive Projects Approach

Alternatively, we can direct our attention to each machine, one at a time. Let’s look at the new machine first. As mentioned before, the new machine would cost $200,000 at time zero. Every year, its after-tax cash flow can be derived by combining the after-tax cash flow from normal operation and the tax savings associated with depreciation expense.

Figure 2: New Machine Cash Flows

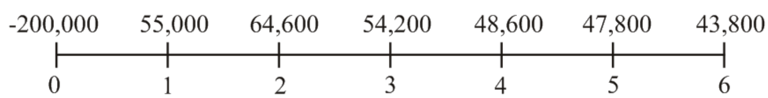


Figure 2 shows the annual after-tax cash flows for the new machine as a stand-alone project. These cash flows result in an NPV of $31,708.14, an IRR of 15.55%, an MIRR of 12.73%, and a PI of 1.16. Therefore, as a stand-alone project, the new machine should be accepted.

Now, let’s turn our attention to the existing machine. If the firm decides to stay with the current machine, it then will not receive $44,640, the after-tax resale value of the machine at time zero. This is an opportunity cost that the firm pays to keep the old machine, and should be regarded as the cost of the old machine at time zero. In return, the firm anticipates the annual after-tax cash flow from operating the old machine and the associated deprecation tax shield.

Figure 3: Existing Machine Cash Flows

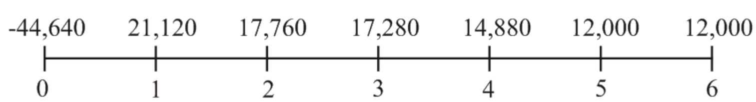


Figure 3 shows the existing machine’s cash flows as a stand-alone project. These are the cash flows that the firm would use to determine whether the project should be kept. Using the same 10% discount rate, we find that the project has an NPV of $26,608.39, an IRR of 31.07%, an MIRR of 18.91%, and a PI of 1.60. All of the DCF metrics indicate that the existing machine is worth keeping.

Table 2: Comparative Profitability Metrics

Metric	*New Machine*	*Existing Machine*
NPV	$31,708.14	$26,608.39
IRR	15.55%	31.07%
MIRR	12.73%	18.91%
Profitability Index	1.16	1.60

Table 2 compares the profitability measures for each project. The question now is whether it is better for the shareholders to keep the existing machine or to replace it with the new one. The new machine with a higher NPV of $31,708.14 should be put into place to replace the old machine. That is, the new project should be accepted; the old project should be rejected. We are able to reach the same conclusion as we did earlier when the incremental approach was implemented. In fact, netting out the NPVs of the new and existing machines yields $5,099.75, the same as the replacement project's NPV when using incremental cash flows. So, evaluating a replacement project is equivalent to assessing two mutually exclusive projects.

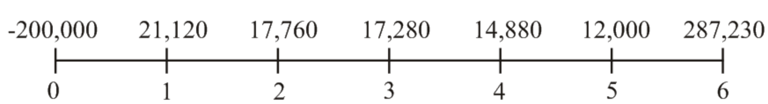
Values derived in this manner can be labeled the Net Advantage to Replacement (NAR). This is similar to the net advantage to leasing (NAL), which is the difference between the cost of leasing and the cost of buying. In both cases, decision makers are faced with two mutually exclusive projects: new asset vs. current asset in the investment decision and leasing vs. buying in the financing decision. If the NAR is positive, then the replacement project should be accepted; if the NAL is positive, then leasing should be the preferred financing method to gaining the usage of equipment. Thus, our proposed approach is very similar to the widely accepted capital budgeting assessment norm for leasing analysis.

Note that while the adoption of the NPV rule allows us to draw the same conclusion with the two alternative approaches, all of the other three DCF rules (IRR, MIRR, and PI) indicate that keeping the existing machine is the better choice. In other words, we have a classic ranking conflict. The result is somewhat expected of the IRR due to its unreasonable reinvestment rate assumption, which is why the MIRR came into existence. The inconsistency with the MIRR and PI (both of which use the same reinvestment rate assumption as the NPV) is due to the fact that the two machines/projects are of different sizes in terms of their costs. The new machine, at a cost of $200,000, is more than three times the size of the old machine of $44,640.

Eliminating the Ranking Conflict Due to the Size Effect

To eliminate the ranking conflict, we propose a remedy that allows the two projects to be of the same size. More specifically, we augment the cost of the existing machine so that it would now cost an additional $155,360: the difference between the two projects' original costs at time zero. Following the same logical thinking behind the development of the MIRR, we assume that the additional amount invested in the old machine will be reinvested to earn exactly the cost of capital, 10% in this case. This practice does not affect the NPV of the old machine (remaining at $26,608.39 as a stand-alone project), since any investment earning its cost of capital has an NPV = 0. It will not affect the old machine's after-tax cash flow for the first five years either. For year six, the terminal year, the after-tax cash flow would increase by $275,229.72, the future value of the additional initial investment of $155,360 compounded at 10% rate for six years. With this increased value, the after-tax cash flow for year six, as shown in Figure 4, now stands at $287,229.72.

Figure 4: Existing Machine Augmented Cash Flows



We can now recalculate the IRR, MIRR and PI using the augmented cash flows. With an IRR of 12.79%, an MIRR of 12.31% and a PI of 1.13, we reach the same conclusion as the NPV rule. The new machine should be acquired because all of its profitability measures, as shown in Table 3, are higher than those for the existing machine. Eliminating the size effect removes the ranking conflict between NPV and the other decision rules.

Table 3: Comparative Profitability Metrics with Augmented Cash Flows

Metric	*New Machine*	*Existing Machine Augmented*
NPV	$31,708.14	$26,608.39
IRR	15.55%	12.79%
MIRR	12.73%	12.31%
Profitability Index	1.16	1.13

This note does not intend to persuade instructors to switch from the conventional incremental approach to the mutually exclusive approach when lecturing about replacement projects. It is our hope that the alternative view can be used as a supplement so that the otherwise confusing materials can be more conceptually receptive to students. Treating the two assets separately is much less complicated to understand than handling both simultaneously under the traditional incremental cash flow approach. In the next section, a revised example illustrates another potential benefit of this unconventional approach.

A POTENTIAL PITFALL OF THE NPV RULE: UNEQUAL LIVES

The example covered in the last section shows that the two different approaches used to analyze replacement projects will always produce the same outcome when NPV is the decision rule. Unlike MIRR or PI, no modification is necessary for the NPV to ensure this consistency. It appears that NPV is the perfect rule to adopt when evaluating replacement projects. This is true when the remaining useful life of the existing asset matches that of the replacing asset. However, this is not the case when that assumption does not hold. Using the NPV rule without any adjustment can be misleading, as the following example shows.

Suppose that all of the basic assumptions in the previous example hold, except for the remaining life and before-tax operating income (excluding depreciation expense) of the existing machine. We now assume that the old machine, purchased two years ago, has an original useful life of six years and hence a remaining useful life of four years; the annual before-tax operating income is $27,000, as opposed to $20,000 in the previous example.

Figure 5: Existing Machine Cash Flows with 4-year Life

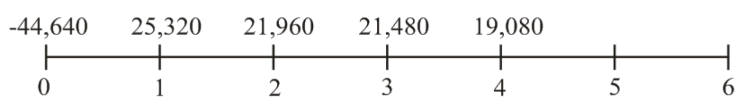


Figure 5 shows the after-tax cash flows for the existing machine with a four-year economic life, as outlined above. On a stand-alone basis, the existing machine has an NPV of $25,697.08. Therefore, it is worth keeping. However, recall that the new machine has an NPV of $31,708.14. As a result, the new machine, with an excess NPV of $6,011.06, is preferred.

Figure 6: After-tax Incremental Cash Flows

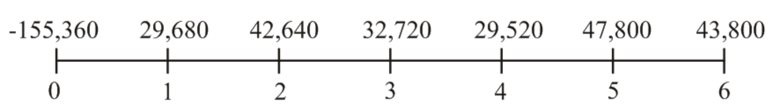


Figure 6 shows the incremental cash flows derived from the traditional replacement approach. The NPV of accepting the new machine is $6,011.06, exactly as we calculated using the mutually exclusive approach. Thus, it appears that the new machine should be brought in to replace the existing one. However, comparing Figure 5 and Figure 6, it is obvious that the NPVs of the existing and new projects are not comparable due to the two projects' unequal lives. While this fact might have been recognized upfront with the incremental approach, the way the analysis is set up under that approach leaves it with no flexibility to adjust the incremental NPV to account for the two projects' unequal lives. By contrast, treating the replacement project as two mutually exclusive projects allows us to evaluate the two projects separately and adjust their respective NPVs accordingly.

Two techniques covered in typical corporate finance textbooks are followed for the modification of the NPVs. One converts the NPVs to equivalent annual annuities (EAA) to reflect the useful lives (in years) of the projects.

$$EAA_{\text{Existing}} = \frac{25{,}697.08}{\left(\frac{1 - 1/1.10^4}{0.10}\right)} = 8{,}106.68$$

$$EAA_{\text{New}} = \frac{31{,}708.14}{\left(\frac{1 - 1/1.10^6}{0.10}\right)} = 7{,}280.42$$

The existing machine generates a higher equivalent annual annuity than the new machine: \$8,106.68 vs. \$7,280.42. Based on the EAAs, the firm should not replace the existing machine.[2]

Alternatively, we can use the replacement-chain approach to extend the useful lives of the two projects to a common useful life of 12 years. Note that we are assuming that we will be able to replicate the two projects mimicking the cost and benefit in their current forms, two times for the new one and three times for the old one. Over a 12-year span, this will produce an NPV of \$55,236.41 for the existing machine and \$49,606.56 for the new one. Based on these common-life NPVs, we once again reach the same conclusion as the EAAs: keep the existing machine. This conclusion would not have been reached had the incremental approach been used for the analysis of replacement project.

CONCLUSION

Corporate finance textbooks, emphasizing and applying the concept of incremental cash flows, have consistently devoted separate sections to address projects that involve replacing assets currently under operation. With a numerical example, this note shows that evaluating a replacement project can be alternatively viewed as assessing two mutually exclusive projects. This unconventional view requires no more knowledge on the part of students than what is required to evaluate an expansion project, which handles one project at a time, as opposed to both the new and old assets simultaneously. Thus, conceptually, it is much easier for students to

[2] Note that, at first, it appears that we have reintroduced the size effect into the example. However, if the existing project is once again augmented with a zero-NPV project then the numerator in the EAA equation would not change because the NPV of the existing project is not affected by the augmentation. Therefore, the size effect is not an issue.

grasp. Moreover, both MIRR and PI are revised in this note to eliminate any decision conflict that may arise between the two rules and the NPV when the sizes of the assets are significantly different from each other. This note further demonstrates an additional benefit associated with viewing a replacement project as two mutually exclusive projects. With a revised example, it is shown that the alternative view allows decision makers to avoid a potential pitfall associated with the NPV rule when the two projects do not have the same useful life.

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