

Chapter 16: Pillars and Essence of Project Finance

As with other parts of this book, I have had many attempts in writing things down about project finance and I have re-structured my thinking over the years. I began studying project finance a long time ago by reading presentations in academic texts where project finance is typically defined as just a special type of debt; by using case studies from business schools where details of debt finance are presented; or by analysing the debt structure in long and complex financial models. When I initially taught courses on project finance, I did not take a step backwards and have students begin by thinking about what makes project finance different from other ways of investing in capital intensive assets with a long life. I now insist that the real essence of project finance is that it can be an effective way to make large investments in essential infrastructure such as electricity plants, railways, bridges, and hospitals. This is accomplished through a unique way to assess risk; though creating incentives to efficiently construct and operate assets; through optimizing cost of capital and obtaining low prices; and, through encouraging investments that are good for society in general. These ways to think about project finance are a lot more than defining project finance as a special kind of debt. I now assert that thinking of project only in terms of debt provisions is a dangerous way to think about why project finance is used.



The more I work on actual projects; the more I teach classes in the foundations of project finance; the more I observe corporate finance in practice, the more I am convinced that from an academic perspective, project finance should be the starting point in assessing investments and not some kind of minor finance specialty. My idea is that only after measuring returns directly from long-term cash flow, assessing the performance and value of single stand-alone projects, and thinking about risk assessment from the standpoint of a lender should corporations (which are portfolios of projects) be studied. I suggest that project finance is a way to achieve low cost of capital through bidding; that risks can be effectively assessed with debt sizing and structuring; that evaluation of lifetime valuation with changing risk is assessed through sale of projects; and valuation is made using equity cash flow rather than operating cash flow. I am old enough and brave enough now to assert the manner in which contracts designed by governments purposely

impose risks on private companies to encourage efficient investments; the manner by which bidding programs in project finance are used to discover the cost of capital; the manner by which bankers and other lenders verify the viability of projects; and the way governments can study the impacts externalities related to projects provides a unique and effective way to make crucial investments in an economy. This contract and financing structure can be better than alternatives without private investment i.e., government ownership or companies with cost plus regulation. It can also be a better way to structure long-term investments than to have no government involvement which will likely have a higher cost of crucial services to consumers.

Instead of beginning project finance discussion with classic terms related to debt features, I advocate thinking about the subject in a broader way that begins with basic principles of investment analysis using a few objectives of project finance that I call pillars. The different pillars include developing investments that (1) achieve a low price of



essential services for society; (2) assets that are constructed and operated efficiently; (3) asset risks over a long time frame that are verified by independent entities who have a vested interest in assuring the projects work; and (4) assets that are determined to have long-term benefits to society above the benefits that accrue to private investors. To consider these objectives relative to other methods of finance, you can think of other ways to

finance projects with long lives where the length of the asset lives implies that they could become obsolete and/or uneconomic. One alternative to financing long-term assets to project finance is government ownership or strict and guaranteed cost-plus regulation. With government ownership or guaranteed regulation there is arguably less incentive for efficient operation and less lender verification of the risks of the project. A second alternative for financing long-term investments is purely private investment without contracts and/or government involvement. In this case private investors must take obsolescence and market risks leading to higher cost of capital and resulting prices that will most probably be higher than the other alternatives. There will also be less lender analysis to justify the investment. In the purely private case, there will be no or less evaluation of whether the project makes sense for society when externalities are considered.

The way the four project finance pillars can be obtained is through using private entities in various aspects of the project along with signing contracts with government entities or companies that are heavily regulated by the government. With the contracts, projects can obtain high levels of debt financing because of stability in cash flow over long lives. Details of contracts, cash flow variability analysis, cost of capital, valuation and other subjects can become quite involved. Before you getting involved in the other complex items of debt sizing and structuring, evaluation of project upsides from risk reduction; interpreting IRR, DSCR, LLCR, and PLCR; interpreting large financial models;

and evaluating credit enhancements like cash sweeps with mathematical analysis of volatility and mean reversion I think you should begin with the four pillars below:

1. Minimizing cost of capital for capital intensive long-term investments through use of competitive bidding which can result in low prices for in transport, water, electricity and other services.
2. Financing the project primarily with lenders (organizations with no direct stake in the ownership and development of the project) who will carefully and objectively evaluate risks and assure the project and will assure the project makes sense from a technical and economic perspective.
3. Using of price, construction and operation contracts that are structured with private entities to provide incentives for efficient construction and operations while not imposing uncontrollable risks on the private companies and allowing for stable cash flow.
4. Government involvement in projects – structuring bids, limiting technologies, defining project parameters -- to encourage development of investments that incorporate positive externalities and betterment of society.

The fundamental problem resolved by project finance is raising money for an asset that will last a very long time. The pillars above cover key objectives to enable long-term financing, but not all aspects of project finance. Aspects of project not in the pillars are the use of IRR and DSCR to evaluate return and risk, changes in the value of a project over its life; upsides in project finance; the manner in which cash flows require mean reversion and/or contracts.

Pillar 1: Minimising the Difference between Cost of Capital and Rate of Return for Capital Intensive Projects

I have repeated many times that finance is about answering the question of whether investments should be made, and this question involves assessing investment costs relative to uncertain benefits. Investments for some typical industries where project finance is used are shown on the accompanying picture. These industries generally involve essential services to a society (I do not agree that the project finance for “criminal justice” with private entities is beneficial). The key differentiating factor of these investments is the long lifetime of the assets and the high level of capital expenditure relative to operating cost. These two characteristics mean that the investments are capital-intensive. I have previously introduced



Social services: Education, healthcare, senior housing, criminal justice, military housing, public housing, municipal facilities



Road and rail: Roads, bridges, rail, public transport, tunnels, parking



Energy and utilities: Pipelines, water (distribution and treatment), power (transmission and distribution), Renewables



Communications: Cable systems, broadband and wireless, satellites



Ports and airports: Airports, seaports

something that is pretty obvious, that if you have a bigger capital investment, the cost of capital and the return on capital matter more. In Chapter 12, titled “Cost of Capital and Distortion of Production Cost”, the effects of capital intensity on the price of services were evaluated. This analysis demonstrated that when the real production cost is computed, that cost of capital has a dramatic cost on capital-intensive projects with a long life relative to less capital-intensive projects.

In modern project finance, revenues and prices are generally structured from a competitive bid process (this has not always been the case). While competitive bids can occur without project finance, the opposite is less true). The implied objective of competitive bidding is that the price to consumers and rate of return will be as low as possible – meaning the investor return is something close to its cost of capital. This idea is demonstrated by something I call the “night before” that I discuss when I meet people who have worked on projects involving bidding. This night before is when people who have been working on developing projects for many months have discussions with the chief financial officer about the acceptable IRR at the end of the process when the final bid is made. I imagine (I think correctly) a phone call between the developers and the CFO where the developer tells the CFO that unless you lower the IRR requirement, we will lose the bid. What this night before is doing is establishing the lowest acceptable rate of return in the context of the risk of the project which is the definition of cost of capital.

The pillar of project finance related to cost of capital versus rate of return is addressed at length in previous and subsequent chapters. For example, the MBA case studies mentioned in Chapter 2 demonstrate that when return earned is far above the cost of capital the cost to society can be very high and project financing often fails. One of the



projects touted by Harvard is the Dabhol project. This project did not have competitive bidding, and investors were able to negotiate a contract that charged prices which resulted in high returns. The project ultimately failed because prices were unaffordable. Another project introduced in Chapter 2 is the Petrozuata project in Venezuela that was suggested to be “a case study in the effective use of project finance.” In this

case there was no flexible contract structure to provide more revenues to the country of Venezuela in the case of higher-than-expected oil prices. This resulted in a very high return and the ultimate nationalisation of the project.

Pillar 2: Using Lenders to Verify the Risk of Projects and Classic Definitions of Project Finance

Pillar number two involves the manner in which lenders are used to verify risk in project finance which contrasts with relying on more traditional measures such as CAPM. The manner in which risk is measured by lenders is introduced in this section and further elaborated in subsequent chapters that discuss the DSCR, mean reversion and debt structuring. If you are an investor applying project finance, you have somebody else verifying that the project will work (i.e. the bankers) through making a large monetary commitment to the investment. This is a luxury that is not available including corporate finance and government ownership. For example, if a large capital-intensive project is financed using general government funds, you cannot use the lender to assess whether the investment makes economic sense.

If you study project finance by reading texts, taking courses, or surveying the internet, the structuring of project finance debt seems to be the only thing that is important. This means that the idea of achieving low cost of capital through competitive bidding and/or contract structuring to provide risks and incentives for private parties does not appear to be a fundamental part of the project finance process. As the debt raised in project finance is a necessary pillar (in theory, project finance debt can be raised without competitive bidding and carefully structured contracts¹), the discussion here is longer than discussion of the other pillars. I begin by reviewing various different definitions of project finance as the basis for discussion of some technical terms. After defining terms, the notion of using debt as the basis for risk measurement of the overall project and providing a stamp of approval of the project is addressed. Finally, the importance of having projects be evaluated on a standalone basis by banks without any support from parent corporations is considered.

The Danger of Defining Project Finance as a Form of Debt – Project Finance is Much More Than Just a Form of Debt

In rare cases when the subject of project finance is taught in business schools, it seems to be just classified as a kind of debt, maybe analogous to asset-backed securities (where debt is tied to an asset such as accounts receivable.) When project finance is defined as a form of debt, while other aspects of the investment are evaluated with standard corporate finance techniques, the investment benefits of the key pillars of project finance can be lost. These problems distort analysis by assuming the amount of debt raised is independent of risk; by mis-estimating the cost of capital through un-levering and re-levering betas; by assuming that WACC and risks remain constant; by believing that risks can be quantified with beta; by implicitly assuming that the distribution of equity cash flows is approximately normal; or applying volatility without mean reversion to cash flow will distort valuation and risk assessment.

¹ An example of this is Merchant Electric Power in the late 1990's and early 2000's which turned out to be massive failures.

The way project finance debt is structured is the basis for the idea that risks of a project are verified by external entities, i.e., banks. This aspect of project finance is not central to government ownership or highly regulated corporations where the debt is related to the overall viability of the government or regulated company financial statements. This pillar of project finance is how project finance is typically defined. While the idea that project finance is just a form of debt financing is wrong, working through classic definitions is a good way to work through technical terms that are used later in this part of the book.

In addition to introducing the debt verification pillar, the project finance definitions prompt the understanding some fundamental and important terms in project finance. I begin with a definition of project from a book written by J.D. Finnerty back in 2007. This first definition is sometimes used in HBS case studies and includes a few terms that I further define after quoting the definition:

*Definition One: ... the raising of funds on a limited or **nonrecourse** basis to finance and economically **separable capital investment** project in which the providers of the funds look primarily to the **cash flow** from the project as the source of funds to **service their loans** and provide the return of and return on their equity invested in the project.²*

The first term in this first definition highlighted in the definition is the term **nonrecourse debt**. In the context of debt, the notion of nonrecourse is analogous to the lack of ability achieve guarantees from your parents where you cannot send an email to them and ask for money. Getting money from your parents is a parent guarantee is recourse, which is the opposite of nonrecourse. The second term highlighted in the definition is **separable capital investment**. The idea of a separable investment means that an asset has separate financial statements and can have different investors and can pay debt service and dividends to alternative investors. The separable investment can be called a special purpose vehicle, which is simply a corporation set-up to own the asset. This separability allows bank financing specifically associated with the project cash flow. The third term I highlighted are the two words **cash flow**. By including the notion of cash flow in the project finance definition (contrasted to earnings that are affected by depreciation, impairment charges other accounting adjustments), Finnerty's definition emphasizes the way cash flow drives valuation (with IRR) and credit analysis (with DSCR) in project finance. The fourth item highlighted is **servicing loans**. Servicing debt introduces the notion that in project finance, the debt service – the outflow for interest and repayment – is directly related to the total cash flow collected by the project.

I list a few additional project finance definitions below, each one of which emphasize the debt aspects of project finance. As with the above definition, I use these definitions to introduce a few more terms central to project finance. I note that all the definitions, including the definition above, miss the pillars of project finance related to

² Finnerty, J.D. Project Finance: Asset Based Financial Engineering. Wiley, 2007, Second Edition.

encouraging efficient construction and operation using contracts; they miss the essential point of achieving low prices for consumers through bidding; and they miss the point of the ability of public policy to manage externalities.

*Definition Two: Project financing is a loan structure that **relies primarily on the project's cash flow** for repayment, with the project's assets, rights, and interests held as **secondary collateral**.*³

*Definition Three: ... financing of a particular economic unit in which a lender is satisfied to look initially to the cash flow and earnings of that project economic unit as the **source of funds** from which a loan will be repaid and to the assets of the economic unit as collateral for the loan.*⁴

*Definition Four: Project finance involves the creation of a **legally independent project company** financed with nonrecourse debt (and equity from one or more corporate entities known as **sponsoring firms**) for the purpose of financing investment in a single purpose capital asset, usually with a **limited life**.*

*Definition Five: Project finance is used to refer to a non-recourse or **limited recourse** debt financing structure in which debt, equity and **credit enhancements** are combined for the construction and operation or **refinancing** of a particular facility in a capital-intensive industry.*

Terms of in these definitions that assist in better understanding project finance include:

- The term “**loan structure that relies on cash flow**” implies a loan structure where the debt service mimics projected cash flow and implies something called debt sculpting which is a system of debt repayment where the total debt service is directly tied to the expected cash flow patterns of the project.
- The term “**secondary collateral**” in definition two and three is the value of a project that can potentially be realised through sale of the asset. I highlight this term because the concept is not important in project finance. It conflicts with the central idea that the value and the risk analysis of a project comes directly from cash flow.
- The term “**sources of funds**” points to the idea of cash flow and that the essence of evaluating project finance are two cash flow statements. The first is the sources of cash flow that are raised for constructing the assets before the project begins generating revenue. The second, often called a cash flow waterfall, is the cash flow returned to investors after operation starts.

³ Investopedia, definition of project finance

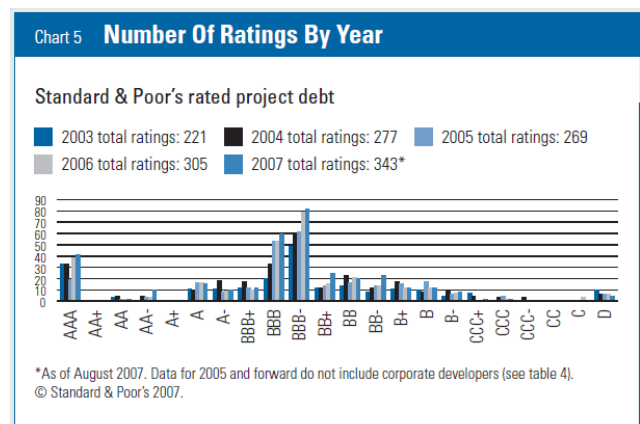
⁴ Nevitt, P.K. and Fabozzi F, Euromoney, Project Financing, 7th Edition, London

- The term “**legally independent project company**” can also be called the special purpose company or the special purpose vehicle. This company can have different investors; it is the company that repays debt; and it is the company that signs contracts with other parties.
- The term “**sponsoring firms**” refers to stockholders or equity investors in a project. While there are often millions of investors in a public corporation; in project finance there are just a couple of partners who own the special purpose vehicle.
- The term “**limited life**” in project finance means what it says, but it is important in understanding project finance because cash flow analysis can be made over the entire life of a project. The amount of time between the end of the limited life and the end of debt term is called the tail.
- The term “**credit enhancements**” in the last definition refers to mechanisms that protect lenders through limiting dividends with various types of covenants. These credit enhancements include covenants that do not allow dividends when ratios fall below a certain level; covenants to repay debt early instead of paying dividends (cash flow sweeps); and cash held on the balance sheet to provide cash in emergency situations.
- The term “**refinancing**” refers to re-paying existing debt (generally before the end of the term of the debt) and replacing the existing debt with new debt that has better terms.

While these definitions include important aspects of project finance debt, the more nuanced and important point about project finance debt is that cash flow risks evaluated by bankers define the risk of a project. In other financing structures such as corporate finance, the risk of a company is

supposedly determined apart from the debt (unlevered beta and WACC), and the debt is adjusted to increase or decrease the risk of equity after enterprise value is computed. Similarly, the classic method for computing bond ratings is to begin with business risk and then, after the business risk is assessed, to interpose the amount of debt to evaluate a bond rating. In project finance the process is the opposite. You start with the size and

structure of debt to roughly target BBB or BBB- bonds or equivalent bank scoring (barley investment grade). This means that the debt size is established from cash flow risk and that projects with less debt have more operating risk and projects with higher debt have less operating risk. Somebody asked me whether wind projects, battery projects or solar projects have more risk. I suggest that you can find out about the risks of projects as a function of which project has a more aggressive debt structure (higher debt to capital; lower DSCR; longer tenor).



Essence of Investing with a Project Finance Framework - Stamp of Approval by Lender Defines Whether the Investment will be Made

The pillar of project finance that involves having an independent institution – the bank – assess the risks and make the vast majority of investment in the project (for example 80% of the cost of the project). Rather than explain this pillar with technical definitions, I suggest an imaginary presentation on the costs and benefits of an investment with a long life. Consider an investment committee assessing the investment with one person makes a beautiful power point presentation to the board of directors on the construction of a large investment in a new battery giga factory. The presentation by this person includes very beautiful and professional slides. It includes discussion of the risks of the project, estimation of WACC, innovations in project efficiency and how the project will be built and operated. The adjacent picture represents this presentation, and it may be representative of an investment decision if there was no project finance.



I then ask people to imagine a second presentation of the same project. In this case there is no power point slide presentation. The presenter arrived late to the board meeting due to a prior meeting with a major bank that had funded similar projects and has experience in the risks of the type of project that are better than the equity investors. All she has is a piece of paper with a signature from the banker that the bank will finance the project and invest 80% of the capital expenditure of the project. The presenter also has other commitments with others such as a constructor regarding who will accept some of the risks of the project. The second picture is supposed to represent this rather silly and hypothetical example.



At the end of a course after we had worked through many nuanced, technical and legal issues associated with project finance, we sat around a table and pondered the benefits of project finance. Some insisted the big reason for using project finance is to keep debt off of the balance sheet of a corporation. I suggest that this is not very important compared to the fact that an entity that does not have upside in the project has done a lot of analysis with their own data and put an incredible stamp of approval on your project. This stamp of approval is particularly meaningful because it is not a consulting firm that does not experience big negative consequences for being wrong. This valuable stamp of approval comes about by putting in their own money into the investment.

Nonrecourse is A Whole Lot More than Just a Provision of Loan Agreements

I used to think about a nonrecourse loan as simply a kind of debt where the lender's risk is high, since repayment depends only on cash flow from one project and does not have added assurance from a parent guarantee that gives the bank many other sources of cash flow. Nonrecourse debt contrasts with normal corporate loans that can access cash flow and re-financing potential from an entire corporation, while a nonrecourse loan can only get money from the separately structured corporation (the SPV). You could go further and sound really sophisticated by discussing limited recourse debt which has some partial guarantees. As a side note, non-recourse can be an advantage when a company when the parent company implodes. The example of ENRON illustrates the point. ENRON could not pay its corporate debt, but SPV's could be working fine.

As with the definition of project finance which miss the essence of what it is all about, diagrams of nonrecourse debt can miss the essence of what project it is all about in terms of assessing an investment. When thinking about recourse as support from your



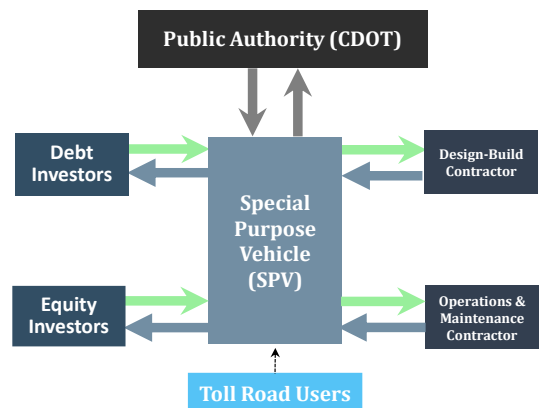
parents, you can think about a scenario where your parents are rich and nice to you. On the other hand, you may have a parent who is absent from your life. If you have run out of money temporarily, the nice parent could respond to your WhatsApp message and send you money. This is recourse from parent support. If you are nonrecourse, you cannot send such a message, and your parents will not support you. The example of parental support (a term used in project finance) makes you understand that the real import of nonrecourse financing is that a project must be able to be viable on a standalone basis, as nonrecourse from your parents mean that you must be able to support yourself on an independent basis. Now think about how wonderful this is for investment assessment. Not only do you have a third party assessing the viability of a long-term investment; this assessment of is made on a pure basis where the risks and the economic viability are directly evaluated without the effect of other investments. Without the debt being nonrecourse, the imaginary example of two people making presentations above would not have the same outcome, where the second presentation with the note from the bank was so powerful. The investment would be back to the power point slides, with estimates of beta, WACC and classic corporate finance criteria.

Pillar 3: Use of Contracts that Include Incentives to Accept Controllable Risks to Allow Long-term Financing of Crucial Infrastructure Projects

Some kind of contract structure is almost universal in project finance, although project finance such as merchant electric power and resource project finance can be applied without revenue contracts (long-term investments in merchant power and resource are supported by assumed mean reversion in commodity prices). Contracts between the SPV and government agencies or other private companies create stable cash flow, mitigating the risk of technological obsolescence (if land lines become obsolete, a government contract can assure that cash flow continues). It is possible to structure an investment with a lot of contracts that impose targeted risks on investor without project finance debt, meaning that some kinds of contracts are necessary for project finance, but contracts do not mean investments will be project financed. Just as important as providing stable cash flow that is necessary for financing long-term investments, contracts with private parties can be used to explicitly impose targeted risks on companies to provide private companies with an incentive to construct and operate projects in efficient manner.

Putting all of the pillars together – bidding, financing and, finally, contract structuring -- is what makes project finance a unique and potentially effective tool of economic policy. The history of project finance (discussed in more detail in Chapter 26) was in large part due to coming up with a way to incentivise private investors by accepting construction cost risk, construction delay risk, plant performance risk, operating cost and other risks. Only by taking risk and incurring a downside will there be a desire to assure bad things should not happen (this is pillar number 3). In order to be able to provide these incentives, and at the same time encourage competitive bidding, many projects can be created from relatively small companies and with different kind of partnership structures. These companies with partnership structures and with the need to attract a lot of debt funding needed to be separable companies. The separable company, an SPV, has the ability to sign different contracts to further impose risks on parties that are qualified to take the risks such as Engineering, Procurement and Construction (EPC) companies. This separability the investment could in turn lead to financing of the projects.

As with other subjects, when you work on a project finance transaction you can get lost in various details and miss the big picture of what you are trying to accomplish. A prominent example of this is getting mired in the language and the details of the contracts. You can work carefully on a formula in the contracts or assure that the language of the contracts addresses details that are quite unlikely; but could potentially become an issue. My idea in this introductory chapter is that you understand the general objectives of contracts which is to provide incentives to private companies to be efficient as well as to assure stable cash flow. The contract provisions should not be structured where risks that cannot be controlled by the private companies. Such risks do nothing other than increase the cost of capital without encouraging efficient behaviour. Examples of such contract provisions that cannot be controlled and do nothing for



prompting efficient management are imposing the risk of oil price changes; inflation rate variation; uncontrollable output such as traffic; and exchange rate fluctuations on the private investor. More nuanced case can impose some risk on a project where there is some control but a lot of factors out of the control of the private company.

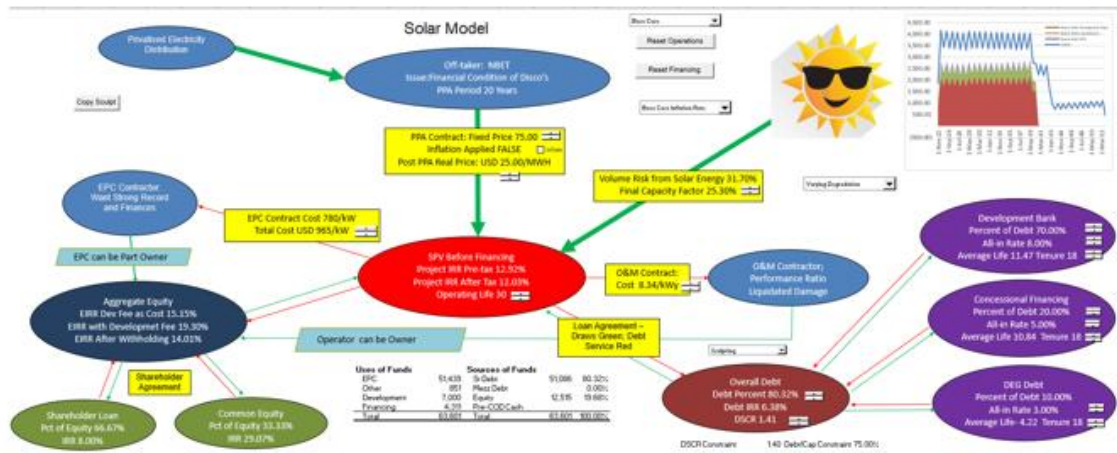
It is common in project finance to illustrate the relationship of different parties who sign contracts with the SPV using a diagram. My eyes used glaze over when I looked at project financing diagrams as I did not see what the diagrams added to the analysis of a project finance investment. An example of a useless diagram is shown in the adjacent picture⁵. This picture does not tell you anything other than that there is an SPV and a government agency named CDOT (the California Department of Transportation). We do not know if there is a minimum toll traffic, how the risks of re-surfacing expenditures will be dealt with, if there are penalties and bonuses from performing maintenance more efficiently, if there are increases in toll rates when the construction materials increase, who are the sponsors to the project, and what are some key aspects of the debt financing. Further the arrows do not represent money where you could follow the cash flow, but some undefined relationship between service provided and payment for the service. In this picture, you do not see the risks, you do not see the returns of different parties.

I now have a completely different (better) attitude to the diagrams. If the diagrams are effective, they can demonstrate the flow of cash, which should always start with how the project will generate revenues. If there is no revenue the project cannot exist; the risks of how revenue is received is often the most important risk. More often than not, if the revenue does not have some kind of security through the price with a reputable contractor, or if the revenue does not have a long-term history as a necessary commodity, it will be difficult to finance the project. As you move through the cash flow, the diagram can demonstrate how various risks can be mitigated with contracts. Contracts shown on the diagram can be designed with different risks and incentives for capital expenditures (EPC), operation and maintenance (O&M) contracts and other items that ultimately transfers risk away from lenders and equity investors. The diagram should demonstrate the contract itself (perhaps with comments) and the parties to the contract (again perhaps with comments), one of which is the SPV. The lack of ability of a contractor to fulfil the contract can become the most important risk in a project finance transaction.

The diagram below is illustration of a transaction that is part of a project finance model. The diagram shows the flow of cash (the green arrows) where the quantity produced comes from the sun with not contract. The price comes from a contract with a government agency in Nigeria (the contracts are in the yellow boxes) that in turn receives revenues from electricity distribution companies that have poor financial conditions. The EPC and O&M contracts and off-takers are illustrated in a similar way. The SPV oval shown with the project IRR can be used to evaluate the reasonableness of the price contract. Finally, the funding from debt and equity is illustrated with the key financial ratios – the

⁵ This diagram comes from a presentation by Wall Street Prep.

equity IRR and the DSCR. The diagram also shows the expected cash flow relative to the debt service. This means the diagram should demonstrate the ability of the contractor to meet the terms of the contract. In the diagram below, the important contracts; how the contracts interact, what are the risks, who takes the risks.



While the contracts can provide incentives and reduce risk for the SPV and debt and equity investors (pillar number 3), the contracts can be expensive. Worse yet the transfer of risk can include country risk premia that do not make sense (if you are buying solar panels from China, and using local labour to install them, why do you need a big markup on an EPC contract). The diagram should also include comments (maybe written with a pen) of whether the contracts are sustainable (for example if the prices are reasonable) and whether the counterparties to the contracts will be around.

If you are old enough, think about twenty years ago when you would return phone calls after receiving voice mails on your land line phone and taking pictures using your Kodak camera. Going back in time would understandably make you feel queasy about investing in a single project that requires you to realize stable cash flow for three decades or more. With hindsight you should not have made investments in things that can become obsolete or do not have some kind of assurance that they will remain economically viable. The example is meant to make you think about what kind of projects can qualify for debt that has a tenure of more than twenty years and requires equity investors to wait a long time before receiving their cash returns. The kind of investments that are qualify for project finance are by definition low risk and boring (the term in project finance is more elegant and known as proven technology). At a fundamental level, project financed investments require some kind of way that long-term cash flow can be reasonably projected (collateral mentioned in the above definitions all comes from the value of the cash flow). Obtaining assurance that cash flow forecasts for long-term investments can be made may be derived from using contracts; locking in forward prices; or estimation of time series that do not depend on things like fashion, obsolescence risk or unstable prices.

Pillar 4: Consideration of Items in Project that Are Not Measured by Private Investor Return or Risk Assessment by Lender

In Chapter 3, two investments were considered where the impacts on society are minor compared to the effects on society as a whole, Christopher Columbus' voyage and NVIDIA. In the case of Christopher Columbus, the money earned by the Italian lenders for funding the project was tiny compared to the negative and positive influences of the voyage ranging from genocide of Indians to beginning the age of discovery and the Spanish Empire. For the investment in chips that allow very fast calculations by NVIDIA, the gains in value realized by some lucky investors are dwarfed by the potential positive and negative effects of artificial intelligence. When highways are constructed to allow easier transportation from city centres to outlying suburbs are built, the effect on the quality of life in different regions is probably a lot more than the cost of building the highway.

Encouragement of projects that have positive effects over and above the private investor return can be accomplished by regulations such as only allowing new electricity investments to be powered by renewable energy. Alternatively, the project can be



assessed with something called an economic IRR ("EIRR"). Quantification of the external benefits that are not measured in the return to private investors (this return can be called the financial IRR or the FIRR). The economic IRR includes the externality effects of a project which are often related to the environment and other items such as the effect on the quality of employment or the promotion of related activity. Rather than thinking about really big investments, I think about externalities of things like going to the dentist, where if you do not allow your teeth to fall out may be not only nicer for you, but for your

friends and family. In my apartment complex, the people who manage the area invested in a bunch of very loud leaf blowers that run on petrol. When making the investment in these horrible things, if they counted the value of disagreeable noise, I think the EIRR would be negative. Other examples of external benefits could be planting some trees to hide a parking lot.

When discussing the EIRR it is common that people will scoff at the statistic as there can be a lot of judgement in computing the number. In a way this use of judgement is a demonstration how lenders verify cash flow allowing objective return statistics. For example, in my case of the loud leaf blower, it would be difficult to quantify the cost to different people in an apartment complex of being irritated by the noise. Finally, if a project has positive externalities that pushes the IRR to 4% with a government grant, would have to come up with some basis how can you judge the adequacy of this return. If the real 4%

return is above the expected growth rate of the economy and the 4% allows a better quality of life, it may be a perfectly adequate return.

I learned about computing the EIRR in an actual case. I was working on a project to bring electricity to villages in Mozambique through the use of solar power plus batteries. The project required funding by a quasi-governmental agency to support the capital expenditures because the financial IRR was below the required return of an investor. To quantify the environmental effects of the renewable energy, we measured the value of the reduced emissions in the EIRR and put a price on them. To measure the effects of having electricity to promote irrigation and other uses, we evaluated the price that people and businesses are willing to pay for electricity when the electricity is not available, called the shadow price. This price that people are willing to pay could be derived from the amount people in Nigeria pay for electricity outages by having a back-up generator and the associated fuel.

Aspects of Project Finance Other than the Four Pillars and the Essence of Project Finance

The list of pillars introduced in this chapter in no way covers all of the characteristics and the objectives of project finance. Subjects that are addressed in subsequent chapters include a detailed contrast between project finance and corporate finance; the use of IRR for evaluating value and the use of DSCR to quantify risk; assessing changes in the value of a project over its life; upsides in project finance from re-financing and selling a portion or all of a project; and, the manner in which cash flows require mean reversion and/or contracts. A particularly interesting subject is changes in risk and value over the life of a project. This involves going through stages where a project begins from something like a venture capital investment; then to a financeable investment with risks that can be handled by a lender; and finally, to a boring investment which looks more like debt than the equity of a typical corporation.

I have tried to come think about an alternative definition It is not easy to derive a nuanced definition of project financing that incorporates the key pillars, but here is my try:

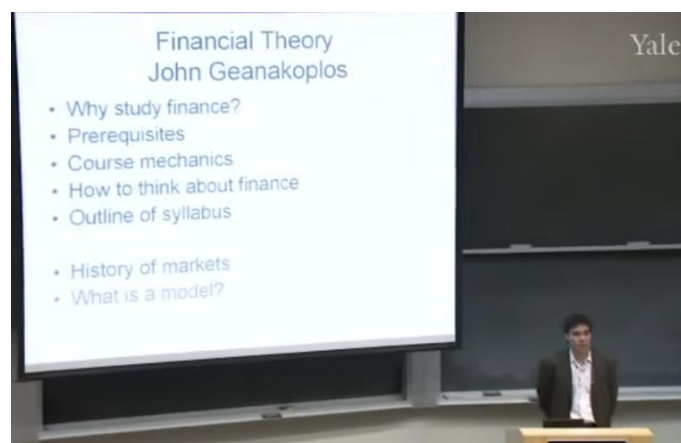
... raising money from a bank and/or an investor for a capital investment where you can prove (through nonrecourse loans and equity cash flow evaluation) that the project is economic on a stand-alone basis and where debt and equity is structured corresponding to the risks, the timing and the pattern of cash flows from the project. Long-term financing is achieved through demonstrating mean reversion in cash flow and/or use of long-term contracts that allow cash flow to meet debt service, incentivise private entities to construct and operate the project efficiently; and provide a reasonable growth rate (IRR) in cash flow to investors and in a low cost for consumers.

Chapter 3 - Philosophical Issues: Cost of Delaying Gratification, Assessing and Compounding Risk

Why is the Study of Finance and Valuation Important in the World and What is the Definition of an Investment

After introducing general problems with finance, this chapter moves to underlying issues involving measuring return on investment and the associated risks. The idea is to prompt you to think about questions of how to evaluate investment decisions, the time value of money and required returns for taking risk. Using fundamental definitions of finance, investments and return along with a very simple economy you can think about what ultimately drives risk-free interest rates, methods for making forecasts and measurement of the risk premium for an investment. By structuring a crazy example of an island without money, stock markets, reserve banks, balance of payments or statistical analysis my hope is that you will ponder questions like whether a real risk free rate much above zero makes sense; whether compensation for taking risk should increase a lot over time and the magnitude of a risk premium that should be added because benefits from an investment are uncertain. In the next chapter we move to evaluating these questions with data from the stock market and economic statistics.

If you have taken a course in corporate finance, investments, banking, financial management, options or something else, it is likely that you will not begin with the question of what is at the heart of any question in finance or what defines the subject of finance. If you ask a high paid investment banker what the definition of finance is, you will probably hear some fast-talking technical jargon like that discussed at the end of the last chapter. When I ask the question to young students, and I get vague answers that finance is about making a lot of money. I watched a video by a Yale professor named John Geanakoplos⁶ give his first lecture in finance to undergraduate students. He spent the session essentially bragging



⁶ Part of American Finance Association. Video is at <https://youtu.be/vTs2lQ8OefQ>

about how his hedge funds earned a lot of money and did not discuss any foundational issues of forecasting and cash flow. Before delving into details of the many different subjects in this book, taking a step backwards and thinking about what is really at the heart of finance will be helpful in thinking more deeply about why finance techniques make sense.

To answer the question about what finance is, I began by wondering how other people define it and how the subject of finance compares to other subjects. I did a little search on the internet to see what others suggest being the definition of finance. I also compared the definition of finance to the definition of some other more traditional subjects. Definitions of physics, chemistry, and economics you find pretty clear definitions (even for economics):

Physics: “the branch of science concerned with the nature and properties of matter and energy. The subject matter of physics includes mechanics, heat, light and other radiation, sound, electricity, magnetism, and the structure of atoms.”

Chemistry: “the branch of science that studies the composition, structure, properties, and behaviour of matter. It explores how substances (elements and compounds) are formed, interact, and undergo transformations during chemical reactions, including the energy changes involved.”

Economics: “Economics is the social science that studies how individuals, businesses, governments, and societies allocate scarce resources. It focuses on the production, distribution, and consumption of goods and services, analysing how choices are made under conditions of scarcity. The field is divided into microeconomics (individual/firm behaviour) and macroeconomics (economy-wide trends).”

Moving to the definition of finance, the first definition of finance that comes up from a google search suggests that finance is both an art and a science:

Finance: “Finance is the art and science of managing money, encompassing the processes of raising, investing, borrowing, budgeting, and forecasting funds for individuals, businesses, and governments. It involves allocating financial resources to achieve specific goals while managing risk and studying financial assets, liabilities, and, importantly, the time value of money.”⁷

The suggestion that finance is either an art or science should make you either laugh, cry or vomit. But if you think about all of the activities mentioned in the art and science definition of finance above – raising money, investing, borrowing, budgeting -- they involve making some kind of cost and benefit analysis. The cost and benefit analysis in turn

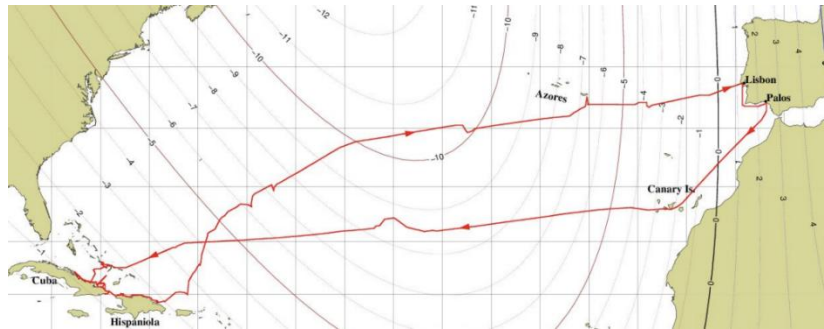
⁷ This is an AI summary of finance that comes from the Corporate Finance Institute.
<https://corporatefinanceinstitute.com/resources/wealth-management/what-is-finance-definition>

requires some kind of forecasting while also accounting for risk that the forecasts can be wrong and the time value of money. When cost of capital is computed from CAPM; when a project financed investment is assessed with IRR and the debt service coverage ratio (“DSCR”); when a stock price is assessed with a P/E ratio; when the value of debt is assessed with a credit spread and just about any other issue related to money, finance boils down to assessing the value of an investment relative to its cost. The problem with any of the cost and benefit analysis is that the benefit is uncertain and must be evaluated with some kind of risk assessment. For purposes of thinking about the subjects in this book, finance involves evaluating risk, making forecasts and assessing the results of investment decision forecasting. The subjects in finance boil down to assessing the cost and benefits of making an investment and assessing the performance of the investment, where an investment involves some kind of initial cost with uncertain future benefits. If the benefits exceed the cost, value is created. If the benefits are less than the costs, value is destroyed.

An alternative definition of finance that I use can be boiled down to measurement of the rate of return as a metric to measure the cost and benefit of making an investment. Rate of return can be measured in different ways depending on whether you are making an investment, assessing the performance of an existing investment, considering effects of an investment on society or comparing different investments. At this point do not worry about the return is measured with return on invested capital (“ROIC”), return on equity (“ROE”), internal rate of return (“IRR”), price to book ratio (“P/B”) or an NPV cost and benefit ratio. Each of the return measures include some kind of periodic or accumulated income or cash inflow relative to the outflow for an investment. In the case of IRR, the measure of the rate of return includes an estimate of future cash flow over a future period compared to cash flow made for investing in the project. For valuing an investment and assessing the performance of an investment, the return is gauged against some kind of benchmark return.

What is an Investment, Christopher Columbus, NVIDIA and Going to the Dentist

I doubt that many finance classes start with the question of assessing Christopher Columbus' effort to secure financing the investment in his first attempted trip to Asia as one of the most important investment decisions in history. But thinking about the risks associated with Columbus' investment risks - the forecast of the distance to Asia being wrong, shipwrecks, mutiny of staff, never finding anything, not being able to return if he did find something. These risks were accepted by a financing structure that has analogies to modern project finance. Columbus had incentives to seek gold and spices to pay back the private investors (his percentage of profit was 10% analogous to bonuses paid to managers in private equity.) Financing of the investment was a public/private partnership with private entities (from a consortium of Genoese and Florentine bankers in Seville) and public parties (Queen Isabela and King Ferdinand of Spain).⁸ As in modern transactions there were incentives provided to sailors – the Spanish Crown promised a lifetime pension to the first person to spot land (which Columbus unfairly attributed to himself).



The financing structure was developed after a road show that failed with other investors. Columbus had earlier approached King John II of Portugal, but the investment proposal was rejected in part because a committee (you can call this an investment committee) concluded that Columbus's calculations of the diameter of the earth were incorrect leading to a forecast of the voyage length that was absurdly optimistic. The estimated distance from Portugal to Asia was the primary forecast model associated with the investment in Columbus' voyage. Using the well-known idea at the time that the earth was round, Columbus projected a distance of about 5,000 km to get from Palos in southwest Spain to India via the Atlantic Ocean. His forecast was way off as the true distance to India from Palos is actually about 20,000 km which would have rendered the voyage impossible without a land mass between. From the perspective of Columbus and his private investors, the risks of the forecast being wrong and the cost of the investment probably far outweighed potential benefits.

Ultimately, the return on investment to Columbus and the private investors was tiny compared to the external costs and benefits of the voyage. For Queen Isabela and King Ferdinand, the risk and return profile was different than for Columbus and the private

⁸ Andrew Mach Contributor, "Christopher Columbus: Five things you thought you knew about the explorer." Oct. 10, 2011, 2:10 p.m. ET. Christian Science Monitor.

investors. From the perspective of the king and the queen, the possibility of finding a new route to Asia, that would allow trading to secure spices and other goods, outweighed the probability of finding nothing even if there was a big probability of failure. This makes you think about the effects on society of an investment and how investment policy with societal impacts can be much more than the effects on the investors themselves. The total investment in the voyage is estimated to be roughly \$1 million to \$3 million in current USD which is miniscule compared to the real impacts of the voyage.⁹

In project finance (the subject of Part IV), analysts try to measure the effects on the overall society of an investment as well as the rate of return to private investors. The return to private investors is measured with the internal rate of return (“IRR”) which vaguely measures the growth rate in cash flow (this is discussed in detail in later chapters). An alternative IRR measured from cash flow to investors can be computed that incorporates the societal costs and benefits as well as the private cash flow. This cost and benefit statistic is called the economic IRR. You could think about computing the economic IRR of Columbus’ voyage, but I think it would be almost impossible to get your head around the societal costs and benefits and even make a vague estimate. Benefits could include starting the "Age of Discovery," providing massive wealth and new commodities for Europe; introducing crops like the potato and maize to the old world; allowing Spain to become a global superpower. On the other hand, the societal costs were devastating – genocide of indigenous peoples killing many millions; initiation of the transatlantic slave trade; the brutality and extreme violence of the conquistadors; the ecological impact of invasive species and livestock that permanently altered the American ecosystem.

Maybe we should think about an investment that is a bit more modern than the Santa María, the Pinta, and the Niña (the Santa María did not make it back). Before moving to discussion of fundamental forecast methods and evaluation of the costs and benefits of investment decisions, I consider another investment -- the series of development investments made by NVIDIA in powerful computer chips and software that eventually allowed the development of artificial intelligence.¹⁰ The reason I choose the NVIDIA story as a second investment case, is the way the company continued pushing ahead with an idea to massively increase computation speed that took a more than a decade to produce large benefits.



NVIDIA was formed from the three people shown in the adjacent picture in 1993 (before iPhones (2007); WIFI was used extensively (2000); the cloud (2006); and

⁹ Bayard Johnson, “Who Could Possibly Be in Favor of Columbus Day?”, ICT is IndiJ Public Media, October 12, 2015

¹⁰ Nvidia's Explosive Rise from Zero to Trillions (Documentary), https://www.youtube.com/watch?v=1QC9X_QW52k&t=1192s

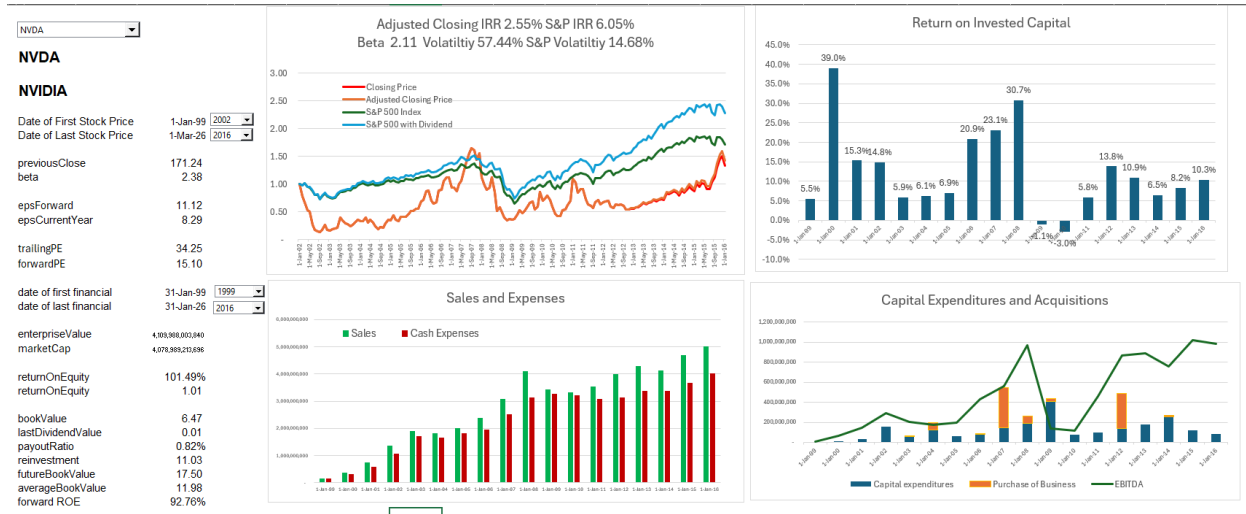
YouTube(2005)). Jensen Huang who was born in Taiwan left his job at Sun Microsystems with his two partners to develop a company that would make computer chips. The company began to focus on chips that increased the speed of calculations for early computer gaming. While NVIDIA famously almost failed after manufacturing a flawed chip – the company had 30 days of remaining cash -- it became successful in chips for the computer gaming sphere and became public in 1999. In 2006 NVIDIA began to develop something called Compute Unified Device Architecture (“CUDA”).¹¹ This combination of hardware and software improved the calculation speed of computer chips by 50 times and arguably eventually enabled the development of AI.¹² If we measure when NVIDIA’s investment in CUDA began really paying off as when GPT began at the end of 2022, the investment took sixteen years to develop. During the time NVIDIA’s investments to increase calculation processing speed began development in 2006, the company did not perform very well from a financial perspective. The accounting rate of return was not very good – the ROIC’s were either negative or around 10% during the eight years from 2009 to 2016 (see the accompanying charts that are part of a program that is free to use and that I developed for this book)¹³. It is difficult to imagine many large corporations worried about earnings guidance and presenting return statistics to investors accepting this kind of very long gestation for an investment. It is more likely that companies would want to focus on

¹¹ According to Google Gemini: “NVIDIA's CUDA is a parallel computing platform and programming model allows the use Graphic Processing Units (“GPU’s”) to be used for general-purpose computing. This software ecosystem enables harnessing GPU power to build AI models.

¹² According to Gemini, “AI systems, particularly large language models like ChatGPT, require enormous computing power. NVIDIA GPUs are designed for parallel processing, making them uniquely suited to handle these complex computations far faster than traditional CPUs.

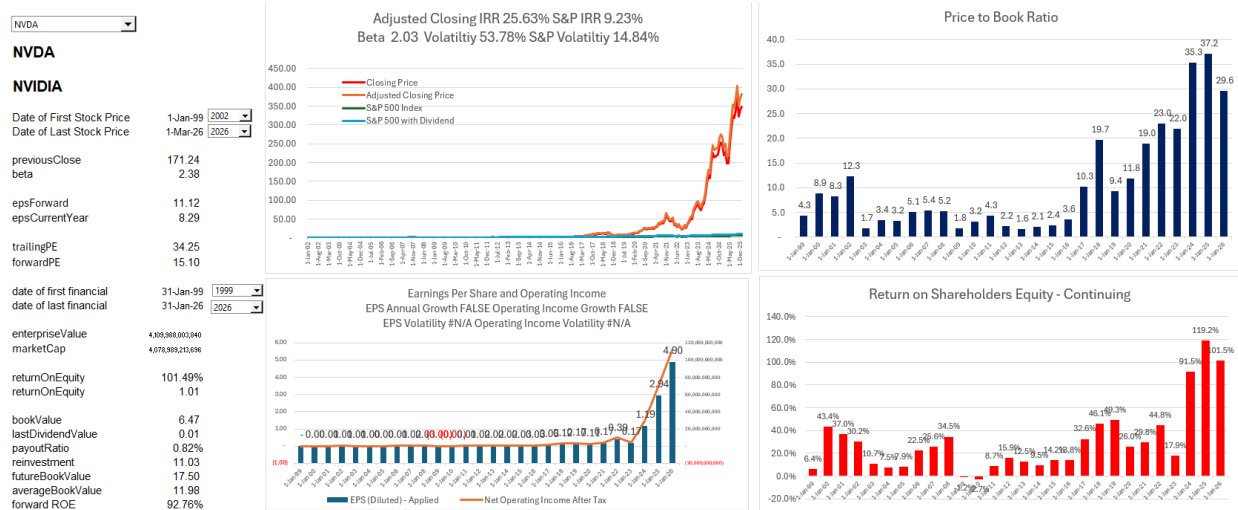
¹³ You can find information on how to scrape data using Python and VBA to make these kind of charts for any public company at www.edbodmer.com.

their core business and ask managers to focus products that could increase current EPS and ROIC per the ideas of Jack Welch.



Once the value of NVIDIA’s chips was finally recognized, the returns and value took off as shown in a second excerpt below (again from the program that retrieves financial data.) The two excerpts demonstrate that short-term ROE or ROIC do not predict the ultimate value of investments and it may be better to develop ideas with a long payout. The excerpt below shows that the ultimate compound annual return you would have earned if you invested at the date of the IPO in 1999, re-invested any dividends you received back in NVIDIA stock and then sold the stock in 2026 would have been 26%, which doesn’t seem

spectacular. I hope the case makes you think about evaluating risks and returns back in 2006 when the development of the process to increase calculation speed began.



Perhaps the most interesting analogy between Columbus’ voyage and the development of CUDA by NVIDIA is the subject of external costs and benefits related to the investment. Personally, I have no idea whether AI is an overly hyped marketing phenomena or whether it will dramatically help the well-being of humans. Some assert that tech industry leaders aren’t asking enough about the ultimate effects of AI. Suggestions have been made that (1) AI itself poses risk to the future of humanity if it gets out of control, and (2) the AI can be dangerous when manipulated by people with bad intent.¹⁴ It is very far outside the scope of this book to suggest some kind of AI regulation; but considering external effects of investment that are not directly measured by financial IRR can be an important issue in assessing the cost and benefits of an investment.

You can think about the costs and benefits of many other investment decisions which are not as dramatic as Columbus’ first voyage or NVIDIA’s investment in CUDA. These could include going to the dentist, taking a jog in the morning, buying a stock, gambling or taking time to read this book. Other investment decisions include the incursions by Hitler and Napoleon into Russia, the Manhattan project or the decision by U.S. cities to remove street cars at the behest of GM and Ford. Each of these decisions involves a cost (whether measured directly in monetary terms or in time or in territory) and each decision has an uncertain benefit in the future. For any of these decisions you can

¹⁴ “‘Godfather of AI’ says tech companies aren’t concerned with the AI endgame. They’re focused on short-term profits instead”, Sasha Rogelberg, Fortune Magazine, March 21, 2026.

compute a private or societal rate of return that is measured by the benefits relative to the cost.

The fundamental definition of any investment decision which is at the heart of finance involves deciding whether to spend something now when you do not know exactly what you will receive in the future. You can think of a company as making a continual series of small and large investment decisions ranging from purchasing inventory to building a factory. Each investment decision whether for advertising, investing in new employees or making a major acquisition is supported by some sort of implicit or explicit forecast of the future and affects the value of the company. Turning to investment decisions made in your personal life, I once thought that the stress, costs and difficulties of having a child was a horrible investment. That changed when I had grandchildren and I realized that sometimes you have to wait a long time for an investment to pay off. Later-on in this chapter and more in subsequent chapters I demonstrate how long-term investments are penalised using many of the conventional financial analysis techniques. In the meantime we can turn to more specific issues in measuring returns and different ways to think about incorporating risks of investments in the analysis.

Robinson Crusoe and Finance – Measuring Costs and Benefits of an Investment Decision in a Simple Economy

To think about finance issues and in particular the acceptable returns to compensate for risks, I have made some ridiculous simplifications. In the paragraphs



below I contemplate financial analysis of an investment decision in a very simple economy with no money, no financial markets and no corporations. The idea is to think about how you would evaluate risk and the time value when assessing future benefits of an investment; to think about whether risk premiums should be compounded over time; and to think about the level of risk

premium given a probability distribution of outcomes. These fundamental questions underlie major questions in finance including measuring the cost of capital and evaluating risks of investment decisions.

Pretend that you are stranded on an island like Robinson Crusoe. But unlike Robinson, assume that you are with your family on an island near Malaysia. Your family likes to spend time together and to relax while looking at the nice scenery on the island (i.e., you want leisure time). But every day you have to look for food and to find wood to make a fire. To get more leisure time in the future and spend more time relaxing with your family, you can make various different investments. These investments can be measured in forgone leisure time in the near future in order to get more leisure time in the future. Maybe you could construct a bath from a barrel you found on the beach or a make a little farm that can make strawberries and other fruits and vegetables.



I have wasted too much time imagining the potential details of how investments could work and even thought about how you could make a contraption to hold warm water so you wouldn't have to collect so much wood (using solar power as an alternative of fossil fuel). Instead of thinking about specific investments, the I have created hypothetical investments where you spend current leisure time in the near term which can potentially save time later on. The benefits and costs of the investment are measured in the amount of time is saved and the entire economy of the island is measured in time (there is no inflation). The island is a bit like the country of Bhutan that I had the honour of visiting to teach a course, where the king measures happiness instead of classic GDP (I understand that there was an election to decide if people wanted a democracy that lost by 99%). On our island, there is no division into producers and consumers, the inventive is simply to make more leisure time for the family. I urge you to not start thinking about whether the economic structure of the island is socialistic or capitalistic; the idea is to focus on measuring costs and benefits of an investment decision.

The Time Value of Deferred Benefits and Risk-Free Rate

The first issue related to an investment in our little example is what is the value of delaying gratification which is the starting point of measuring the cost of capital and the real risk-free rate. In modern economies, when we compare future money with current money, we have to adjust the future money by how much purchasing power we will lose because the future money buys less stuff. This is inflation, and to compare the future money with current money we need to take inflation out of the calculation. For our island economy, inflation adjustments are not necessary as everything is measured in working time and leisure time. Assume that you make an investment of 175 hours in the next few weeks (5 hours per day times 7 days per week times 5 weeks), and you expect to save the same amount of time in the future . Further, assume that there is no risk at all associated with making this investment, meaning you are completely sure about the future savings,

and you are sure the investment will take exactly 175 hours. The question of whether you need more expected future leisure time savings than the time it takes to make the investment is the same as the question of whether the real risk-free rate is more than, less than or equal to zero.

I have wasted time considering this investment with a simple model shown in the adjacent table.¹⁵ If the investment pays off in one year and the risk-free rate is zero, then the future savings are the same as the amount of your investment. The risk-free rate of zero implies that there is no cost to you of delaying gratification from having more leisure hours in the future and less today. I don't know if delaying gratification has a cost as most economists would assume, and it is not difficult for me to imagine that there is no difference between having the leisure hours today or in one year. I did see the effects of delayed gratification when having a discussion with my grandson and his mother. When telling my grandson that if he can wait until tomorrow to get ice cream, he can have two ice creams instead of one, he strongly protested suggesting a preference for current consumption (he may also have been gauging whether the promise of ice cream tomorrow really was risk free). I hope I am not insulting anybody by suggesting the having a big preference for current consumption is essentially a childish idea and it is reasonable for adults to have little preference. This implies a real risk-free preference of something close to zero. If you explain to your family that you will have about the same increased leisure time in the future than the lost leisure time in the near term once you make your investment, and your family agrees, you could argue that the risk-free rate with no inflation is close to zero.

| Timing | | | |
|-------------------------|--------|----------|--------|
| Period | | 0 | 1 |
| Investment Period | 0 | TRUE | FALSE |
| Return Period | 1 | FALSE | TRUE |
| Operations | | | |
| Hours for Investment | 175.00 | 175.00 | - |
| Hours Saved | 175.00 | 175.00 | - |
| Net Hours | | (175.00) | 175.00 |
| Net Present Value at Rf | 0.00% | \$0.00 | |
| Return on Hours | 0.00% | | |

The closest way to evaluate the risk-free rate in markets without inflation is using Treasury Inflation-Protected Securities ("TIPS"). For these U.S. government bonds, the principal adjusts based on the Consumer Price Index ("CPI"). When inflation rises, the principal increases; if deflation occurs, the principal decreases. The yield on TIPSs is shown on the adjacent chart. TIPS yield is the "real" yield meaning for example, if a 5-year TIPS has a 1.2% yield and inflation averages 3% over that period, the nominal return is roughly 4.2% annually. If the yield is zero, then investors are willing to accept a return equal to the inflation rate and, consistent with the proposition that future delayed consumption is equal to current consumption.



¹⁵ This model is documented at <https://edbodmer.com/step-by-step-process-to-complete-exams/>

(The yield shown in the graph depends on actions of the federal reserve bank and interest rates on other bonds that do not adjust with the inflation rate).

General Philosophical Ideas About a Risk Premium in the Simple Economy

Perhaps the risk-free rate is very low, reflecting non-childish thinking about deferring gratification, but what if the investment has a probability of failure and is not risk free. To address this question, assume that our investment has a 50% chance of failure. Given this probability of failure, the amount of hours if you can successfully develop the investment should be at least double the amount of hours in the risk-free scenario if the investment is to make sense. With the 50% probability of success, you can compute the expected value of the saved leisure hours. Without a risk-free rate, the saved leisure hours in the success case must be double the 175 hours spent, or 350 hours. With a positive risk-free rate and preference for current hours, savings in a successful scenario should increase. The increased hours to meet the risk-free hurdle with a 1% IRR and with the NPV being equal to zero when a 1% discount used is shown in the adjacent table.

The difficult question about our investment is how to measure the effect of anxiety on our investment decision that has a 50% chance of failure, and which means that your family may require more saved hours than those implied by a 50-50 weighting for incurring

| Timing | [Driver] | [Sum] | | | |
|---|----------|--------|----------|--------|---|
| Period | | | 0 | 1 | |
| Investment Period | 0 | | TRUE | FALSE | F |
| Return Period | 1 | | FALSE | TRUE | F |
| Operations | | | | | |
| Hours for Investment | 175.00 | | 175.00 | - | |
| Hours Saved | 176.75 | 176.75 | - | 176.75 | |
| Net Hours | | | (175.00) | 176.75 | |
| Net Present Value at Rf | 1.00% | \$0.00 | | | |
| Return on Hours (IRR) | 1.00% | | | | |
| Expected Value - No Risk Premium - 50% Chance of Success | | | | | |
| Hours for Investment | 175.00 | | 175.00 | - | |
| Hours Saved - Successful Case | 353.50 | 353.50 | - | 353.50 | |
| Hours Saved - Failure Case | - | | - | - | |
| Expected Hours Saved | | | (175.00) | 176.75 | |
| Net Present Value at Rf | 1.00% | \$0.00 | | | |
| Return on Hours (IRR) | 1.00% | | | | |
| Expected Value - Risk Premium -- 7.00% | | | | | |
| Hours for Investment | 175.00 | | 175.00 | - | |
| Hours Saved - Good Case | 378.00 | 378.00 | - | 378.00 | |
| Hours Saved - Bad Case | - | | - | - | |
| Expected Hours Saved | | | (175.00) | 189.00 | |
| Net Present Value at Rf | 8.00% | \$0.00 | | | |
| Return on Hours (IRR) | 8.00% | | | | |
| Risk Premium in Hours/Year | 6.93% | | | | |

this anxiety.¹⁶ Finance implies that a risk premium to the received benefits (more required future leisure time) should be added to compensate for the uncertainty. This means the benefits must be more than twice as much as the expenditure for your family to be willing to accept being nervous about spending the time to construct your investment. I suggest that the idea of trying to put a number on risk is mysterious and cannot be boiled down to a formula. But when studying questions like this in finance, you are taught that you can put an objective number on the risk premium. You may learn about the standard deviation of returns as measuring risk,

a capital markets line that represents an efficient frontier, and the notion that you can develop different portfolios or risky and risk-free investments. This all leads to

¹⁶ When people gamble, they gain pleasure from taking risk that has a negative expected return.

quantification of the risk premium as the increased growth rate you need to earn on investments.

The idea of the risk premium is that stock markets have more variability than investing in a short-term government bond, and investors require compensation for being nervous about the possibility of losing money. It is difficult to make analogy between measuring the risk premium in the actual economy using these concepts and the way risk premium could be measured on our little island. Maybe there could be some kind of risk placed on each percentage of failure in an investment (more anxiety with a higher percentage of failure), and a general premium could be placed on risky investments with a benchmark of 50% chance of failure. This would be something like measuring an overall risk premium for stocks compared to risk-free bonds, the equity market risk premium (“EMRP”) and then applying a beta statistic that measures risks of individual risks relative to the market.

Maybe the risk premium for a project with a 50% chance of failure is 7% which is the overall equity premium used in the Petrozuata case introduced in Chapter 2 (this is completely arbitrary, but so is the 7% and other premia plopped out of somewhere by the writers of the HBS case to ultimately arrive at a risk premium of about 14%). To see how a risk premium works, begin with the risk-free case where a cost of delayed gratification is assumed. Because of the assumed risk-free rate driven by delayed gratification of 1%, the future savings to justify the investment must be 1% higher than the 175 hours spent or 176.75 hours of leisure time for a one-year investment. This is shown in the section of the table titled “Expected Value – No Risk Premium.” Because of the cost of the anxiety, the amount of hours generated from our investment must be higher than the 176.5 hours in the risk-free case. Now you need to have the amount of expected saved hours be 8% (7% plus 1%) above the invested hours, which is 189 hours (you can divide 189 by 175 and assure the growth rate in hours is 8% - this growth rate is the same as the IRR). The net present value (“NPV”) of the hours at discount rate of 8% -- $189/(1.08)$ -- is equal to the investment demonstrating that the IRR and the NPV measure essentially the same thing. You can say that the definition of the IRR is the discount rate that makes the NPV equal zero which is a very dangerous thing to think about as explained in Chapter 7).

We Compound Everything in Finance – Does That Mean Risk Premium Should be Compounded

If we assume that a 7% risk premium we just discussed is somehow applied as in the last example, the next question is whether this risk premium should be increased for investors if the investment has a longer-term horizon than one year. As I cannot recall this issue of compounding risk premium being raised in discussion of finance, I was initially afraid to even raise this question as the idea of compounding risk premia is ingrained in finance. Later in the book I will raise a number of questions related to changing risk and whether an increasing risk premium makes sense. I label WACC as what absolute

complete crap in part because of the way it assumes that risks of investment projects do not change over time. I also protest the idea of not gauging whether cash flows follow a process where volatility increases over time (which could justify compounding risk premiums), or alternative whether the cash flows exhibit mean reversion.

In financial analysis, when the risk-free rate and risk premium are computed, both of the items are implicitly or explicitly assumed to compound. If the risk premium is 7% and the risk-free rate is 1% to make 8%, as in our one-year case, then in the case with a longer time frame, the 8% compounds over time, the 7% compounds and the 1% compounds. This happens whether the investment is evaluated with IRR or NPV and is illustrated for a 5-year case in the shown in the adjacent table. The effect of the compounding returns is dramatic and conforms to the quote that is probably not from Einstein that where he supposedly called compound interest “the most powerful force in the universe”.¹⁷

In our simple example, the total amount of hours saved to achieve the 8% return in the one-year case was 378 hours. If the saved hours are measured over five-years as illustrated on the adjacent table, the required saved hours to justify the risk premium on our investment increases to 438 hours, an increase of 16%. If you increase the investment period to 20 years, the amount of saved hours must be 849 hours. Think about this, the probability of success has not changed and there is no change in the assumption about the technical efficacy of the investment. But just because the investment has a longer life, you need have a much more efficient investment.

| Timing | [Driver] | [Sum] | | 0 | 1 | 2 | 3 | 4 | 5 |
|---|----------|--------|----------|-------|-------|-------|-------|-------|-------|
| Period | | | | | | | | | |
| Investment Period | 0 | | TRUE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE |
| Return Period | 5 | | FALSE | TRUE | TRUE | TRUE | TRUE | TRUE | TRUE |
| Operations | | | | | | | | | |
| Hours for Investment | 175.00 | | 175.00 | - | - | - | - | - | - |
| Hours Saved | 36.06 | 180.28 | - | 36.06 | 36.06 | 36.06 | 36.06 | 36.06 | 36.06 |
| Net Hours | | | (175.00) | 36.06 | 36.06 | 36.06 | 36.06 | 36.06 | 36.06 |
| Net Present Value at Rf | 1.00% | \$0.00 | | | | | | | |
| Return on Hours (IRR) | 1.00% | | | | | | | | |
| Expected Value - No Risk Premium - 50% Chance of Success | | | | | | | | | |
| Hours for Investment | 175.00 | | 175.00 | - | - | - | - | - | - |
| Hours Saved - Successful Case | 72.11 | 360.57 | - | 72.11 | 72.11 | 72.11 | 72.11 | 72.11 | 72.11 |
| Hours Saved - Failure Case | - | | - | - | - | - | - | - | - |
| Expected Hours Saved | | | (175.00) | 36.06 | 36.06 | 36.06 | 36.06 | 36.06 | 36.06 |
| Net Present Value at Rf | 1.00% | \$0.00 | | | | | | | |
| Return on Hours (IRR) | 1.00% | | | | | | | | |
| Expected Value - Risk Premium -- 7.00% | | | | | | | | | |
| Hours for Investment | 175.00 | | 175.00 | - | - | - | - | - | - |
| Hours Saved - Good Case | 87.66 | 438.30 | - | 87.66 | 87.66 | 87.66 | 87.66 | 87.66 | 87.66 |
| Hours Saved - Bad Case | - | | - | - | - | - | - | - | - |
| Expected Hours Saved | | | (175.00) | 43.83 | 43.83 | 43.83 | 43.83 | 43.83 | 43.83 |
| Net Present Value at Rf | 8.00% | \$0.00 | | | | | | | |
| Return on Hours (IRR) | 8.00% | | | | | | | | |
| Risk Premium in Hours/Year | 21.56% | | | | | | | | |

Later in the book, when critiquing finance theory, I will argue that many problems come from the implicit assumption that the risk required by investors compounds over time at a high growth rate. Perhaps the primary example is in applying the CAPM, the equity market risk premium is assumed to compound over time. By implication, this suggests that risks also increase at a compound rate over time rather than being defined at the time the

¹⁷ According to Barbara Wolff, former archivist at the Albert Einstein Archives, “To the best of my knowledge - and I have searched for a reliable source of that and similar statements a number of times over more than 20 years - Albert Einstein neither said that “compounded interest is more complicated than relativity theory”, nor did he call it the most powerful force in the universe”.

investment is made. Similarly, when evaluating credit spreads on loans (and especially loans to developing countries), the margin compounds over the term that the loan is being repaid.

The question I hope you ponder is whether this risk premium is really necessary to compensate for risk and if the hoped-for risk premium is not present, the investment will not be made. If the compounded risk premium is not really necessary, as in our island example where we just want more leisure time and we are not worried about delayed gratification, then a long-lived investment is inappropriately penalized. The force that Einstein supposedly discussed but probability did not, may not seem like a big deal. But later I discuss very long-lived projects such as hydro power plants in Africa.

To demonstrate evaluation of risk premium, consider in a situation in which cash flows fully mean revert. Assume that you need a premium for taking the risk of rolling a dice, compared to receiving a fixed payment. Maybe you can receive 3.5 today, the average of the rolls $(1+2+3+4+5+6)/6$ or you can receive the value of the roll of the dice (1 or 2 or 3 or 4 or 5 or 6). When you receive the specific value of the roll of the dice instead of always receiving the average, you may need a risk premium because of your anxiety. Let's assume that the risk premium required is 10% to accept the uncertainty. Now your expected value in the case where you take the risk is $3.5 \times 1.1 = 3.85$.

| Roll Die Today | Safe Option 3,500 |  | Risky Option |
|----------------|----------------------|---|--------------|
| | | 1 | 1,100 |
| | | 2 | 2,200 |
| | | 3 | 3,300 |
| | | 4 | 4,400 |
| | | 5 | 5,500 |
| | | 6 | 6,600 |
| | | Expected | 3,850 |
| | | Risk Premium | 10.00% |

Now change the example and assume that you can receive the same proceeds for the risky case and the risk-free case in 5 years. Assume the risk-free rate is 3.5%. Consider first the risk-free alternative. As the risk-free rate measures the value of purchasing power you have in five years, instead of receiving the fixed amount of 3.5 you would be just as happy to accept $(1.035)^5 \times 3.5$ or 4.16 in five years. This can be considered receiving the amount in a different currency. You could convert the risky alternative to the different currency and measure the risky alternative as $(1.035)^5 \times 3.85$ or 4.57. But if you applied the risk premium to the investment, and you included the loss in the time value of money, you would require $(1.135)^5 \times 3.5 = 6.59$. As the risk has not increased over time, there is no reason to require much higher amount. You can now ponder whether the probability of a country defaulting is more like the rolling of a die or a time series where the volatility increases over time. If the probability of default of a country is stable (even if it is high), do you really need to earn a much higher risk premium on long-term debt relative to short-term debt.