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COMPLEXITY AND THE LEASE VS. OWNERSHIP DECISION

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INTRODUCTION

There are two types of leases, only one of which represents a special problem in the area of capital budgeting. First, there is the Operating (Cancelable) lease, which, to the extent that it does not use up long-term financing availability, is not to be dealt with as a capital budgeting problem. This type of lease should be dealt with in the same manner as any other fixed or semi-fixed operating cost problem encountered by the firm. The second type of lease is a Financial (Non-cancelable) lease, which, to the extent that it does use up some long-term financing availability, clearly represents one aspect of the capital budgeting problem for the firm.

However, the lease vs. ownership decision is "special" in the sense that it will determine legal ownership of the tangible resource. The investment decision attempts to predetermine the return associated with a project which can then be compared with the appropriate required rate in making the decision. The return for a project is independent of "ownership." It is the financing decision that determines "ownership" and clearly implies that the lease vs. ownership decision deals with alternative means of financing an investment.

COMPLEXITY AND APPROACHES TO DEALING WITH IT

There are only two approaches to dealing with complexity. The preferred approach is to break it up into parts and deal with the parts individually. To illustrate the point, in making the demand forecast for a durable good, there are two markets, i.e., the expansion and replacement markets, which have entirely different market characteristics (economic forces affecting elasticities and growth rates). The forecasting results will be of better quality if the total market for the durable good is broken up into two segments and dealt with individually rather than by forecasting the demand for the total market. However, it is not always possible to break complexity up into parts and deal with the parts individually, in which case a holistic approach must be taken.

For instance, in the evaluation of products in a product line for product retention decisions, if Product A compliments Product B, which in turn compliments product A, and both compliment Product C, which in turn compliments both Products A and B, then it would be extremely difficult, if not impossible, to evaluate each product individually. In such a case, the holistic approach must be taken by evaluating the entire product line.

This bears directly on the current approach generally taken in the evaluation of leases in the Finance literature. With few exceptions, such as Van Horne, the holistic approach is taken by integrating the investment decision with the financing decision. In so doing, an endless debate about the appropriate discount rates for the different types of fund flows has been generated. If the preferred approach to dealing with complexity is taken in this area, i.e., separating the investment decision from the financing decision, then the problem of the appropriate discount rate disappears.

The investment decision presents no more than the usual problems and the evaluation should proceed under the assumption that the firm has command over the resource whether or not it has legal title to it. Should the results prove that the investment itself is undesirable, then alternative means of financing which affects ownership is not relevant. Only where the investment worth is deemed acceptable will there be a question raised as to the means of financing.

LEASING AS A FINANCING DECISION

The lease decision necessarily locks the firm into a particular type of financing which must be evaluated as a financing decision. The question is, "what type?" There are three distinct types of financing for the firm, i.e., debt, preferred stock, and equity, with all other forms being variations on these three themes. Essentially, the main reason for having three themes with many variations (options, convertibles, etc.) is to allow the financial manager the opportunity to package the objective risk in the firm to meet the subjective needs of the investors in such a way that, for a desired level of the firm's financial risk for the financing, costs are minimized.

In this paper, objective risk is defined as the risk inherent in the character of the investments, while financial risk is the risk inherent in the character of the non-equity financing (the degree of rigidity of the fixed financing commitment associated with non-equity financing). In other words, three themes with variations provide the basis for managing financial risk and integrating it with the objective risk in the firm. This is the art of financing management, which clearly distinguishes it from the art of investment management.

The sum of debt, preferred stock, and equity themes must equal 100 percent. For each theme, the sum of the variations on that theme must equal 100 percent. Given that there is an upper limit to a theme and that the variations of that theme must equal 100 percent, to use more of one variation would displace another variation. In such a case, whether the displacement should take place can only be determined by comparing the cost and risk of that which is displaced with that which is doing the displacing. The relevant question at this point is just what is being displaced when a firm leases. Does the lease represents a variation of debt, of preferred stock, or of equity financing? The cost and risk comparison cannot proceed without first resolving this question and then developing a model that will permit quantification of the lease financing cost embedded in the lease payments.

The search for the variation of a type of financing that is being displaced when a firm leases necessitates a search for common characteristics. There are two major characteristics to be associated with any means of financing, i.e., the profit impact via the leveraging effect and the financial risk effect.

That there is a profit leveraging effect created for the stockholders by way of long-term debt and preferred stock financing is beyond question. Granted, because of the tax shield on interest payments and no tax shield on preferred stock dividends, dollar for dollar the leveraging effects for long-term debt will be more powerful than for preferred stock financing.

This raises the interesting question as to why firms continue to use preferred stock if the profit leveraging effect is weaker than that of long-term debt. We will see that the offset to this is in the incremental financial risk associated with each means of financing. The point is that there is a leveraging effect for both long-term debt and preferred stock financing even though the power of each is different. It is also indisputable that there is a leveraging effect generated from a financial lease. To maintain that there is a leveraging effect for equity financing is to deny the very definition of financial leverage.

Before risk can be considered, it must be defined. Simply put, risk is "uncertainty of consequence." To understand the consequences of an uncertain event taking place, the risk effect must be perceived as a systems phenomenon. Each element in the system has a different degree of rigidity associated with it. A change brought about by an external force will create different movements for each element in the system depending on the relative rigidity of that element. In other words, the balance in the system has been upset by an external shock which can create either favorable or unfavorable effects. Favorable and unfavorable effects are a matter of degree which depend on the ability of the elements to adapt to change.

In other words, the potential consequentiality of an uncertain event taking place partially depends on the ability to adapt to change, which itself depends on the relative degrees of rigidities of the elements in the system. One of the two major determinants of the degree of rigidity is the concept of divisibility. The greater the divisibility the less rigidity in the element.

To illustrate, an element in a system, such as a machine, that has multiple uses (use divisibility) has less rigidity and greater adaptability to change than a machine that is specialized (no use divisibility). The character of an investment in a multiple-use machine is different from the character of an investment in a specialized machine. Hence, the objective risk is different for the two investments. Similarly, the lock-in period for an investment (or means of financing) will determine the time divisibility. A five-year lease with options to renew in five-year blocks up to a total of twenty-five years has greater time divisibility than a lease which has a lock-in period of twenty-five years.

The conclusion must be drawn that the consequentiality aspect of risk is related to, amongst other things, the degree of divisibility of the elements at risk.

What risk impact is there to be associated with the three major forms of long-term financing? There is no question that for a given variable stream of earnings before financing charges, the introduction of a fixed financing commitment associated with debt financing introduces a rigidity in the system. Hence, financial risk, when interacting with objective risk, raises the spectre of risk of default. This is true for each and every year in the time frame associated with long-term debt. Can this same conclusion apply in the case of preferred stock financing? The answer must be no to the extent that a preferred stock dividend can be passed up in any given year (which creates at least some ability to adjust to change in a given year). Whether or not the preferred stock dividend is cumulative is not relevant to the central issue of whether there is a fixed commitment in each and every year as a result of a particular means of financing.

If time is analyzed as divisible into one-year segments, then there is no risk similarity between debt and preferred stock. However, if time is analyzed as less divisible, then there is a closer risk resemblance between debt and preferred stock. If time is segmented into five-year chunks, then there is a fixed commitment for preferred stock in the same way that there is for long-term debt. That there is no financial risk associated with equity financing requires no elaboration.

A financial lease introduces a profit leveraging effect that more closely resembles that of long-term debt than preferred stock since, like interest payments, lease payments are tax deductible. There is also a similarity between a financial lease and long-term debt in terms of the risk that is introduced by way of a fixed commitment. In both cases, there is a fixed commitment no matter how time is segmented. Whereas, time would have to be segmented into fairly large chunks before a fixed commitment becomes evident in the case of preferred stock financing.

The conclusion has to be drawn that a financial lease is in reality a variation of long-term debt and when a comparison is made between lease vs. ownership as a financing decision, the financing cost of the lease must be compared with the cost of long-term debt variation(s) that would be displaced as a result of the decision to lease.

Since lease vs. ownership are mutually exclusive alternatives, economic fundamentals dictate that an incremental approach is required in the evaluation of the financing alternatives.

Several points must be discussed before an incremental cash flow model can be developed to evaluate the leasing alternative. The intended purpose of the model is to facilitate the comparison between the explicit financing cost of other debt variations and the implicit financing cost associated with a lease by solving for the financing rate implicit in the lease payments.

The model used must consider the displacement functions that are operative in a lease vs. ownership decision. It may appear inconsistent with the intended purpose of the model (comparison of financing costs) to include certain flows that are ordinarily considered investment rather than financing flows such as depreciation tax breaks, changes in after tax repair and maintenance costs, and terminal value. The reality is that there is no inconsistency when these incremental flows are considered in the model.

The lease payments represent two components, i.e., investment flows and financing flows. The investment flows included in the lease payments must be neutralized to isolate the financing flows. Including the previously mentioned investment flows in the model will have the effect of neutralizing the investment flow component of the lease payments.

THE MODEL

Incremental Cash Inflows

1. The first incremental cash inflow created by leasing rather than owning is represented by the investment outflow that will not have to take place if the project is leased.

2. The second incremental cash inflow created by leasing rather than owning would be the annual after tax repair and maintenance costs that would be saved if the lessor provided these services (for which there would be a charge included in the lease payments).

Incremental Cash Outflows

1. The annual after tax lease payments constitute the first incremental cash outflow arising as a result of leasing.

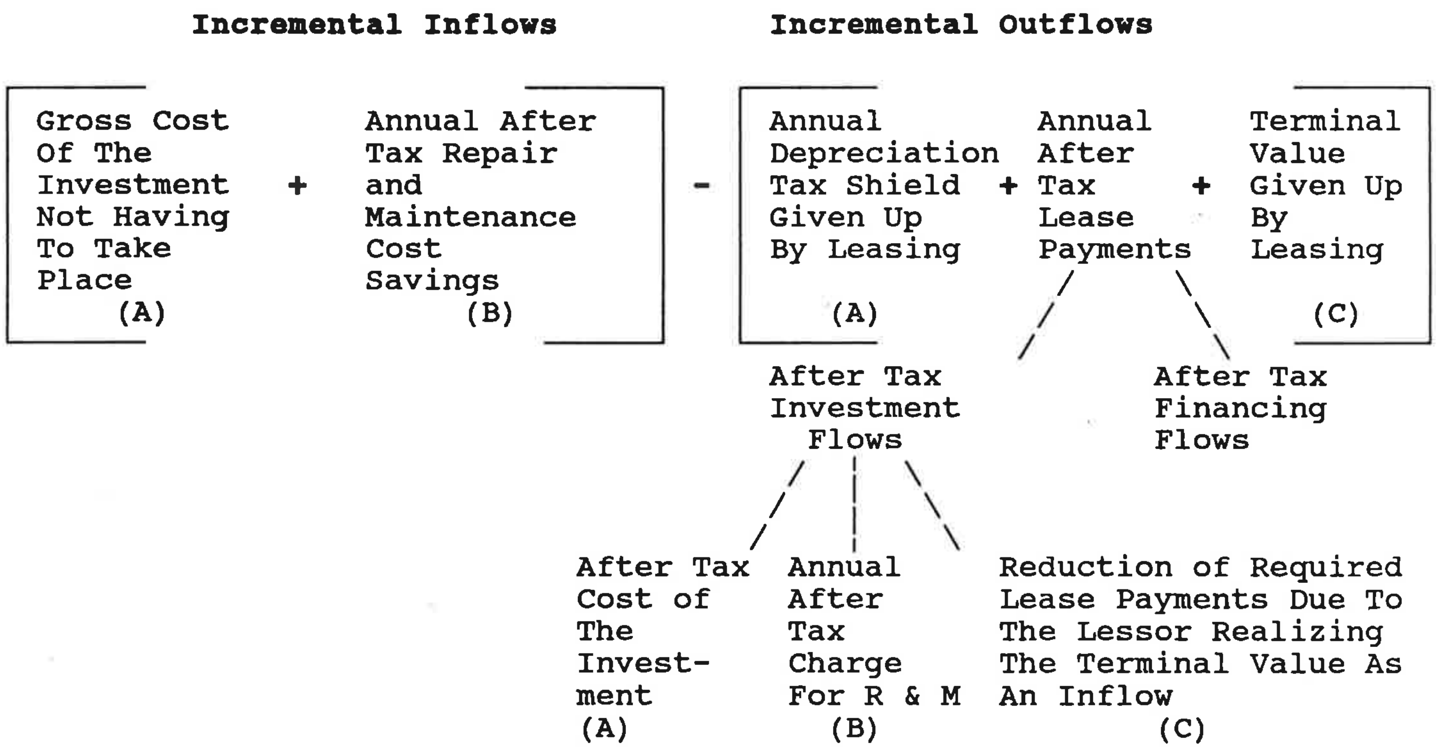
2. The annual tax subsidy for the periodic depreciation charge is given up by going into the lease.

3. The terminal value is the value that would have been realized if ownership rather than leasing had taken place.

Again, the intended purpose of the model is to arrive at the implicit financing charges embedded in the lease payments by neutralizing the investment flow portion of the lease payments and expressing these financing flows as a rate. Graph I illustrates the neutralizing offsets which will leave the financing flows as a residual.

Graph I

Illustration of the Offsetting of Investment Inflows and Outflows In the Leasing Model



All of the preceding incremental inflows should be discounted at some rate that will achieve a value equal to the present value of the incremental outflows. This discount rate represents the lease financing rate cost which should be compared with the cost of other debt variations that would be displaced in making the decision. If the lease financing cost is less than the cost of other variations of the debt displaced, then the lease is the better of the alternatives, provided there is no difference in risk of default.

To illustrate the validity of the model, let us assume that a lessor wishes to solve for the required lease payments to achieve a 10 percent after tax required return given the following information:

1. Purchase price to lessor is $800,000
2. Life = 10 years
3. Terminal Value at the end of 10 years is $100,000
4. Before tax annual R & M costs are $10,000
5. Straight line depreciation per year is $70,000
6 Tax rate is 50%

From the preceding data we have:

	Value in T_0
Purchase Price	-$800,000
Present Value of Depreciation Tax Shield of $35,000 per year at 10%	215,061
Present Value of After Tax R & M Costs of $5,000 at 10%	-30,723
Present Value of Terminal Value of $100,000 at 10%	38,550
	-$577,112

Solving for X (the required after tax lease payments to achieve a 10 percent Required Return) we have,

X (6.1446) = $577,112

X = $93,922

Given a 50 percent tax rate, the before tax required lease payments to achieve a 10 percent Required Return would be $187,844. The lessor's annual fund flows would be as follows:

Before Tax Lease Payments	$187,844
Depreciation	-70,000
Repair and Maintenance Costs	-10,000
Before Tax Income	107,844
Tax at 50%	-53,922
After Tax Income	53,922
Add Back Depreciation	70,000
Annual Fund Flows	$123,922

If the lease payments charged were $187,844 annually, the required return will be achieved as shown below.

Time	**Fund Flows**	**Factor Value**	**Present Value at 10%**
0	-$800,000	1.0	-$800,000
1-10	123,922	6.1446	761,450
10	100,000	.3855	38,550
			0

At this point let us apply the model to solve for the implicit financing charge expressed as a rate that is embedded in annual lease payments of $187,844. Let us assume:

1. The cost of the facility would be the same for the lessee if ownership existed.

2. The Terminal Value for the lessee would also be $100,000 if owned.

3. The annual before tax repair and maintenance costs would be $10,000.

4. Straight-line depreciation of $70,000 per year would be reported by the lessee if ownership existed.

5. The tax rate for the lessee is also 50 percent.

6. The life would be 10 years if owned by the lessee.

The preceding assumptions will provide for perfect neutralizing offsets for A, B, and C in Graph I and to solve for the 10 percent financing rate exactly as if the model is correct.

The discount rate which, when applied to the differential flows in the model that will result in a NPV of zero, is 10 percent as follows:

Time	Fund Flows	Factor Value	Present Value at 10%
0	$800,000	1.00	$800,000
1-10	5,000	6.1446	30,723
1-10	-35,000	6.1446	-215,061
1-10	-93,922	6.1446	-577,113
10	-100,000	.3855	-38,550
			0

If the repair and maintenance charges embedded in the lease payments are different from those that would be incurred if the firm did not lease, the differential should properly be viewed as a financing cost. In effect, by doing this we are applying an opportunity concept which is always relevant in a displacement situation. Similarly, the depreciation tax shield generated by way of ownership under other variations of debt financing is being displaced by the adjustment of the lease payments for the depreciation tax shield realized by the lessor. Again, any residual must be perceived as a financing charge. In short, if in Graph I the offsets for A, B, and C do not net out to zero then the residual represents a financing charge given the displacement functions at work.

CONCLUSION

The complexity of the leasing decision can be significantly reduced to a manageable level by taking the preferred approach in dealing with complexity, i.e., by separating the investment decision from the financing decision. The model to evaluate leasing as a financing decision is unambiguous and valid. The illustration used to verify the validity of the model assumed that the ownership life was the same as the leasing life. However, even in the case where the ownership life is greater than the lease term, the model is still valid if the assumption can be made of a renewal of the lease at whatever terms. In the case where this assumption is not valid, then the terminal value date and amount would have to be adjusted.

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[1] Van Horne, James C., Financial Management and Policy, 8th ed. Englewood Cliffs, NJ: Prentice Hall, 1989, p. 519.

A TAXONOMY OF RATIONING

by

Frank A. Janus, Ph.D.

INTRODUCTION

While it is true that in the financial literature attention is given to rationing, it is also true that it is too limited in scope. What is needed is a comprehensive treatment of all types of rationing.

To begin with, rationing should first be dichotomized along the lines of rational versus irrational rationing. In this paper, irrational rationing is defined as the non-acceptance of investment projects that meet the required rate, however that is defined, but which are rejected simply because of an arbitrary fixed amount budget. Rational rationing, on the other hand, represents that situation where the rejection of some competing projects is attributable to constraints that are not of an arbitrary nature. Of course, the ideal solution to this situation would be to eliminate the constraint(s), thus eliminating the need for the rejection of some projects which would, if accepted, contribute to the value of the firm.

As will be seen, the ideal may not always be achieved, in which case a methodology is needed for the selection of those projects to be accepted/rejected which would maximize the value for the firm. In the development of the methodology the economic logic required for the solution methodology to provide economically valid results should be stressed.

IRRATIONAL FINANCIAL RATIONING

The use of fixed amount rationing techniques to meet rigid budgetary provisions can be highly uneconomic and should be discouraged. Procedures (budgetary) should be adapted to valid economic concepts, rather than fudging concepts ("efficient" fixed amount rationing) to meet rigid procedures. Most of the budgetary requirements can be avoided by taking a longer time horizon for capital budgeting. A five-year capital budgeting plan is more likely to accommodate economically the segmentation of capital costs and the "lumpiness" of investments than a one-year budget. The potential use of financing techniques, such as a build up of short-term investments and/or use of short-term borrowing, to adapt to the discontinuities in long-term financing and financing requirements should be stressed. In short, there should be a conceptual analysis of the validity of the given rigidity in fixed amount capital budgeting before techniques, however sophisticated mathematically, are employed in adapting to such rigidity. In particular, this writer is concerned with the promotion of mathematical programming techniques to solve, with precision, conceptually invalid fixed amount capital rationing. Their aura of precision and mathematical objectivity is all too likely to hide their fallacious base.

In this writer's opinion there is too much of a tendency in current Finance texts to stress the mathematical programming techniques, rather than short term financing and/or investment techniques, in adjusting to capital budgeting rigidities, even where the fallacious basis of fixed amount rationing is explicitly recognized.

RATIONAL FINANCIAL RATIONING
RESULTING FROM CAPITAL COST DISCONTINUITIES

To have rational rationing of this type requires a set of conditions that are rigid and specific. To begin with, a discontinuity in the capital cost curve must exist. That there are discontinuities in the capital cost curve induced by both macro and micro forces is well substantiated.[1] The second condition is that the required dollar financing for the investment package must overlap the point of discontinuity in the financial capital cost curve. The third condition must be that, despite the fact that all the investments in the package pass the required rate test before the point of discontinuity, there is an insufficient amount of funds to accommodate all investments in the package. The final condition that must be present is that the required rate is raised so high that the necessity to reject at least one of the projects still exists.

Except where an opportunity cost or a comparative cost is relevant, the required rate includes not only the marginal financing cost of funds but a risk premium. Since the risk premium is an independent consideration, it will be left out of the subsequent discussion to more readily focus on the main point.

Assume that the firm has two projects as a package of investments and that Project A requiring $1,000 has an anticipated return of 12 percent and that Project B requires $2,000 and returns 12 1/2 percent. Further, assume that the first $2,000 of funds costs 10 percent and that the next $1,000 costs 20 percent. Both projects meet the 10 percent test but there are insufficient funds for both. The amount required to finance both projects would cost 13.4 percent, which introduces a hurdle rate that neither project would be able to meet.

As previously mentioned, short-term investment and/or short-term financing may provide a solution to this problem. To illustrate, if the long rate was expected to decrease from 20 percent to 15 percent in the future and if short-term financing costs 15 percent, then short-term financing could be used in anticipation of refinancing long term at 15 percent. This in effect would reduce the hurdle rate down to 11.7 percent ($2,000 at

10% plus $1,000 at 15% = 11.7% for the $3,000) and both projects A and B would be acceptable.

Alternatively, if short-term financing rates were not significantly lower than long-term rates but the long rate was expected to fall from 20 to 15 percent, then short-term investments may be used in anticipation of refinancing long in the future at a 15 percent rate. Adding a short-term investment to the two long-term investments may make the entire package acceptable in anticipation of refinancing long in the future which would have the effect of making not only the package of long-term investments acceptable but the individual investments as well.

As an illustration, assume that the firm had a short term investment opportunity for $1,000 at 25 percent, then the average return for the package for the time period of the short-term investment would be 15.5 percent ($1,000 at 12%, $2,000 at 12 1/2% and $1,000 at 25% = 15.5% for the $4,000). Financing $2,000 at 10 percent and $2,000 at 20 percent would provide a hurdle rate of 15 percent for the package. Refinancing $1,000 of the $2,000 costing 20 percent in the future at 15 percent would create a hurdle rate of 11.7 percent, which would make the individual long-term investments acceptable.

Obviously there are other possible permutations of short-term investments and/or financing that may in effect eliminate the need to reject A or B. Equally obvious is the fact that no matter how creative the financial manager is, the elimination of the need to reject A or B will not always be possible. In such a case, a displacement function exists and an incremental analysis is required for a correct solution methodology based on fundamental economics. This will be developed in the next section dealing with the mutually exclusive alternative problem.

RATIONAL RATIONING - MUTUALLY EXCLUSIVE INVESTMENTS

Where there are multiple possibilities for satisfying a particular function then the acceptance of one of the possibilities precludes the acceptance of the other possibilities, hence a displacement function exists and an incremental analysis is warranted to introduce the opportunity cost(s) into the analysis.

As an illustration, in the replacement of a machine on the assembly line there may be several machines that are candidates as replacement alternatives. To begin with, a distinction must be made as to whether the machine function being replaced is at the end of its physical life or prior to it. Replacement may be under consideration prior to the end of the physical life of the old machine in order to achieve greater reliability, lower operating costs, better quality end product, or some combination of these considerations. In the first case, where the old machine is at the end of its life a minimum investment is required. To the extent that the machine function represents an integral component of a system that is profitable, the evaluation of the minimum investment is rather academic, since the system would be inoperative without the component.

Amounts above the minimum do require profitability evaluation, since only the minimum investment is needed to maintain an operative system. In other words, if there are "n" alternatives, then "n-1" evaluations are required. However, where the old machine is still capable of functioning but is under consideration for replacement due to the prior mentioned reason(s), then even the minimum investment must be evaluated in terms of profitability since the system would still be operative without the replacement. In the foregoing illustration of mutually exclusive investments in a replacement situation, the second set of conditions will be assumed.

Assumptions:

1. There are two machine possibilities as replacement alternatives with the following information:

Period	**Machine A**	**Machine B**
0	($15,000)	($60,000)
1-5	5,000	19,000

2. A financial cost of capital of 15%.

Machine A is subject to the 15 percent financial cost of capital as a rejection rate. If it meets this test then Machine B representing the larger investment is subject to two rejection rates. For the amount of the investment in A that it would displace ($15,000), an opportunity cost concept is relevant (the $5,000 earnings per year that would have been realized by investing the $15,000 in A or expressed as rate, 20 percent), while for the amount above that ($45,000) the financial cost of capital should be used as the rejection rate. In effect, the implementation of two rejection rates for B can only be achieved if an incremental analysis is performed.

As long as an incremental analysis is performed as required by fundamental economics, whatever tool is used, whether it is NPV or IRR, the results will be valid and consistent. To illustrate from the above data, the following results would be obtained using NPV.

Period	A	B	B-A
0	($15,000)	($60,000)	($45,000)
1-5	5,000	19,000	14,000
NPV(RR=15%)	1,761	3,691	1,930

It should not be surprising that the acceptance of the higher NPV for the two investments would be the correct choice since the difference between the NPV of A and B is the NPV for the incremental investment (B-A). The NPV for B could not conceivably be greater than that for A if the incremental investment generated a negative NPV. What is difficult to understand is why B would not be accepted if an incremental analysis was used with an IRR analysis. The IRR for B-A must be greater than the financial cost of 15 percent being used as the required rate for the NPV of B-A to be positive. Many authors have concluded that the use of IRR would incorrectly lead to the acceptance of A given the following results:

	A	B
IRR	20%	17.6%

This conclusion warrants closer examination since there are several logical flaws in it. To begin with, since the IRR for B-A is 17 percent and the required rate is 15 percent, why should the incremental investment going from A to B be rejected? The conclusion that A should be accepted over B because the IRR is higher obviously does not represent a correct incremental analysis since the IRR of 17.6 percent for B represents a weighted average of the returns for A and B-A (1/4 X 20% + 3/4 X 17% = 17.6%). The second failure in economic logic is that the higher return for A is preferable to the lower return for B. The goal for the firm is not to maximize a rate of return. If that was the case, all but the highest return project would be rejected. A 20 percent return on a $15,000 investment will not add as much value to the firm as a 17.6 percent return on a $60,000 investment if both investments meet their required rates. The goal for the firm is to maximize a dollar return by increasing the investments as long as the extra (incremental) investments meet their required rates. The incremental investment of $45,000 meets the relevant cost of 15 percent, given an IRR of 17 percent.[2]

RATIONING - PROPRIETARY CAPABILITY

Having a proprietary capability is what gives a firm the competitive edge over other firms in the marketplace. The source of the proprietary capability may lie in highly efficient components of a system (including human components), in the ability to efficiently integrate these components into a system, in the system design itself, or in a combination of these capabilities. Unique capability in integrating highly efficient sub-systems (marketing, financing, etc.) into a larger system called the firm may itself be the source of proprietary capability.

Clearly the proprietary capability must be highly inelastic in its supply, otherwise competitors would be able to expand the supply and it would cease to be proprietary. Given a limit in the supply of a proprietary facility, it must be rationed in such a way as to maximize the NPV for the firm. If there was a 100 percent correlation between the dollars invested and the portion of the total proprietary facility desired by all alternative uses wishing to draw on the limited supply, then the same methodology as that used for mutually exclusive alternatives would be warranted.

To illustrate, if A, with an investment of $100,000, requires 10 percent of the proprietary facility and has a NPV of $15,000 and an IRR of 15 percent and if B, with an investment of $100,000, requires 10 percent of the proprietary facility and also has a NPV of $15,000 with an IRR of 15 percent, then they would be equally desirable. However, if all facts were the same with the exception that B requires use of 20 percent of the proprietary facility, then clearly A is preferable over B. Even if B had a higher NPV and IRR than A, given the disparity in the rationing of the proprietary facility, A could still be more desirable. The selection process is, of necessity, complex.

Ranking the projects on the basis of NPV's or IRR's would ignore the capacity units required by each project. Consequently, a comparative cost approach must be used in the selection process. In terms of rationing, it is the dollar return per unit of proprietary facility which clearly reflects a difference when compared with mutually exclusive investments. In the case of mutually exclusive investments, a financial displacement is operative, while in the case of proprietary rationing a non-financial displacement is operative, together with a financial displacement.

An iterative approach to this problem is required since the appropriate discount rate is a comparative cost rate determined by the return on the marginal investment, which in turn is determined by the selection process itself.

To obtain a first approximation discount rate, determine the rate of return on all of the potential investments, which can then be ranked according to their returns. Going down the ranking from the top, the number of investments which add up to 100 percent of the available capacity is determined. The return on the lowest rate investment, rejected on the basis of a rate above the cost of capital, can serve as a first approximation discount rate. Since this rate was determined by ranking on the basis of rate, the actual optimum discount rate cannot be lower. The present value of all of the investments is then determined. These present values can be expressed per unit of capacity displaced. This introduces comparative capacity costs. If any of the non-selected investments offer a higher net present value, relative to its capacity displacement, than any of the selected investments, then they should replace the originally selected investments.

The rate on the next higher return investment which would be rejected on the basis of a rate should then be used to discount again to net present value the potential investments, in order to determine whether any replacements of previously selected investments is warranted. The process should be repeated until all of the accepted investments are higher in present value per unit of capacity than all of the rejected investments.

A quantitative illustration will help. Assume the following data related to an array of investments competing for a limited proprietary facility. For simplicity, assume the total unit capacity to be rationed is 80 units.

Projects	Capacity Units Required	IRR	Required Investment	Return Flows Period 1	Return Flows Period 2
A	20	50%	$30,000	$35,000	$15,000
B	10	82%	5,000	8,000	2,000
C	15	28%	20,000	10,000	20,000
D	5	27%	10,000	8,000	6,000
E	10	9%	15,000	9,000	8,000
F	15	31%	10,000	7,000	8,000
G	30	18%	20,000	15,000	10,000
H	20	11%	20,000	15,000	8,000
I	10	32%	8,000	6,008	6,008
J	5	24%	6,000	5,000	3,000
K	20	57%	10,000	8,000	12,000
L	30	27%	40,000	35,000	20,000
M	15	60%	5,000	3,000	8,000
N	5	32%	4,000	3,004	3,004
O	10	18%	12,000	9,000	6,000

Assuming a financial cost of capital of 10 percent the lowest acceptable rate is 11 percent (Project H). Project E with a 9 percent rate does not meet the 10 percent financial cost of capital used as a minimum hurdle rate. The financial cost of capital is no longer relevant as a rejection rate if all the projects have a return above this rate and the total demand for capacity units exceeds the 80 capacity unit limitation. If Project H with an 11 percent return is going to be displaced by another project because of the rationing, then 11 percent constitutes the first discount rate to be used in determining the NPV per capacity unit for all acceptable projects and ranked accordingly. We have the following schedule:

Project	IRR	Capacity Units Required	Cumulative Capacity Units	NPV at 11% Discount Rate	NPV Per Capacity Unit
B	82%	10	10	+3,832	383
M	60%	15	25	+4,199	280
K	57%	20	45	+6,952	348
A	50%	20	65	+13,715	686
N	32%	5	70	+1,146	229
I	32%	10	80	+2,292	229
F	31%	15	95	+2,803	187
C	28%	15	110	+5,250	350
D	27%	5	115	+2,080	416
L	27%	30	145	+7,775	259
J	24%	5	150	+941	188
O	18%	10	160	+981	98
G	18%	30	190	+1,635	55
H	11%	20	210	+11	.6

Projects F, J, O, and G have a lower NPV per capacity unit than any of the tentatively accepted projects filling the 80 unit capacity to be rationed. Projects C and D replace projects N and I since they have a higher NPV per capacity unit. Project H is dropped from further consideration since discounting at a higher rate would create a negative NPV for H. The new schedule ranking the projects by NPV per capacity unit is as follows:

Project	IRR	Capacity Units Required	Cumulative Capacity Units	NPV Per Capacity Unit
A	50%	20	20	$686
D	27%	5	25	416
B	82%	10	35	383
C	28%	15	50	350
K	57%	20	70	348
M	60%	15	85	280
L	27%	30	115	259
N	32%	5	120	229
I	32%	10	130	229
J	24%	5	135	188
F	31%	15	150	187
O	18%	10	160	98
G	18%	30	190	55

The lowest return project that would be dropped on the basis of a rate ranking is 18 percent and this constitutes the next discount rate to solve for the NPV per capacity unit. The results are as follows:

Project	IRR	Capacity Units Required	Cumulative Capacity Units	NPV at 18% Discount Rate	NPV Per Capacity Unit
A	50%	20	20	10,415	521
D	27%	5	25	1,084	217
B	82%	10	35	3,212	321
C	28%	15	50	2,830	189
K	57%	20	70	5,392	270
M	60%	15	85	3,285	219
L	27%	30	115	4,005	134
N	32%	5	120	701	140
I	32%	10	130	1,402	140
J	24%	5	135	389	78
F	31%	15	150	1,673	112
O	18%	10	160	* -69	-7
G	18%	30	190	* -115	-4

* The reason for negative NPV's is that the returns for O and G are a little less than 18 percent (the original IRR's were rounded off).

None of the projects below M have a higher NPV per capacity unit than the projects up to M and, therefore, there would be no replacements. Effectively this ends the process. This raises an interesting problem since the demand of 85 units exceeds the 80 unit limit. Project D requires 5 units and can be dropped.

The accepted projects would be A, B, C, K, and M and this would maximize the NPV per capacity unit given the displacement functions that are relevant. Superficially, it would appear that N and I, having a 32 percent return using 15 units, are unfavorably displaced in the selection process by C giving only a 28 percent return for the 15 units. However, C requires an investment of $20,000, while N and I combined require only a $12,000 investment. Given that the goal for the firm is not to maximize a rate but a dollar amount, the selection of C over N and I is a wise choice.

The preceding analysis of proprietary rationing was simplified by assuming that all projects have the same economic life (two years). Where the lives of the projects are not equal, then an additional element of complexity is introduced. To illustrate this point, assume the following with 30 units to be rationed:

Required Capacity Units	Project	IRR	Period 0---------5---------10
30	A	20%	---------------------
30	B	25%	----------

One acceptable way of dealing with unequal lives would be to add on to the discount rate a premium for longer time segments in solving for the NPV per capacity unit. As an illustration, a premium of 5 percent may be added on to the discount rate for time segment 5 through 10 and a premium of 8 percent for the time segment 11 through 15, etc.

The problem may be even more complex if allowance is made for a project requiring different amounts of the proprietary facility over time. As an illustration, starting up a new venture may require more key executive time than after it is operational. The complexity of the problem obviously explodes by introducing the combination of projects with different lives, with some projects drawing different amounts of the limited facility in different years. This degree of complexity will not be dealt with in this paper, which is more modest in scope.

As we have seen, there may be three distinct types of rational rationing in the capital budgeting problem, two of which exclusively involve a financial rationing (each for a different reason) and the third which includes a nonfinancial rationing. Whatever the reason for the financial rationing (mutually exclusive alternatives for a function or financial cost of capital discontinuities) the methodology used is the same and by its nature is simpler than for rationing a proprietary capability. Whereas, in the first case there is one displacement function at work, in the second there are two. The proprietary capacity rationing involves both a nonfinancial rationing as well as a financial rationing, both of which are rational.

The introduction of proprietary capacity rationing has implications which at first glance may be considered irrational financial rationing. In fact, that which may be considered irrational may after all be rational. To illustrate, assume that the firm has five projects, each requiring a one million dollar investment and all having a return above 15 percent. Assuming a 15 percent financial cost of funds to cover the five million dollars required, it would appear that the firm would be irrational in not accepting all five projects. However, if a proprietary capacity was being rationed and the combination of the five projects exceeds the limits of the proprietary capacity being rationed, then it is not acting irrationally to invest in less than five of the projects. Accepting only four or three or two of the projects may represent rational behavior. The discussion of irrational rationing in the financial literature implicitly assumes that there is only one kind of rationing (financial). As we have seen, there is more than one kind of rationing.

ENDNOTES

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