PROJECT FINANCE FLIGHT SIMULATOR

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Abstract: Project Finance addresses the need to secure large-scale, capital-intensive investments in face of expenditure constraints. Efficiency and more logical distribution of risk among stakeholders are major advantages. The high amounts involved and the usually high proportion of debt—millions, in any currency—call for detailed risk analysis and risk allocation. In Project Finance there is limited or no recourse over the sponsor's assets and so investors rely on future cash flows for profitability. Growth prospects are therefore preferred to absolute values at any given time. However, most investors still decide based on the Net Present Value (NPV) of an opportunity and use risk-adjusted discount rates to cope with uncertainty. This additional mark-up can ultimately turn down an otherwise profitable venture. By making the continuous-time behavior of cash flows visible, simulation models based on System Dynamics avoids these drawbacks and provides a method to assess and manage financial risks that takes growth into account.

BASICS OF PROJECT FINANCE

Although there's evidence of its ancient use as a financial architecture, Project Finance has been the preferred approach for large-scale, complex and capital-intensive engineering systems since the eighties (Patramanis, 2006; Finnerty, 2007). Perhaps the reason has roots in the oil crisis, in the seventies, with the emphasis on building strategic energy hydropower infrastructures. Or maybe the reason is a more adequate way of financing and risk-sharing among stakeholders when promoting large projects. For example, the Trans-Alaska pipeline system, involving eight of the largest oil companies and completed in 1977, employed project finance to build the 800-mile pipeline for US$7.7 billion.

Project Finance is typically used to accommodate the difficulties of financing large or complex projects such as airports, plants, harbors, toll roads, naval shipyards, power generation plants, wind farms, and some defense projects (Fight, 2005). Project Finance can be thought about as a form of asset-based financial engineering. It is asset-based because financing is tailored around a specific asset or a related pool of assets (Finnerty, 2007). And it is a form of financial engineering because the financial structure usually cannot be copied from one project to another—it must be designed specifically for each project.
As a financial engineering approach, Project Finance has different goals and meaning when compared with corporate finance and is also different from funding projects within a firm (Finnerty, 2007).

In project finance, the sponsor may be the main user of the product or service, the main constructors or suppliers, a joint venture, or a government, but the target operation—or Special Purpose Vehicle—is financed and controlled separately from the operations of the sponsors. Because it is limited or even no recourse over the sponsor's assets, lenders will accept the financing arrangement if, assuming negotiation ability with national and international credit entities, the project is economically viable, sponsors show appropriate credibility, and there is the know-how for project implementation and operation.

A critical factor for the appraisal of complex projects by investors and lenders is that the cash flows from the project will be completely identifiable, stable, and predictable. The difficulty comes from uncertainties associated with long lifetimes and large amounts of debt. That is, the focus of Project Finance is on the future project cash flow and not on the balance sheet of the sponsors. In fact, the lenders, who supply most of the financing—can be 100%, in theory—have security contracts that guarantee them a higher priority on the remaining debt over shareholders and suppliers.

In particular, after paying O&M costs, debt obligations have different priorities: senior debt, regular debt, suppliers, taxes and finally the project sponsors. As a result of the credit support provided by other stakeholders, project finance provides greater leverage than project sponsors could get from an internally financed project. In regular investment projects, there are moments when there are cash outflows and other moments when there are cash inflows. But in Project Finance, because there are multiple security contract arrangements, there is a "waterfall" of cash outflows after project revenues bring in cash inflows (see **Figure 1**.)

(In short, Project Finance is usually an attractive choice when: (a) large projects can stand alone as an independent economic unit, (b) sponsors are conscious about its debt limitations, (c) sponsors agree about the complex contractual arrangement, and (d) sponsors are sensitive to risk exposure. Overall, stakeholders are faced with several kinds of risks: completion risk, technological risk, material supply risk, economic risk, financial risk, currency risk, political risk, environmental risk and force majeure risk. In Project Finance, the risk is allocated among whoever is in a better position to accommodate a given risk type. **Figure 2** depicts basic stakeholder relationships within a Project Finance arrangement.

INVESTMENT UNDER UNCERTAINTY

Risks can be analyzed taking into account variation, and both predictable and unpredictable uncertainty. Variation increases with the complexity of the project. The sources of predictable uncertainty are identifiable, although its magnitude is not known beforehand. Unpredictable uncertainty is not identifiable during project planning and is not covered by contingent or risk mitigation plans. If, according to Dixit & Nalebuff (1993: 170), "the right amount of unpredictability should not be left to chance," in a large financing operation this is particularly relevant.

Capital-intensive engineering systems, often involving multinational issues (host country different from sponsor's country) bring increased uncertainty to project development and overall risk management. Due to potential and abrupt socio-economic changes in some countries, uncertainty comes not only from different currency and inflation rates, but also from the market itself (Faus, 2001; Hawawini & Viallet, 2002; Murphy, 2005).

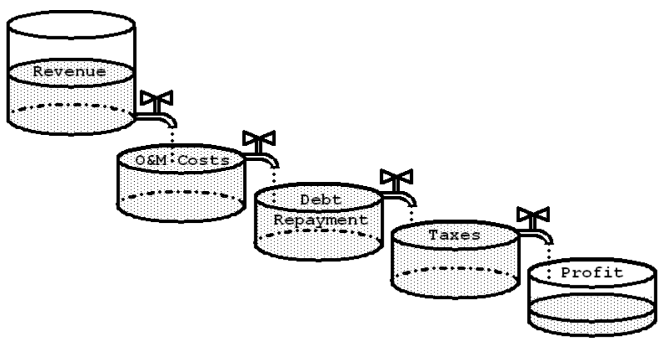

Figure 1. Profit is what remains after priority payments.

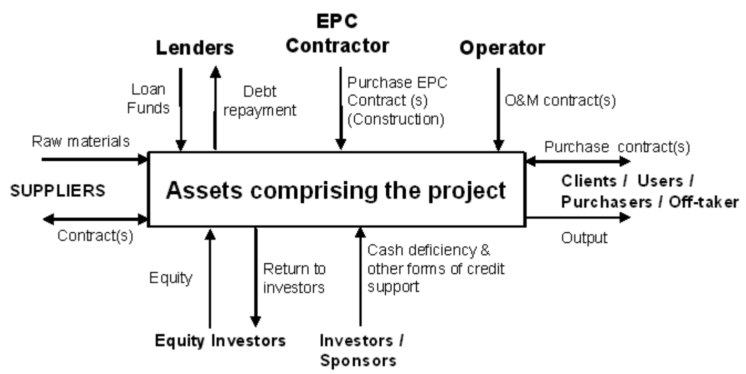

Figure 2. Stakeholders agree on contractual relationships (Adapted from Finnerty, 2007.)

Many of these large projects are financed in developing countries where economies and political institutions are less stabilized. Market risk becomes economic risk due to sales fluctuations in uncertain economic, political, social and competitive environments. Market risk also equates to operational risk due to high fixed costs during the project lifetime. Business risk is the sum of economic and operational risks. In addition, the presence of fixed interest and foreign currency exchanges adds another risk factor—financial risk.

The cumulative effect of business risk and financial risk, which contribute to the project's total risk, affects the project's net profits. Although currency risk is a major issue in international projects, the focus at this time is anticipating economic and financial risks. Risks only have an impact if they materialize in future cash flows. And in spite of all the risks, investment is still acceptable if the project can be shown to be attractive. When making a decision to invest, attractiveness within the project's horizon is traditionally expressed in terms of the well-known Net Cash Flow (NPV) relationship:

$$NPV = -C_0 + \sum_{i=1}^{n} \frac{N_i}{\left(1+r\right)^i} \qquad (1)$$

where C0 is the initial project cost, Ni is the net operating income at the end of year i, r is the discount rate, and n is the terminal year or investment horizon. An associated concept is the Internal Rate of Return (IRR), which is computed as the value of r that makes NPV=0. Therefore, the project becomes attractive if NPV exceeds zero and IRR exceeds the discount rate of a reference best alternative. Other decision criteria include expected monetary value, utility, cost-benefit ratio, or cost-utility ratio.

Uncertainty, and therefore risk, comes into play when the investor is faced with the need to pick values to plug in equation (1). Traditional approaches use spreadsheets for this purpose because they are flexible, cost-effective, and portable (Kennedy, 1997). The calculation of the denominators in the summation terms of equation (1) is repetitive and poses no problem. The challenge is to estimate the numerators for successive years, identifying the cash inflows, the cash outflows, and how they all evolve. The spreadsheet is then used as an exploratory tool, tentatively trying different seed values and growth factors. The resulting projections help to assess the credit risk, to structure financing over time (and improve the risk position), and to identify negotiation points.

ESTIMATING OPERATING INCOMES

The nature and scope of risk assessment range from technical risk assessments, concerned with the prevention of accidents or engineering failure, to strategic risk assessments, concerned with avoiding business or organizational failure. Project Finance focuses on the latter. From the perspective of Project Finance, hazards and threats and their associated risks can be managed to increase the probability of relative gain. The discount rate r is not affected by management but can be negotiated and, in typical infrastructure projects, NPV becomes very sensitive to the discount rate due to the long-range horizon. The successive operating incomes Ni are potentially affected by different kinds of risk, which good cash management practice may contribute to reducing (see **Figure 3**).

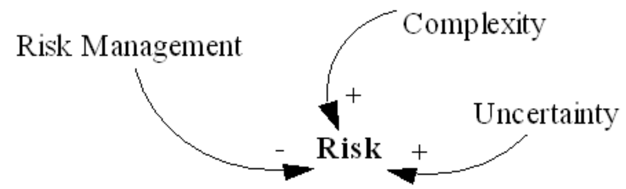

Figure 3. Good management practice helps to attenuate risk.

The term C0 in equation (1) describes the infrastructure building stage, where lenders and investors supply important amounts of financing. Although financing may be provided by equity, the largest portion comes from debt. After this initial stage, the project enters its operating stage. A single term C0 is a simplification because the investment is phased and, whenever possible, the operation will start with parts of the infrastructure still under construction. Therefore, C0 includes the loan(s) and equity capital, if any, identified in the spreadsheet as separate cash inflows, along with operating income sources. In turn, cash outflows list initial construction costs, operating costs and debt service, as well as payment of taxes and of dividends to shareholders. By the end of the project lifecycle, there is no more debt, and all generated cash flows will serve to pay taxes and return for shareholders.

If we call operating outflows the sum of initial construction costs plus operating costs, then the sum of all cash inflows minus operating outflows is the net operating cash flow (NOCF). Subtracting the repayment of principal and interest from this value yields the cash surplus/deficit at the end of each period (spreadsheet column). This procedure is straightforward. At this point, when NPV and IRR make the project worth considering, financial analysts usually start tampering with some of the figures in an attempt to improve the debt service ratio. Lenders tend to pay special attention to this ratio, which shows how the total financial outflow compares to the NOCF.

A frequent assumption that drastically simplifies building a spreadsheet is that values evolve regularly. The implication is that different sources of uncertainty tend to cancel each other in the long run. Another often overlooked assumption is that all values remain constant between successive periods. Faus (1999) presents a detailed example where a calculated (averaged) cash flow forecast shows a negative peak of, say, Y in a given period. When calculated for half the interval, the same period actually shows more critical, unhidden peaks as severe as -2.5Y. Elsewhere, an apparent cash surplus actually hides a negative peak that shows up when the time interval is halved. Irrespective of how optimistic the overall figures maybe the drawback is that the project can run out of cash if some time constants are small enough—often with critical impacts on stakeholders. This may end up undermining the confidence of investors and, in practice, prevents using the original spreadsheet as a planning device. Improved cash management, allowing for timely and more favorable negotiation of interest rates in case of additional financing needs, would be more difficult too. But the spreadsheet would need to be gigantic to obviate these drawbacks and account for all the minute changes in the project's cash position over time.

PROJECT FINANCE DYNAMICS

The System Dynamics body of knowledge is large enough to make building a model for Project Finance a relatively easy task. More difficult is perhaps to convince investors and other stakeholders that such a tool may better serve their interests than the devices they are so used to work with. Similar difficulties have been reported elsewhere (e.g., Repenning, 2003). At the heart of this difficulty is the need for modelers to "portray the way the agents represented in their models form forecasts and update expectations" (Sterman, 2000: 631). The agents here are project sponsors and investors (lenders) who, despite invoking expensive market studies to justify spending very large sums, ultimately rely on naïve extrapolation: "they adjust the parameters and values of exogenous inputs until the output of the model is 'reasonable,' that is, until it matches their intuition" (ibid, p.655).
Project Finance is all about forecasts. And technical, market forecasts will likely be poor because no business can claim to live in a stable dynamic environment. This is particularly true when we talk about cash flow-based decisions. Although Forrester (1961: Ch. 17-18) claimed to keep the cash flow part of his customer-producer-employment model simple, the resulting behavior clearly shows that financial variables reflect overall business policies. Therefore, Sterman's advice about improving the benefit/cost ratio of forecasts seemed more than appropriate: "reduce the cost […and...] focus on the development of decision rules and strategies that are robust to inevitable forecast errors" (Sterman, 2000: 655). Following this advice assumes understanding and adhering to the System Dynamics methodology.

The first step is to build a model that agrees with existing knowledge and those sponsors, and investors accept as a reliable representation of their business environment. Because there is no reference mode to compare with, the output of a project finance dynamic model is more difficult to accept. Motivating arguments, such as invoking cash-related issues investors may face, seemed to cause no reaction. Simply put, cash-related issues are:

• Presence of "negative" cash peaks. This is an abstraction —either the project has enough cash to fulfill its obligations or some consequence happens. But being a "continuous time" methodology, System Dynamics reveals instantaneous peaks, should they occur.

• Presence of "positive" cash peaks. The existence of cash surplus reveals missed opportunities (e.g., overnight accounts management). Although less critical, its detection allows improved cash management and profit.

The counterargument was that these effects should not be relevant in long-range projects, at least in face of so many other sources of uncertainty. To make a long story short, as arguing over the merits of System Dynamics models would be pointless, the decision was to make a dual model. On the one hand, the model could replicate the behavior of the spreadsheet when fed with identical inputs. On the other hand, it could include features, like circular (feedback) relationships, forbidden in spreadsheets. A binary variable enables switching between spreadsheet and dynamic modes (see **Figure 4**).

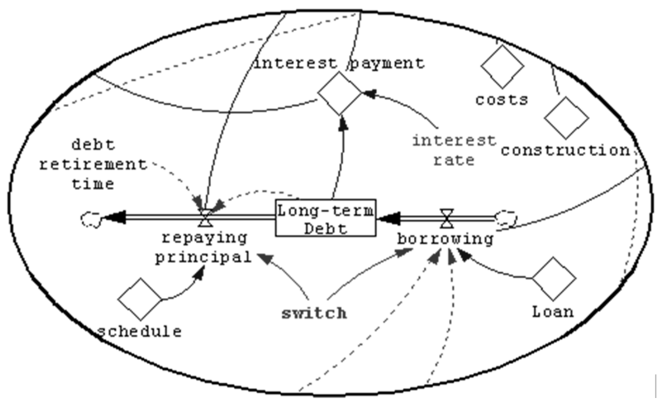

Figure 4. Detail of model shows switching between behaviors.

The diamonds in Figure 4 represent input taken directly from the spreadsheet. This is done adding successive values Vi*PULSE(i, 1) to mimic the introduction of different Vi in each period i. The dotted lines represent relationships between dynamic (model) variables. The decision to use the diamond inputs is simply to assign values to switching variables. For instance:

*interest payment = IF THEN ELSE(interest rate = 0, (V1*PULSE(1,1)+...), "Long-term Debt"*interest rate)*
repaying principal = IF THEN ELSE(switch = 0, schedule, "Long-term Debt"/debt retirement time)

This procedure is simple enough. When discussing cash behavior, the calculation of NPV and financial ratios derives directly from their definition (see Figure 5). Total expenses add together operating and financial expenses which, in this case, consist only in repaying the principal and paying interest. Expense variables and income can either be fed from the spreadsheet or calculated, namely:

operating expense = fees + IF THEN ELSE(switch = 0, construction + costs, new investment + direct costs)
income = borrowing + equity capital + IF THEN ELSE(switch = 0, inflows, cash receipts)

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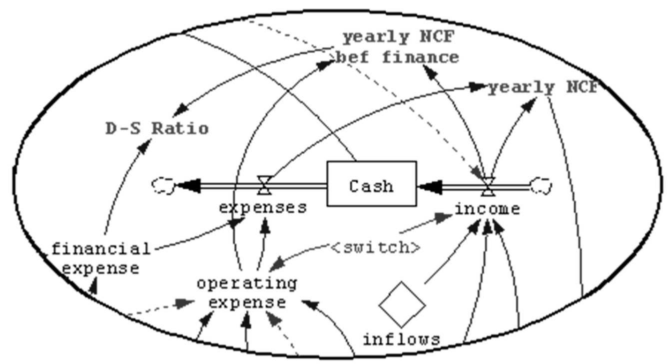

Figure 5. Flow rates influencing cash behavior depend on input selection.

Finally, concerning the development of the model, there can be many sources of variation, ranging from exchange rates to productivity performance. But ultimately, without reference behaviors to compare to, introducing complexity in the model implies relying on somewhat arbitrary decisions about time constants and similar auxiliary variables. Uncertainty in Project Finance comes primarily from market behavior. And for the sake of discussing with sponsors and investors, this was made as simple as reasonable (see **Figure 5**):

*contracts = sales fraction * Potential Customers * Customers / total market*
servicing = production / avg service per customer

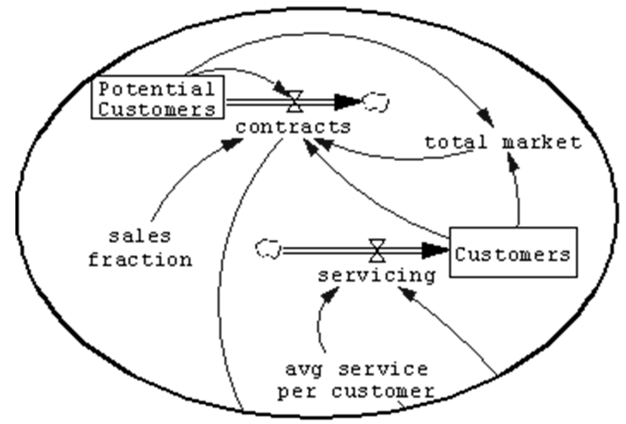

Figure 6. Uncertainties in demand drive market risk.

Showing that the model structure was inherently the same was helpful. But at the time of submitting the paper the authors still need to meet with sponsors and investors to find out to what extent they internalize the difference between manipulating quantities in the spreadsheet and changing the system structure (e.g., add/eliminate relationships). Hopefully, they will also appreciate the effect of delays and the influence of the discount rate as a system leverage point. The major advantage will be, however, the possibility of taking into account the structure behind some known behaviors to help identify the causes of problems and make changes. This will be an improvement not only in investment decision-making but also in cash management.

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