STANFORD BUSINESS GRADUATE SCHOOL OF

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INTRODUCTION TO FINANCIAL MODELING

I don't throw darts at a board. ... Every battle is won before it is ever fought.
I look at a hundred deals a day. I pick one.

- Gordon Gekko, *Wall Street*

People who run ball clubs, they think in terms of buying players. Your goal shouldn't be to buy players. Your goal should be to buy wins and in order to buy wins, you need to buy runs...

- Peter Brand, *Moneyball*

It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so.

- *The Big Short*

OVERVIEW—WHY BUILD A FINANCIAL MODEL?

Academic papers and textbooks on financial modeling almost always start with heroic yet convoluted attempts to encapsulate the essence of a financial model in ten words or less. Such attempts invariably use words like "mathematical representation," "input, output, decision and consequence variables" and "exogenous and endogenous factors." As the tone of the opening movie quotes suggest, the approach we will take in this note (and, indeed, more generally in this course) will avoid such abstractions and instead offer real-world, application-driven explanations of concepts and techniques. We will try to keep the language simple, avoid unnecessary charts and diagrams, and focus on what really matters in building successful, useful, and accurate financial models.

With that as our goal, let's consider the essence of a financial model. It is, at its most basic level, a tool—nothing more. It is a tool that lets us understand how the results of a business, investment or portfolio of investments change over time and across different scenarios. A good financial model will do exactly what this course aims to do: take a complex system and represent it as simply as possible. Ideally, by doing so it should help us to understand the system, and what drives it, in new ways. It will help us pick the best deals from amongst hundreds.

Consider an example: you own a small book publisher that prints texts on financial modeling. Many financial aspects of this business are probably easy to understand with a basic level of intuition. You could, undoubtedly, calculate last year's profit without much difficulty. Similarly, you could price the next order based on your experience (so many books at such-and-such a price less some number of man hours and a bunch of paper equals "x" profit). But what if the questions were a bit more complicated? What if you wanted to retire in 10 years and wanted to project how much cash your business would generate over that time if it continued at its current rate of growth? What if you were concerned about your market migrating online over the next five years, and that prices would fall, but that your marketing costs and overhead would decline? How easy would it be to understand that impact in your head?

Due to the simultaneous interplay of many operating assumptions and many time periods, these questions become complicated quickly. Consequently, we need a tool to help answer them. That tool is the financial model. Each of the above questions can be answered using a relatively simple financial model, perhaps just an income statement with a few operating assumptions. But what if the questions are more complicated? What if I want to buy your business? What if I want to buy your business with leverage? What if I want to buy your business and merge it with my publicly reporting financial modeling software business? These questions require special purpose extensions to your basic financial model. In this case, such extensions would be a valuation model, a leveraged buyout (LBO) model, and a merger model—all topics that we will cover in depth in this course.

From the above examples, it might be tempting to think of a financial model as an answer generator. In almost any context, it is tempting to say: "If I assume x and y, then the answer (such as valuation or purchase price) is z." In practice, this puts too much weight on the model. Remember, a financial model is just a tool—it is a helpful guide that allows us to represent complexity. The model itself will only be as good as the quality of the inputs (i.e. "garbage in, garbage out"), and rarely will we know what inputs to use with any certainty.

Therefore, the real predictive power of a financial model lies in two places. First, the model is powerful in its ability to sensitize outputs. A well-constructed model will allow us to pressure test our assumptions and play with "what if" scenarios. You may not know with certainty at what price you can sell your product in 2025. But you probably know a range of likely prices. The model can help you understand how your business will look across this range: the best, worst and most likely cases (sometimes called the "aggressive/upside," "conservative/downside," and "base" cases). The second power of the model is its ability to help us focus on what matters. There are myriad variables that may impact a business's performance. By allowing us to sensitize each of these variables, the model can help us discover which assumptions materially drive the performance of the business and which have only a minor effect. When we understand these drivers, we know where to focus our attention as managers and our diligence as investors.

In this course, we will develop a variety of financial models targeted at helping us address and solve a diverse mix of business questions. On top of these models, we will layer a collection of techniques that allow us to perform increasingly sophisticated sensitivity analysis, and these techniques will allow us to use the tool to its full potential. In addition, we will develop a toolkit for auditing financial models. These audit tools will help us look inside the black box of the model and approximate its output as a means of ensuring that the model itself is functioning correctly. Finally, we will develop intuition for what is happening in the model, why the sensitivities behave the way they do, and how the model's output impacts management decisions.

Unfortunately, financial modeling is much more of an art than a science. There are very few hard and fast rules that will apply in all models. Consequently, what follows in this note and others is a playbook of sorts—a collection of lessons learned from a multitude of models of all different types. In addition to these lessons, we will attempt to share, where possible, "industry wisdom and practice"—the way things are most commonly done and the rationale for those approaches. However, in the end, the choices you make about the level of complexity in your models, their organization, and their format are yours.

Much of this note and the notes that follow are a bit technical. Do not worry if every point is not clear, as we will discuss each concept in greater detail during the course. The purpose of these notes, rather, is to serve both as an orientation to the kind of topics that we will be discussing and as a reference for specific questions that may come up throughout the course. When you encounter a more complicated technical section, make sure you feel that you have grasped the general concept, then feel free to skim the remainder of that section.

TYPES OF FINANCIAL MODELS

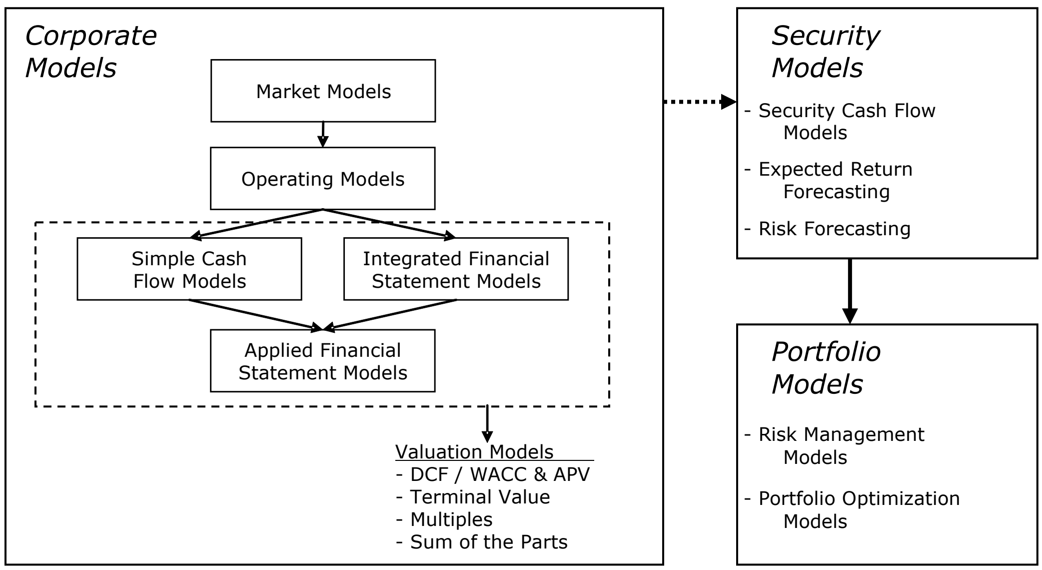
Before we discuss any framework for understanding the types of financial models, we need to make an introductory caveat. In general, there are two distinct classes of models: (i) outside-in models and (ii) inside models. The outside-in models include all of the models that we may build by looking at a company from the outside. These encompass virtually any type of model that we would build as investors, bankers, or consultants to analyze a company—public equity valuation models, leveraged buyout (LBO) models and portfolio models fall into this category. In contrast, inside models are models that would be built in an operating context where much of the relevant financial data of the company is known to a high degree of detail. This category includes capital budgeting models, budgeting and forecasting models, and treasury models. Since we do not have access to information for a specific firm at the level of detail typically available for an inside model, we will focus primarily on outside-in models in this course. However, the concepts, frameworks, and techniques used in building and analyzing outside-in models will allow you to effectively construct and utilize inside models. As an investor, corporate development manager, or investment banker, you will often have access to management's inside models at later stages of the due diligence process. To arrive at these stages, you will first have to build your own outside-in model of the business.

Now, we turn to the framework. Broadly speaking, most financial models are either models of the corporation (its profits, losses, cash flow needs, etc.), models of individual securities (their cash flows, returns, risks), or models of portfolios of securities. In this course, our main focus will be on the six main types of *corporate* financial models: (i) market models, (ii) operating models, (iii) basic cash flow models, (iv) integrated financial statement models, (v) applied financial statement models, and (vi) valuation models. We will also consider security cash flow models in the context of venture capital. Finally, outside the scope of this course, one can move beyond individual companies and consider portfolio optimization models. Each of these types of models is explained below.

These terms are not technical. There is no "industry standard" terminology. You are not expected to classify models into these (admittedly) rather arbitrary buckets. Instead, we will simply use these terms to help simplify our thinking about financial modeling, provide some structure for the course, and help illustrate the interplay between different types of models.

Figure A outlines a taxonomy that may be helpful in understanding the interrelationships across the hierarchy of these models:

Figure A
A Working Taxonomy of Financial Models



Market Models

Almost every financial model will start (implicitly or explicitly) with a market model. Market models serve as quantitative representations of the markets into which a company will sell its goods or services, and from which it will procure the required raw materials. The construction of a good market model is very difficult. In many cases, market models are built from large consumer data sets, surveys, macro- and microeconomic models, demand curve estimates, economic forecasts, and a panoply of other assumptions and data. The fact that these models are so difficult to develop is a large part of the reason that market research reports are very expensive and management consultants are in high demand by corporations as well as private and public equity investment firms.

We will cover the development of market models in a very limited fashion in this course. One major reason for this choice is that there is no universal market model. Each industry faces different market conditions, different demand drivers and different macro issues. A good market model will be customized to reflect each of these variables. Additionally, the development of a good market model is much more of an exercise in statistical analysis, economics, and business judgment than core financial modeling.

In a few weeks, when we study Fortune Brands, we will encounter a limited market model (i.e., the market for new housing and home remodels). In the development of such a model, there are a few, high-level guidelines that may be helpful. First, think of a good market model as a bridge between high-level market drivers and a company's revenue. This idea defines the input and output of the model.

A company sells a specific product; take high-definition TVs as an example. It is difficult to say, without some external reference points, what the size of the market for HDTVs will be in 2025 with any confidence. A market model for HDTVs will bridge from the known (historical data and broad market trends) and the estimable (such as consumer spending and product penetration curves) to the unknown (future HDTV sales). In this particular case, we know that HDTVs are a consumer product in the adoption phase: while it has a significant installed base, a sizeable portion of its eventual consumer base has yet to adopt the product. If we wanted to build a market model, we could look at historical adoption rates for HDTV compared with similar precedent consumer products (such as DVD players). From academic marketing studies, we also know that consumer product adoption trends typically follow a "penetration curve" or "S-curve." Based on some empirical research about the slope of such curves, several historical benchmarks, some statistical analysis, and historical sales data, we can create a forecast for HDTV unit sales (and most likely a confidence interval around this forecast). On top of that, we would overlay pricing assumptions, perhaps informed by consumer surveys, as well as market share projections. In the end, we would arrive at a forecast for HDTV revenue.

While this approach may work well for adoption-phase consumer products, it is not perfect for all markets—remember, there are very few general rules for building a market model. A good market model will begin with a clear vision of what really drives the size and growth of the company's market and will incorporate as much information about those drivers as possible. Most markets will, on some level, demonstrate some correlation (either positive or negative) with a major macroeconomic factor such as GDP growth. However, this is so broad that it is usually unhelpful, and very few good market models use GDP growth as a fundamental driver. Instead, we should look deeper and see if there is a more specific driver of the market.

Again, an example may be helpful. If we are looking at John Deere tractor sales, we might find that they are correlated with commodity agricultural prices such as wheat, soy and corn (i.e., if prices are high, farmers are more likely to make major capital investments). We can then ask what drives commodity agricultural prices (e.g., supply / demand imbalances, weather and substitute prices, etc.) and gather data on those drivers. In the end, our goal is to have a fairly defensible market model that ties the market in which we are interested with drivers that may be easier to forecast (for example, forward agricultural commodity prices from futures markets). In so doing, we make the market model more robust by incorporating much broader market intelligence (i.e., futures markets should incorporate almost all relevant data). By identifying the correlation between these markets and the tractor market, we have brought this wealth of information to bear on our slightly more difficult to ascertain market. Regression analysis can be particularly helpful in identifying and quantifying such correlations.

Finally, it's important to keep in mind that any market model—no matter how good—will rely on predictions and assumptions about the future. Sometimes, these may be assumptions we are making ourselves—either implicitly or explicitly. For example, if we forecast the HDTV market based on an S-curve adoption pattern, we are implicitly assuming that the HDTVs will behave like most other consumer products, whereas it may be a disruptive technology that exhibits very different growth characteristics. We may also make an explicit assumption about the maximum potential market size for HDTVs. It is helpful to both recognize and sense-check these assumptions. The assumptions inherent in our model may not always be our own. In the case of tractors, we are incorporating a number of assumptions made by the futures markets. In building such a model, you should always identify these assumptions, sense-check them and build a range of "cases," or possible scenarios, around what could potentially happen. For example, what if grain prices decline due to increased competition from Asian suppliers? Or what if bad weather in Latin America caused a spike in U.S. soy prices? A good market model will always consider such possibilities and incorporate the flexibility to pressure test such assumptions.

Again, these are only general rules. It cannot be said enough that building a good market model is really an exercise in understanding a market. It combines the skills of strategic analysis, a marketing toolkit, the study of consumer behavior, and a healthy quantity of statistics. What we will cover in this course is just the tip of the iceberg.

Operating Models

The most fundamental component of any financial model is the operating model. Virtually all financial models begin with an operating model. The operating model is designed to transform certain assumptions about a business, its market, and its operating structure into a picture of the earning power of that business. A well-built operating model will take us from basic input assumptions (such as market size, market share, pricing, and cost structure) to EBIT (earnings before interest and taxes, also called operating income). Often, the input or starting point of such a model will be the output of a market model. We then forecast and apply operating performance metrics (margins, etc.). By the end, we should have a view of EBIT.

A good operating model will help us focus on what assumptions are very important to the model and what operational factors most directly influence that business's performance. In some cases, we may find that the model is very sensitive to revenue growth. In other words, the business has a lot of "operating leverage" in its model (i.e., a high fixed-cost component results in incremental revenue requiring less incremental costs). In other businesses, we may find that the small changes in marketing expense has substantial earnings consequences. The Netflix case (GSB No. F291) or the Sirius XM case (GSB No. Fxxx) serve as a good example here. Due to the uncertainty inherent in many of the assumptions made about a business in an operating model, good operating models will build in as much flexibility as possible. They will allow us to test assumptions and examine business performance across an array of scenarios. The actual construction of such a model is covered in much greater detail in the "Note on Basic Financial Models" (GSB No. F290). For now, it is only important to recognize what an operating model is and what it does. The obvious drawback of such a model is that while it provides insight into the actual operations of a business, it does not provide us with all the outputs required for more advanced analysis. That output is provided by another type of model, either the simple cash flow ("mini") model or the integrated financial statement (IFS) model.

Simple Cash Flow Models ("Mini Models")

The most significant limitation of the operating model is that we are left without a view of cash flow, which is critical for more interesting analysis such as valuation. Therefore, developing a perspective on cash flow is the focus of the simple cash flow model.

The simple cash flow model does exactly what its name would imply: it develops a cash flow forecast. But this obvious statement has an important consequence. In a simple cash flow model, we do not worry about anything that does not directly bear on cash flow. For example, accounting issues, generally accepted accounting principles (GAAP) earnings, and other non-cash metrics are largely ignored in the interest of time and simplicity. In addition, we will frequently make further simplifying assumptions about the components of cash flow. For instance, we will not create a detailed forecast for working capital. The specifics of creating a simple cash flow model are covered in the "Note on Basic Financial Models" (GSB No. F290).

The advantage of such a model is obvious: it provides us with the information we need to value and analyze a business with a minimum of work and time. The disadvantages are equally obvious: it relies on a number of assumptions that may often be implicit in the modeling technique itself. It does not provide us with non-cash outputs, such as GAAP net income or a robust balance sheet that may be helpful in several managerial, transactional or public valuation situations. Also, a simple cash flow model does not afford us the luxury of making granular or sophisticated assumptions about more nuanced elements of the business. Given this, it is important to bear in mind that this tool, while appropriate for some situations, is not exactly the highest form of modeling. The more robust tool is the integrated financial statement model.

Integrated Financial Statement Models

The integrated financial statement (IFS or "three-statement") model is one of the core tools used in financial analysis. While well-developed market and operating models are important to sound analysis and basic cash flow models provide additional insights into the financial characteristics of a company's business, these models can only tell part of the company's story. Using the basic framework of GAAP financial statements, IFS models capture all three aspects of the company's results: (i) operating performance (income statement), (ii) cash flows (cash flow statement), and (iii) assets and liabilities (balance sheet). With this more complete picture of a company's financial position, it is possible to project a number of important financial metrics, including return on assets, return on equity, and GAAP earnings / EPS (earnings per share).

On a stand-alone basis, these models can be used for a variety of purposes. For example, IFS models can help to evaluate the earnings potential and value of a public company by projecting GAAP EPS and applying an appropriate valuation multiple. In addition, we can use these models to forecast a company's cash requirements and its ability to support a given level of leverage. Furthermore, the basic IFS model can be combined with other analytical tools to develop a new set of "applied" or special-purpose models that can be used to analyze investments or other transactions (discussed below). The details of IFS models are presented in a later note "A Note on Integrated Financial Statement Models" (GSB No. F292).

Applied or Special-Purpose Models

While models can be very valuable for looking at companies on a stand-alone basis (e.g., analyzing projected performance of public companies, evaluating investments in an LBO context), models are also used to evaluate transactions involving the combination of one or more companies. These mergers and acquisitions (M&A) models are similar to the integrated financial statement models that we have just discussed. However, with M&A models a couple of complexities arise that are worth noting. First, in combining two companies, there will be accounting adjustments required to reflect the GAAP accounting associated with acquisitions. Second, in an M&A context, one plus one will not always equal two. Said differently, projecting the financials of the combined company will not be as simple as projecting each company independently and summing together the comparable line items. For certain line items, there may be significant cost savings associated with merging the two companies (i.e., "cost synergies"). Additionally, the combined product portfolio of the two companies might create additional selling opportunities, resulting in faster combined company growth than the two companies could have achieved independently (i.e., "revenue synergies"). Therefore, M&A models require an additional layer of analysis to generate reasonable projections of financial performance.

In addition to the mechanical differences between M&A models and integrated financial statement models, there are a number of analyses that are typically conducted in connection with M&A models. These auxiliary models allow companies or financial advisors to evaluate the potential risks and opportunities associated with a potential transaction. Supplemental analyses are also performed to evaluate different methods of structuring and funding the transaction (e.g., cash versus equity, etc.). During the latter part of the course and in a subsequent note, we will walk through the key techniques associated with M&A modeling and work through an analysis of the merger between Saucony and Stride Rite, a real-world transaction.

Another common type of applied financial statement model used in financial analysis is the leveraged buyout (LBO) model. LBO models are used in primary contexts both by LBO firms in evaluation of potential investments and by third-party financial analysts and investment bankers as a "floor" in their valuation analyses (i.e., private equity investors usually have a higher cost of capital, and fewer opportunities for synergies, than publicly traded strategic buyers and are consequently willing to pay less for a given target company). In many ways, leveraged buyout models are an amalgamation of modeling elements that you will work with in the early part of the course. These models contain four basic components: i) an operating model, ii) a de-leveraging integrated financial statement model, iii) certain transaction structure assumptions, and iv) a collection of output analyses including returns calculations and sensitivity analysis.

The key difference from previous models is that an LBO model replaces a company's existing capital structure with a highly leveraged structure. Then the cash flow generated by the business is used to pay down debt over time. The key implication for modeling arises in the cash flow statement, where we will modify the traditional cash flow statement used in a typical integrated financial statement model to incorporate a "cash flow sweep" mechanism. This mechanism will utilize all excess cash to pay down the company's outstanding indebtedness. We will discuss the mechanics underlying LBO analysis in a later note "Introduction to Leveraged Buyouts Note" (GSB No. F302).

Valuation Models

Constructing a simple cash flow model, integrated financial statement model, or special purpose model is an interesting exercise, but on its own, it is not terribly insightful. It does not, in and of itself, help us decide to buy the stock or acquire the company. To do this, we need something more. We need a set of valuation techniques that we can overlay on these models to get a sense of what they mean and what conclusions they suggest. We will spend a great deal of time in this course focused on developing these valuation techniques and implementing them in the context of the different models.

It is important to note that different valuation methods will require different inputs, and these inputs may guide the type of financial model that we initially build. For example, for a standard discounted cash flow valuation, a simple cash flow model together with an assumption about the appropriate weighted-average cost of capital may suffice. But often we will find that this method is highly sensitive to our assumptions about the firm's long-run growth rate. For more robust results, we may want to estimate the firm's terminal value at the end of our forecast horizon using a multiples approach based on comparable firms. In this case, we will need the output of an integrated financial statement model to estimate the inputs for various multiples. For more complex situations like an LBO setting, we will need a full model of the cash flow sweep and the resulting debt dynamics to appropriately estimate the firm's future tax shields and (changing) cost of capital. We will cover these details further in future readings and class sessions.

Security-based Models

Each of the models that we have discussed thus far focuses on the cash flows generated by an individual company. Suppose instead that we are interested in the cash flows of a specific security issued by that company. In these situations, we will make use of security-based financial models.

Security cash flow models are used to forecast the cash flows that a security will ultimately pay out to its investors. These financial models will combine a model of the underlying assets that back the security with a model of the allocation rules that determine how these cash flows are partitioned across different security claims. For example, a security cash flow model might be used to forecast the cash flows of a particular debt security in a highly leveraged transaction.

In this course, we will build a security cash flow model in the context of a venture capital case, Catch Technologies (GSB No. F299). In this case, we will develop a simple cash flow model for the firm, and consider how these cash flows will be divided across different series of the firm's preferred stock. Since each series has specific conversion and liquidation rights, the cash flows of any one security will depend on the decisions made by other security holders. Thus, to forecast the cash flows of a given security, we need to combine our model of the firm with a model of the behavior of different security holders.

We can use a security cash flow model to analyze the security's expected return and risk characteristics. Specifically, the security's risk can be estimated by looking at the sensitivity to various factors that drive the cash flow model, and the security's expected return can be gauged by looking at the average internal rate of return (IRR) associated with the cash flows across different scenarios. When we do fundamental analysis of corporate securities, these security cash flow models are often built on top of robust financial models for the firm itself, like the models we described earlier. In other cases, the firm may be treated as a black box, and the security's cash flows and risk characteristics may be based on extrapolations of past data using sophisticated statistical "factor" models.

Portfolio Models

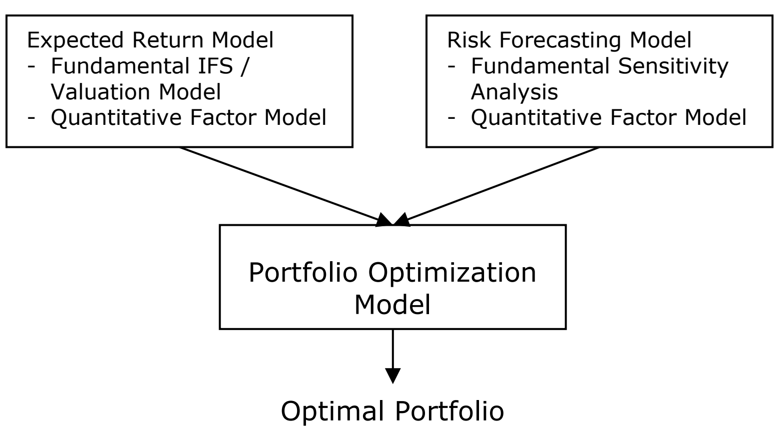
Each of the models that we have discussed thus far focuses on an individual company or security. But what if we wanted to allocate our assets to a portfolio of companies or securities? To do this, we would need another type of model: the portfolio model.

Recall from Finance that constructing an optimal portfolio involves selecting the investments that offer the highest level of expected return for a given amount of risk. Therefore, three types of models naturally come into play: (i) expected return forecasting model, (ii) expected risk forecasting model, and (iii) a portfolio model, which combines the other two models to form an efficient portfolio. Figure B outlines the interplay between these types of models and the portfolio model.

In terms of a public equity portfolio management process, fundamental analysis is often used to build an integrated financial statement model and forecast the financial position of a company—with the IRR or some related valuation metric used as an expected return forecast. However, it is less common to use fundamental models for risk forecasting. Most investment managers do not bother building their own model, but rather use a "black box" provided by a commercial source such as MSCI Barra and Northfield.

Note: We will not include portfolio optimization models in this course, and will instead focus on corporate models. A separate course on Modeling for Investment Management (F341) is available and will focus on portfolio optimization models for asset allocation.

Figure B
The Interrelationship of Corporate, Security, and Portfolio Models



MODELING BASICS —THE DOS AND DON'TS OF MODELING

Armed with a robust array of models, we now turn our attention to the more nuts-and-bolts topic of how to construct them. In this section, we will largely leave the academic behind and focus instead on industry wisdom – critical guidelines based on "best practice." What follows are only the most basic suggestions. Over the course of the quarter, we will add to these tips and build a more complete list of modeling conventions. In general, there is no right or wrong way to construct a model, as long as it gets to the most accurate answer. However, there are a series of practices that function as industry convention which will make the model much more useful, flexible, and easier to share with others. In this course, we encourage you to follow these conventions.

The first rule of modeling is: **keep it simple**. The second rule is: **when in doubt, refer to the first rule**. There are two important perils of over-complication: (i) each new assumption introduces room for error, and (ii) creates the impression of false precision. Keeping your model simple (by which we mean confining it to as few details and assumptions as you need to get your desired output with maximum accuracy, as well as building your model using clear and simple calculations) not only avoids these perils but also helps in presentation. Remember: you will almost always be sharing your models with other people. The simpler the model in its design and construction, the easier it will be for a third party to understand. *In fact, being able to interpret and operate other people's models, as well as build your own so that someone else could easily understand and use it, is such a critical modeling skill that we have designed it into the course.*

The third rule of modeling is: **never hardcode**. A hardcode is industry-speak for embedding an assumption (typically a specific number) into a calculation. For example, if I wanted to calculate next year's revenue by growing this year's at 5 percent, I could make next year's revenue = Value(This Year)*(1.05). It would yield the right answer. But in modeling, everything is subject to change without notice. Four days after you have built your model, you may realize that revenue will not grow at 5 percent, but will instead grow at 8 percent. If you had built the assumption into your calculation, you would have to go back and look in each specific calculation to find where you made this assumption. This is easily avoidable. If you create a separate assumption for the growth rate and calculate next year's revenue as Value(This Year)*(1+Growth Rate), you can change the growth rate at ease and have the result flow through your model. These separate assumptions that we can easily find and change are called "softcodes."

There is a second reason why we never want to hardcode an assumption. It is important that we are sober and honest about the assumptions that we are actually making. This allows us to understand where we could be wrong, what might change that would affect the answer, and where to focus our diligence. If you have hardcoded a critical assumption into a calculation, you may forget about it; this oversight happens more than you think. Consequently, hardcoding can turn errant assumptions into permanent flaws in your model or create additional difficulty in understanding why a particular change—made at a later date—did not flow through the model as you would have expected. This issue becomes even more pronounced if someone else makes changes to your model, naturally assuming that it has no hardcodes. Therefore, no matter how simple the calculation is, always put numeric inputs in their own cells. For instance, if you want the model to multiply A*B to get C, have three cells: one for A, one for B and one for C.

As you can probably foresee, calling out each assumption will produce a lot of "input" cells. Since we created each of these input cells to allow us to easily and quickly identify the assumptions that we are actually making, it makes sense to put all of these assumption cells (the cells into which we will be entering numbers) in one place. Therefore, the fourth rule of modeling is: **centralize assumptions**. Most good modelers will create a sheet (or area on their one sheet) where these assumptions are located. This area is sometimes called the "dashboard" or "control panel" of the model. When you look at the sample models that we will discuss in class and in future notes, you will always find a clearly distinguished area for assumptions.[1]

In addition to centralizing assumptions, we want to be able to easily recognize what a cell is actually doing. For instance, we want to be able to know – on first look – that one cell is an input cell (one we might change) and another is a calculation. Similarly, we may use one data point or assumption in several places. Since we want to ensure consistency, we will only enter the data in one place and will then link to it (in Excel: =(Assumption Cell)). Therefore, we need a way to recognize the original input cell and those that link to other cells. We accomplish this using the fifth rule of modeling: **use color coding**. The industry has largely standardized on the following color-coding scheme:

Blue = Input Cell / Assumption / Inputted Numeric Value
Black = Calculation
Green = Direct Link to Cell on Another Sheet ("Pulling a Value")
Red = Error / Does not Tie / Need to Revisit / Otherwise needs attention

Using these colors will help you and others who are using your model instantly recognize the way in which any particular cell is functioning in the model.

Color coding cells is a gateway to our sixth rule: **always be formatting**. Here it is difficult to provide any simple guidance save this: format, format, format. There are no universal model formats. Everyone develops their own style (unless your bank or firm specifies a "look" for the entire firm). What every model has in common is that it will apply whatever format the author has selected relentlessly. At a minimum, you should make sure that the formatting of your numbers is consistent (same number of decimal places, percentages are in the form of 0.0%, etc.), time periods are clearly labeled, you do not have any rogue error messages (#DIV/0!, #VALUE!, #REF!, #NUM!, etc.) and there are not errant numbers or calculations without a label or heading. Consulting firms often speak of materials as "client ready." In modeling, the general formatting objective should be for your model to be "client ready" at all times, meaning that anyone in the same job could pick up your model and understand it with no explanation. There are a number of reasons for this: (i) you may be working in a team (as in this course), (ii) you may get reassigned, or (iii) you may place a model aside, only to be forced to revisit it six months later. In the latter case, due to the complexity of most models, it is highly unlikely that you will remember specific assumptions or non-standard formatting tricks you used six months ago. Here, you are the client, and the model should be easily interpretable to you. The peer grading component of your weekly modeling assignments will help you to understand what types of formatting and other "best practices" are critical to clear, easily interpretable models.

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[1] The one exception to this rule is historical values (since these will not change). For example, we do not need to have an assumption for revenue in 2003. It was what it was and will not change. As a result, we locate these inputs in the financials themselves.

There is an additional, simple formatting rule that should be universally followed: *lay out time periods horizontally and calculations vertically*. In other words, the format of your model should be no different than the format of basic financial statements. You should be able to look across the page horizontally to get a sense of trend, and you should be able to look down the page, vertically, to understand the math in any given period.

In addition to formatting within any given worksheet, you should always be cognizant of the way it will print. Unless told otherwise, Excel will print every value on a worksheet (even if these values are hundreds of cells apart). To avoid having the printer burn through a small forest, you should select the print area and formatting of each worksheet. The easiest way to do so is to turn on the “Page Break Preview” option (available on the “View” menu; alternatively, this can be done with the keystrokes Alt-V, P). Here you can adjust the print range to ensure that Excel only prints what you want it to; this range is shown by the blue lines around the border of your sheet. You can also go to the “Page Layout” tab in Excel (Alt-P) to change the orientation, margins, etc. If you send a model to a third party, you should always assume their first action will be to print all the worksheets in the model. Also, this is likely the first thing that will happen with the models you turn in. As a result, you should be careful to format each worksheet for printing.

Ironically, one of the most basic formatting questions is the one with the least harmony of opinion: *Should you build your models on one worksheet or across several?* There are merits to both schools of thought. Those who use only one sheet to build even the most complex of models argue that such tight integration makes auditing (i.e., tracing back the inputs into various calculations) easier. When you use one sheet, Excel can point to and color code the inputs into any calculation, as we will discuss later. Those who support the multiple-sheet approach observe that models become exceptionally cumbersome and difficult to format if they are confined to one worksheet. In such a setting, it is also difficult to print only selected portions of your model.

Based on experience, we would suggest the following guideline: if you are building a simple cash flow model (such as for Sirius XM), use one sheet. If you are building a more complicated model, like an integrated financial statement model or an LBO (e.g., Fortune Brands or The Sports Authority), use multiple sheets divided by function (separating the assumptions, operating model, capital expenditure [capex] or depreciation and amortization [D&A] forecasts, financial statements—which may themselves be separated—and finally, key model outputs). As there is no accepted practice, you are free in this course to make your own decisions on this topic, just be mindful of the trade-offs in each approach.

Finally, it is generally helpful to follow the taxonomy for model building with which this note began:

1) Start with a market model (if you’re using one).
2) Build an operating model.
3) Layer on either a simple cash flow model or an integrated financial statement model.
4) Augment this model with any special functionality you need (i.e., valuation model, LBO assumptions, etc.).

You will find that doing so both greatly reduces the potential for error and makes the process a lot smoother.

THE AUDIT TOOLKIT: PART ONE

Even well-formatted and well-structured models can be "wrong." Even worse, due to the complexity of many models, the sheer number of assumptions being made and the exponential interplay of different variables and assumptions, it is often difficult to know exactly when a model is generating the "right" answers and when it is simply "wrong." We put "right" and "wrong" in quotes because no model will ever be one hundred percent accurate. Even when built correctly, it can only be as accurate as the assumptions that we put into it. Instead, we want to focus on making sure that the model generates the "right" answer, given the assumptions that we have made. In this course, we will work to develop a set of tools that will help us recognize those cases in which our model is behaving correctly and those cases in which something is off or in error. Below are the most basic audit tools. As we explore different types of models in different contexts, we will add to these with more advanced and specific tools.

The most basic and fundamental audit tool is *"ticking and tying."* This is just a fancy way of saying "check your work." The term has its origin in the audit process of certified accountants. In a formal audit, accountants will trace each input in a financial statement back to its original source document or ledger. When they have satisfied themselves that the number is accurate, they will place a tick mark next to it. Once they have "ticked" all of the inputs, they will check the calculations on the statement. When the calculation is certified to be correct, the accountants will mark it with a straight line with a loop at the end, implying that it "ties" out. We use this term in financial modeling because it encompasses the two most basic steps we take in "checking our work."

In our audit process, we will take steps very similar to those taken by accountants in a formal audit. We begin by "ticking" all of our assumptions and inputs. Such values should be easy to find, if we followed the formatting taxonomy and color coded them all as blue. In the process of "ticking" these numbers, we want to check for several things. First, if the number is a historical financial data point or was pulled from a source outside the model, is it accurate? Second, if the number is an assumption, is it reasonable, is it logical, and is it defensible? Finally, if the number is being pulled from a different sheet or section of the model, is it pulling the correct number?

Assuming we have "ticked" each of these numbers, we proceed to "tie out" the model. We do this by replicating, by hand, the math imbedded in the spreadsheet for a representative projection year (importantly, it is not necessary to do this for each year as we have presumably just copied the formulas forward). The most basic "tying" exercise can be done on the income statement. Using a calculator, we want to be sure that revenue less cost of goods sold (COGS) ties to the gross profit in the model. We then want to check to be sure that gross profit less operating expenses ties to EBIT. While this may seem a bit tedious, in a very complicated model, it is easy to overlook an expense category or fail to link a series of cells into a calculation. As a result, these basic errors of omission (which are easy to spot in a ticking and tying exercise) are very common.

Our second audit technique is to *look at patterns in numbers across years*. Does revenue grow at a predictable or steady rate? Do margins remain relatively consistent across the projection period, or do they fluctuate radically? Are our cash flows growing linearly or do they jump around? Sometimes there may be logical reasons for discontinuous patterns; for example, a company operating in a cyclical market will demonstrate an up-and-down pattern in line with this cyclicality. (In such a case, you should understand how this pattern impacts cash flow in the year used to calculate the terminal/exit value. In other words, is that year's cash flow representative of the business going forward, or is it a one-time distortion?). But often, spotting discontinuous or irregular patterns can help identify places in which the model is malfunctioning or may be pulling incorrect assumptions into a calculation.

The third audit tool that we use on any type of model is to *check output using growth rates*. By including compound annual growth rates (CAGRs) for key input variables, we can estimate the growth rates in outputs. For example, if we know revenue is growing at 10 percent per year and costs are growing at 8 percent, we would expect EBIT to grow at a rate that is greater than 10 percent. As costs are growing slower than revenue, we should see margin expansion (i.e., margins should be growing) and consequently, EBIT should grow faster than revenue. The reverse is obviously also true. We do not need to know the exact rate at which EBIT will grow for this exercise to be instructive. We could also perform this exercise on the output from a cash flow statement. Developing just a rough sense for the direction and magnitude that you would expect to see in the growth rate of output variables can help to ensure that the model is functioning correctly across time periods.

Finally, the 6-line cash flow statement, which we will discuss in much more detail in the "Note on Basic Financial Models" (GSB No. F290) can be a helpful audit tool.[2] For now, it is simply worth flagging that this important component of several models also functions as an audit tool. At its most basic level, this tool will allow us to pull together the outputs from a number of supporting schedules (i.e., depreciation, working capital, interest on debt and cash balances, etc.).[3] As such, we can apply the audit tools described above to this "read out" to make sure that all of the various components of the model are working correctly. When we discuss LBOs later in the course, we will expand the concept of the 6-line cash flow as an audit tool and demonstrate how it can be used to manually check an IRR.

As we move forward in the course, we will develop additional audit tools. These first four tools will help us check a simple cash flow model, such as Sirius XM. As we add complexity, such as in an integrated financial statement model, we will need to develop increasingly sophisticated audit tools to manage and error check this complexity.

EXCEL TRICKS AND TIPS

No introductory note on financial modeling would be complete without a few words about unleashing the power of Excel. However, we should note upfront that this course is not a course in Excel. Over the next few weeks, we will explore much of Excel's functionality, including how to build more robust financial models with greater speed and more accuracy. To the extent that you have questions about a specific function or task, you are encouraged to use Excel's help function (accessible by pressing the F1 key, using the "Help" menu or typing a question into the blank white box at the upper right-hand corner of the Excel screen) or a search engine like Google (as you will be surprised at the number of people who had the same question and the helpfulness

[2] The 6-line cash flow provides a bridge from EBIT to Levered Cash Flow). The six components of this tool are: 1) EBIT, 2) depreciation & amortization, 3) taxes, 4) interest expense and income, 5) change in net working capital and 6) capital expenditures.

[3] Again, each of these schedules is covered in much more detail in notes that follow.

of "the crowd", often using language that is less cryptic than Microsoft's). That said, let us turn to a few initial pointers. We will cover many of them in more detail over the course of the quarter. Of course, these tips are optional – they are simply practices that many people find helpful and/or useful.

There are numerous apocryphal stories that circulate about the first days of investment banking training. For instance, a frequently heard "myth" suggests that many investment banks prevent new analysts from using a computer mouse for their first six weeks. Admittedly, there is a very logical reason for such a draconian policy: you can work much faster in Excel when your hands stay on the keyboard. Conveniently, everything can be done (including formatting) in Excel using keyboard shortcuts *without ever touching the mouse*.

Excel has a rich set of built-in keyboard shortcuts and sequences that can be accessed using the Ctrl or Alt keys on your PC keyboard (or the Command key on the Mac), and learning them will make modeling much faster (and more fun).[4] While complete mastery is probably not worth the time investment, there is significant value in forcing yourself to begin learning shortcuts for any repetitive actions you find yourself doing frequently.

For example, you are probably already familiar with the shortcuts to change to bold (Ctrl+B) or italics (Ctrl+I), or cut and paste (Ctrl+C and Ctrl+V), and using them saves a lot of time you would have spent with your hand in the air going back and forth to the mouse. Excel has many other similar shortcuts, including ones to insert rows and columns, fill or sum a range of cells, move to the end of a column or row, etc. Some of the most common shortcuts are shown in **Exhibit 1**. For a more complete list (as well as their Mac equivalents), see the ***Excel Shortcuts and Macros*** page on NovoEd.

While Excel's built-in shortcuts are impressive, they are not constructed with financial modeling as the primary application, and so are not always optimized for our purposes. This problem can be solved by adding "custom shortcuts" using macros (don't worry, you do not need to write any macros or even know what they are in order to use them). At their most basic level, macros are a sequence of instructions for Excel. These macros can then be assigned to a keyboard shortcut to be executed whenever that key sequence is pressed.

There a number of standard keyboard macros that circulate within the industry and are designed to make formatting spreadsheets for financial modeling easier. These macros are built into a spreadsheet that Excel can load at start-up, making them available in any workbook in which you model. The "Personal_F350_2021.xlsb" workbook containing many of these macros is available for download from NovoEd. **Exhibit 1** also lists the additional "turbo" macros that are embedded in "Personal_F350_2021.xlsb".

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[4] If you would like a systematic overview of keyboard shortcuts in Excel, see Keyboard shortcuts in Excel (microsoft.com), or type "keyboard shortcuts" into Excel's help function. For more a more general introduction to Excel, Microsoft offers a series of free online training courses at: http://office.microsoft.com/training/.

You can use these macros by having the workbook open while running Excel. To automatically load the macro workbook whenever you open Excel, simply copy the file into the XLStart directory of your Microsoft Office program installation. Under a typical PC installation, the location is:[5]

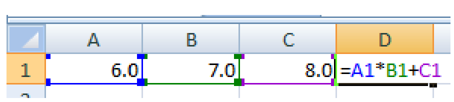
C:\Users\username\AppData\Roaming\Microsoft\Excel\XLSTART

Importantly, the "username" is your username. When you copy a file into this directory, Excel will automatically load its contents at start-up. Therefore, you can uninstall these formatting macros by simply deleting the file from this directory. You can also make this file load in the background by making it hidden (View > Hide).

Within Excel itself, there are several simple tricks that can make modeling faster and more productive. First, it is worth noting that the plus sign "+" can be used to introduce a calculation in the place of the equals sign "=". Some people find it easier to reach for the + on a numeric keyboard (since it is located next to the arrow keys) than to reach across the keyboard for the = key. If you are modeling on a laptop, you are likely to stick with the = sign.

Also, some people find it helpful to "name" cells. If you are modeling across numerous worksheets and do not want to have to go hunt down a cell to which you will refer often (e.g., general parameters like the tax rate or inflation rate), Excel allows you to "name" this cell so that you can summon its value simply by typing = or + followed by the "name." To name a cell, or range of cells, select them and then type the name in the "name box" in the upper left corner just above your spreadsheet. It will usually show the cell reference, such as "A1," if you have not yet named the cell. You can also add and delete names by accessing the "Define Name" box with keystrokes: Alt-M, N, N. You can type any "name" that you want for the cell. The only restriction is that you are not allowed to use blank spaces. Therefore, most people use the underscore in the place of a space. For example, if you wanted to set the effective tax rate as a named cell, you would define the name for the cell as "Tax_Rate". Once you have done this, you can simply type "=Tax_Rate" into a cell to summon that central assumption from any worksheet. You could also embed the name into a calculation (e.g., "=A24*(1-Tax_Rate)").

The F2 key may be the most helpful key in Excel. When you strike that key, it will allow you to edit the contents of that cell without clicking into it. However, more significantly, it will show you (using colored boxes) to what cells the calculation is referring and in what order. This functionality is a bit difficult to describe in words, so consider this simple example:

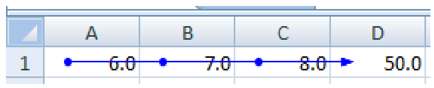


When the F2 key is pressed over final cell (D1), Excel displays the formula in the cell, color codes names of the cells it refers to, and places boxes of the same color over the input cells themselves. This tool has the added benefit of allowing you to drag the colored boxes to different cells (with the mouse) and edit the equation without retyping it. Using this tool to its full potential requires a

[5] You can also try the shortcut %AppData%\Microsoft\Excel\XLSTART. In Excel, you can verify the location by checking File > Options > Trust Center > Trust Center Settings > Trusted Locations and look for locations of the XLSTART folder. Alternatively, under File>Options>Advanced>General you can set the option "At startup open all files in:" to set up your own custom start folder. On a Mac, you can try saving as Personal.xlsb to: ~/Library/Containers/com.microsoft.Excel/Data/Library/Application Support/Microsoft/Roaming/Excel/

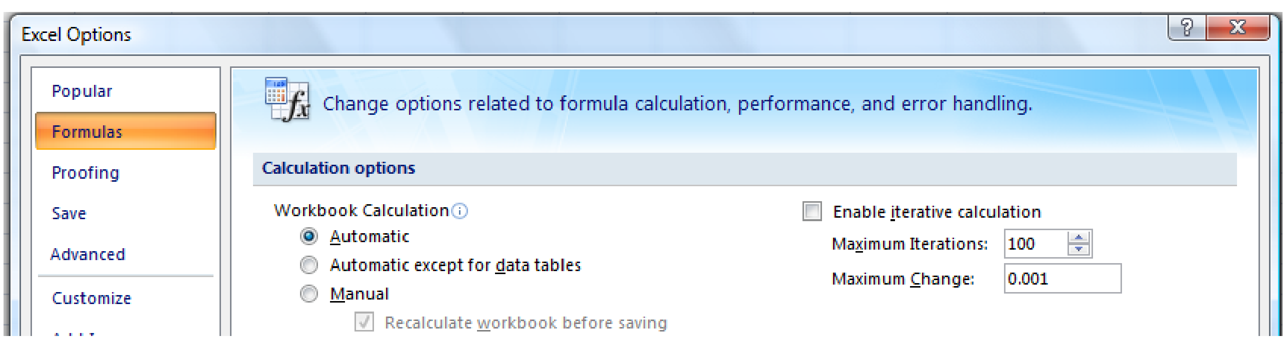
bit of experimentation and practice, but it is undoubtedly the best audit function in Excel. (Unfortunately, the F2 key is located next to the F1 key which loads the help file. As a result of this unfortunate placement and the frequency with which most banking and private equity analysts use the F2 key, you will frequently see many computers at such firms from which the F1 key has literally been broken off so they can avoid accidentally hitting F1 and slowing things down!)

In addition to the F2 key, there are two additional powerful tools for auditing in Excel. First, is "Formula Auditing" under "Formulas" in Excel. If you have a cell with an embedded calculation and would like to know where the inputs are coming from, use "Trace Precedents" or Alt-M-P (or turbo-macro Ctrl-Shift-P) as a shortcut. When auditing your model, you may also want to understand which cells in your model are affected by a certain assumption. In that case, put the cursor on the cell containing your assumption and use "Trade Dependents" or Alt-M-D (turbo Ctrl-Shift-D). When you use these functions, blue arrows will point to cells that are either precedents or dependents. Use "Remove All Arrows" or Alt-M-A-A (Ctrl-Shift-R) to clear the screen.



The second alternative auditing tool is Control-[. Again, put the cursor on a cell that you would like to audit. To figure out which cells are feeding into a certain calculation, hit Control-[, and the input cells will be colored in a grey. You may scroll through the various input cells by using the Tab key. Conversely, Control-] will do the same for cells which are dependent on the selected cell.

When models become large and cumbersome (incorporating data tables or circularity—both topics that we will cover later in this course), they can begin to slow down. In such cases, calculations will take a few seconds, and you will not be able to continue modeling until Excel has finished. To avoid this problem, Excel offers several calculation options. These are accessible under Excel Options (ALT-T,O) and selecting "Formulas" (see the "Calculation" tab in Excel 2003). The menu presents the following options:



As you can see, there are three basic calculation options: (i) Automatic, (ii) Automatic except tables, and (iii) Manual. The first of these, "Automatic," is self-evident—Excel will automatically perform every calculation in the model anytime a cell is changed. This option is the one you will typically use. The second option, "Automatic except tables," is like the first except that data tables are only recalculated when manually requested (by striking the F9 key). This option can be useful because recalculating data tables for a large model can noticeably slow your computer. While these data tables are important “outputs” of your model (to be discussed below), they do not need to be continuously updated while you are working on the model itself.

Option (iii), “Manual,” causes Excel not to perform any calculations until you tell it to (by striking the F9 key). This option can be useful in models that work on large datasets, so that each recalculation is slow. It can also be useful if you want to make several changes to your model and do not want Excel to recalculate until you are finished (e.g., in cases where two or more changes need to be made to avoid a broken link or “#REF” errors). Be aware, though, that none of the numbers in your model will “add up” correctly until you hit F9.

In addition, notice the “Iteration” option in the above menu. Excel has the power to overcome circular references by repetitive iteration of the calculation, progressively honing in on the correct answer. In general, it is a bad idea to turn on this function unless/until it is needed, as most circular references are caused by model error and not by design. Turning on iterations will mask any inadvertent circular references in your model and may lead you to an errant result.

Later in the course we will see specific cases where circular references can be both valid and extremely powerful. However, even in the cases where we will want to use a circular reference, it is often safest to build the model first without the circular reference (to be sure it actually works), then add the circularity only once it is absolutely needed.[6]

Finally, in analyzing sensitivities, it is often helpful to do so by using a data table. Data tables allow us to change two variables simultaneously and see their impact on an output. As an example, it is very common in LBO models to sensitize the IRR by simultaneously changing the purchase price and exit multiple. This sensitivity analysis can be easily done by using a data table. If you are unfamiliar with data tables, **Exhibit 2** provides Excel’s overview of this function.

In addition to these tips and tricks, **Exhibit 3** provides a list of Excel functions commonly used in financial models. If you are unfamiliar with any of these functions, it might be helpful to spend a few minutes looking them up with the Excel help function.

SUMMARY

Financial models are powerful in their ability to help us manage and represent complexity. However, they are only tools; they are not answers. Due to the complexity and uniqueness of any individual business, much thought needs to be put into the specific assumptions and format of a financial model that will represent such a business. There are a number of “best practice” approaches to modeling complexity. Nevertheless, there are few hard and fast rules that will apply in all situations. As a result, we must think carefully about the specific business that we wish to model. In general, it is helpful to start with a market model (if appropriate), construct an operating model that draws on the outputs of this market model, and then extend the operating model using a simple cash flow model or an integrated financial statement model. Against these models, we can apply valuation techniques or extend these basic models to achieve a special purpose, such as

[6] A common case in which we will use a circular reference is to calculate average interest on debt and cash balances. If the balances are changing during the year, we would like to calculate interest on the average balance. But because the end of year balance depends on interest, we have the circular reference.

valuing a leveraged buyout. Finally, we can extend these models to analyze individual securities or entire portfolios.

In this course, we will attempt to convey as much industry wisdom and as many best practices as possible. However, at the end of the day, modeling is more of an art than a science. As such, you should always use your judgement and think carefully about the choices that you make in your models and the implications of those choices.

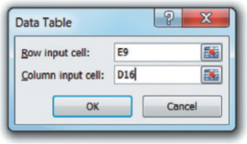
Exhibit 1: Excel Shortcuts

Useful Keyboard Shortcuts (Excel 07|10|16|365)				
Enter data and formulas			**Moving Around**	
	Ctrl Z	Undo	arrow keys	Move one cell
	Ctrl Y	Redo	Ctrl + arrow key	Move to end of column or row
	Ctrl C	Copy	Ctrl Tab	Toggle workbooks
	Ctrl X	Cut (Move)	Ctrl PageUp	Move to next worksheet
	Ctrl V	Paste	Ctrl PageDown	Move to previous worksheet
	Ctrl Alt V	Paste special	Ctrl F	Find
	F4 (in cell)	Toggle absolute/relative reference	F5	Go to
	Alt I R	Insert row	Ctrl Home/End	Go to first/last cell in worksheet
	Alt I C	Insert column	**Selecting Cells**	
	Ctrl R	Fill right	Shift + move	Select cells
	Ctrl D	Fill down	Shift + bkspace	Deselect cells
	Alt =	Auto sum	Ctrl + space	Select column
	Ctrl -	Delete cells	Shift + space	Select row
	Ctrl +	Insert cells	Ctrl+Shift+space	Select all
	Ctrl ;	Insert date	Shift F8	Add to selection
	Ctrl :	Insert time	**Auditing tools**	
	Esc	Cancel entry	F2	Edit cell and color code precedents
Naming, Commenting, Grouping			Ctrl [	Go to precedents (use tab to cycle)
	Alt M N N	Name a cell	Ctrl]	Go to dependents (use tab to cycle)
	Ctrl Shift F3	Create name from adjacent labels	Ctrl `	Toggle formula view
	Alt D G G	Group rows or columns	Alt M P	Trace precedents of cell
	Alt D G U	Ungroup	Alt M D	Trace dependents of cell
	Alt R C	Add comment	Alt M A A	Remove arrows
	Alt R D	Remove comment	Alt M V	Evaluate formula (step by step)
Turbo Macros in Personal F350.2021.xlsb				
	Ctrl Shift M	More decimals	Ctrl Shift N	Toggle number format:
	Ctrl Shift L	Less decimals		Number (0.0)
	Ctrl Shift I	Zoom in		Dollar ($0.0)
	Ctrl Shift O	Zoom out		Percent (0.0%)
	Ctrl Shift W	Set column width = 1,2,3		Multiple (0.0x)
	Ctrl Shift P	Trace precedents of selection		General
	Ctrl Shift D	Trace dependents of selection	Ctrl Shift C	Color toggle:
	Ctrl Shift R	Remove arrows		Blue, Green, Red, Black
	Ctrl Shift V	Paste format	Ctrl Shift A	Alignment toggle:
	Ctrl Shift H	Home on all tabs		Left, Right, Center across selection,
	Ctrl Shift U	Single/Double Acct Underline		General
	Ctrl Shift Q	Toggle Iteration	Ctrl Shift B	Border Toggle
	Ctrl Shift E	Easy Auto Color		Top, Right, Bottom, Left, None
	Ctrl Shift X	Replicate Range	Ctrl Shift F	Fill Toggle (Grey,Yellow,Red,None)

Exhibit 2:
Using Data Tables in Excel

Data Tables for Sensitivity Analysis

Data tables, which we introduced in the appendix of Chapter 7 to construct the NPV profile, allow us to compute the sensitivity of NPV to any other input variable in our financial model. Excel can also compute a two-dimensional data table showing the sensitivity of NPV to two inputs simultaneously. For example, the data table below shows NPVs for different combinations of the Hardware R&D budget and HomeNet's manufacturing costs.



	C	D	E	F	G	H
55	NPV		HomeNet Cost / Unit			
56		7,627	$110	$105	$100	$95
57	Hardware R&D Expense	(5,000)	7,627	8,817	10,008	11,198
58		(5,500)	7,227	8,417	9,608	10,798
59		(6,000)	6,827	8,017	9,208	10,398
60		(6,500)	6,427	7,617	8,808	9,998
61		(7,000)	6,027	7,217	8,408	9,598
62		(7,500)	5,627	6,817	8,008	9,198
63		(8,000)	5,227	6,417	7,608	8,798
64		(8,500)	4,827	6,017	7,208	8,398
65		(9,000)	4,427	5,617	6,808	7,998
66		(9,500)	4,027	5,217	6,408	7,598
67		(10,000)	3,627	4,817	6,008	7,198

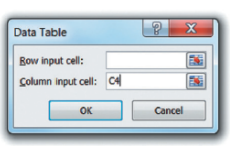
To construct this data table, put the values of each input along the sides of the table (shown in blue), and a formula for the value we want to compute in the upper left corner (cell D56, which in this case is just a link to the cell in which we computed the NPV). Select the entire table (D56:H67), bring up the Data Table window (see the Data > What-If Analysis menu or keyboard shortcut Alt-D-T), and input the locations in our project dashboard (see page 255) of the cost assumption (row input cell E9) and hardware budget (column input cell D16). The data table shows, for example, that NPV increases if we lower our manufacturing cost to $100 per unit by increasing the hardware budget to $7.5 million.

Scenarios in the Project Dashboard

The project dashboard on page 255 only shows our base-case assumptions. We can build multiple scenarios into our project dashboard by adding additional rows with alternative assumptions, and then using Excel's index function to select the scenario we would like to use in our analysis. For example, rows 5–7 below show alternative annual sales assumptions for HomeNet. We then select the scenario to analyze by entering the appropriate number (in this case 1, 2 or 3) in the highlighted cell (C4), and use the index function to pull the appropriate data into row 4.

	A	B	C	D	E	F	G	H
2	***Key Assumptions***			**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**
3		*Revenues & Costs*						
4		HomeNet Units Sold	1	-	100	100	100	=INDEX(H5:H7,C4)
5		*Base Case*	*1*	-	*100*	*100*	*100*	*100*
6		*Fast Adoption*	*2*	-	*125*	*150*	*200*	*125*
7		*Slow Adoption*	*3*	-	*50*	*75*	*100*	*100*

We can then analyze the consequences for each scenario using the one-dimensional data table in C70:D73 below, with column input cell C4.



	A	B	C	D
69				NPV
70		HomeNet Units Sold		7,627
71		*Base Case*	*1*	7,627
72		*Fast Adoption*	*2*	24,007
73		*Slow Adoption*	*3*	540

Note that "Row Input cell" = input that changes according to top row of table, and "Column Input cell" = input that changes according to left column of table. See Excel help files and Berk and DeMarzo, *Corporate Finance*, Chapter 8 for further details.

Exhibit 3:
Common Excel Functions in Financial Models

AVERAGE	MATCH	*When dealing with loans:*
AVERAGEIFS	MAX	PMT
CHOOSE	MIN	FV
COUNT	OFFSET	PV
IF	SUM	RATE
IF(AND(	SUMIFS	EFFECT
IF(OR(	SUMPRODUCT	
IFERROR	TRANSPOSE	*Sometimes used:*
IFS	VLOOKUP	NPV
INDEX	XIRR	XNPV
IRR	XLOOKUP	

Hint: to see more information on any Excel function, enter = + function name + Ctrl A to get help on the specific function arguments and the corresponding result.