Measurement and Financial Economics Valuation

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VALUE BASED BALANCE SHEET (VBB): CONNECTING IFRS FAIR VALUE MEASUREMENT AND FINANCIAL ECONOMICS VALUATION

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ABSTRACT

For many years accounting was based on historical data while finance was based on expected future data. This difference creates a gap between accounting and finance regarding issues like the values of assets held by companies and liabilities, including equity, issued by them. IFRS in general and the fair value measurement as introduced by IAS in the last few years brings accounting and finance together. In this study we present, discuss and test a measurement instrument called Value Based balance Sheet (VBB). The VBB rests on three major propositions in accounting and finance; first, the accounting paradigm that describes a firm by its assets and liabilities and defines the identity between them. Second, the finance valuation model that defines the value of a firm as the discounted risk adjusted cash flows to be generated by the firm, and then allocate the actual cash flows over time to different claimants. The third proposition has two parts; in a complete and perfect market the value of the firm is independent of its capital structure, in an incomplete market with monopolistic competition the risk profile of the liabilities should be congruent with the risk profile of the assets. Ex ante Incongruence between the risk profile of the liabilities and the assets will reduce the value of the firm. The VBB focuses on the third proposition, but it also reflects the first two propositions. The VBB differs from other valuation instruments like Economic Value Added (EVA) in looking at both the assets and the liabilities of the firm and the relationships between them. We test the VBB as a way to gain better insights into the development of value over time. We do that by using a unique data set of venture capital backed (VC) young innovative companies in the software industry. The test shows that the VBB is an effective way to trace and better understand the dynamics of the value of these firms.

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1. **Introduction**

Fair value measurement is a main feature of IFRS accounting. As of January 2013 the process of introducing IFRS 13 Fair Value measurement will become mandatory, although it has been already adopted in many countries. In May 2011 the International Accounting Standards Board (IASB) published a detailed analysis of the fair value measurement (IFRS, 2011). In this document the IASB defines what they called "Fair value hierarchy as composed of three levels of inputs for valuation. The three levels are:

"Level 1  Quoted prices in active markets for identical assets and liabilities. Level 1 input must be used without adjustments wherever available.

Level 2  Inputs not included within Level 1 that are observable for the asset or liability, either directly or indirectly.

Level 3  Unobservable inputs, including the entities own data, which are adjusted if necessary to reflect market participants' assumptions".

In a seminal article published more than fifty years ago Modigliani and Miller set up the basic valuation model for financial economics (Modigliani and Miller 1958). In this study, commonly known as the MM model, they use the accounting paradigm of a balance sheet. They define assets as the risk adjusted discounted cash flows to be generated by firm, and liabilities (including equity) as the risk adjusted discounted cash flows to be paid by the firm to all claimants (holders of the liabilities issued by the firm). Value in the MM model is measured by the assets and the liabilities (including equity) is a list that tells us how the value of the firm is allocated among different claimants, shareholders, debt holders and other stakeholders of the firm. In the original 1958 article MM assumes complete and perfect market. Given this assumption all assets and all liabilities are traded continuously in perfect public markets with complete information that is shared by everybody. In such a world all valuation is done by Level 1 data. In the more realistic world of incomplete markets and monopolistic competition in which actual valuation is done there is a need to use Level 2 and Level 3 data.

IFRS 13 Fair Value Measurement brings the accounting valuation and the financial economics valuation very close together. In this study we present and discuss an instrument that allows a better and more complete valuation of assets
and liabilities within the definition of IFRS 13 where Level 2 and Level 3 data is used. The instrument called Value Based Balance Sheet (VBB) is based on the identity of both the current value of assets and liabilities and the identity of the risk profile of the assets and the liabilities of the firm. Moreover, as the value and the risk of the assets of the firm is developed over time so does the value and the risk of the liabilities (including equity) of the firm. The VBB measures in an explicit way the value and the risk of the assets and the liabilities of the firm. In a world of incomplete markets and monopolistic competition it is possible and even likely that given a particular type of assets there is an optimal set of liabilities (including equity). Thus if the assets are very risky we would expect them to be financed by equity only.

In section 2 the VBB is defined and discussed but using a numerical example. The example demonstrate what data is needed and how the VBB is used to value assets and liabilities. In section 3 we discuss the VBB in the context of financial economics. We begin with the classic MM valuation model. In a world of perfect and complete markets where Level 1 data would be available for all assets and liabilities there would be no need for specific measurement and valuation instruments like the VBB as current market prices will reflect precisely the value of all assets and liabilities. The VBB is useful in a world of Level 3 data where markets are incomplete and information is often based on specific assumptions made by agents in the markets. An important part in both the financial economics valuation and the IFRS 13 valuation is that the risk profile of the assets and the liabilities (included equity) of the firm are identical. A specific feature of the VBB is the focus on the risk profile of the assets and the liabilities of the firm. The literature of financial economics provides a way to measure the risk profiles of both assets and liabilities. In section 4 we apply this concept called "risk classes" as it is discussed in the literature (Fama and Miller 1972) in the section we develop two related concepts, financial congruence and derived internal) and external liabilities. The former are given by the organization of the firm and the latter can be chosen within limits by the management of the firm. In the last section of the paper, section 5, we estimate the VBB as a financial management tool on a data set of venture capital backed firms. All the firms in the sample are in the software industry and they went through an IPO either in NASDAQ or in TASE (Tel Aviv Stock Exchange). We collect data on the private pre IPO valuation of the firms in
the sample as well as post-IPO data from the market. We estimated the VBB based valuation based on the five years expected sales and on intellectual property (IP) values using various simulation techniques. The VBB captures the dynamics changes in the value over time as the firms grew and developed. We conclude the paper in section 6 with a discussion of the VBB as an instrument to improve the use of Level 3 data in Fair Value measurement in a consistent way with the financial economics valuation model.
2. The Definition of Value-Based Balance Sheet – A Bridge between Accounting and Finance

Value-Based Balance sheet, (VBB), is an instrument to measure the value of assets and liabilities in a firm's balance sheet in a congruent way with both the IFRS Fair Value Measurement and the classic MM financial economics valuation model. The VBB draws from two major propositions:

1. The Accounting paradigm where the firm is presented as the sum total of its assets, and the way that this value is allocated is presented by its liabilities and net worth.

2. The Risk Adjusted Net Present Value (RAD - NPV) practice where the value of the firm is presented by the risk adjusted discounted value of its free cash flows.

The VBB keeps the form of a balance sheet. Future positive cash flows and future payments by the firm to its stakeholders are discounted taking time and risk into account. Like all balance sheets the current value of the assets in the VBB is identically equal to the current value of the liabilities (including equity). However, there are some differences between the way that assets and liabilities are calculated in an accounting balance sheet and in the VBB.

1. Assets and liabilities in the VBB are calculated as the discounted cash flows of the revenues, (assets), and the expenditures, (liabilities). Therefore, the VBB reflects future cash flows, revenues and expenditures, rather than historical values.

2. Instead of the past being the basis period the VBB reflects the future. Therefore the relevant future periods for the measurement of the VBB have to be defined.

3. Calculating the assets and the liabilities as discounted cash flows requires estimating the level of risk involved in the cash flows and

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1 We ignore the usual separation between “Stocks” and “Liabilities” in the context of the issuing firm. The liability to the firm’s shareholders is viewed here as any other liability.

2 A useful procedure is to define the VBB over the period for which the firm has a business plan or a budget. Future periods after that can be dealt by using a multiplier from the last period of the business plan on.
therefore to choose appropriate discount factors.\(^3\) In this we follow the traditional assumptions that limit the joint probability distribution of the future cash flows of a given investment project.

4. The future expenditures are presented as liabilities in the VBB. The liabilities are divided into two classes: (a) derived liabilities, and (b) discretionary liabilities. Liabilities to owners of specific factors of production that are a part of the production process of the firm are derived or internal liabilities\(^4\). Liabilities to providers of general capital like bank loans, bonds and shares are regarded as discretionary or external liabilities.

5. The standard accounting balance sheet reflects the past. The identity between assets and liabilities does not have any direction and they just reflect each other. The VBB is future oriented so such a direction exists– from assets to liabilities. Such a link was proposed by Fama and Miller in “The Theory of Finance”, (1972). The assets (the real side) determines the value of the firm, the liabilities (the financial side) tells us how this value is distributed among different security holders. The directional relationship between assets and liabilities is more pronounced once we allow for incomplete and imperfect markets.

To see how the Value Based Balance Sheet is measured and interpreted consider the following example:

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\(^3\) It is likely that any source of revenues, for example the sales of a given product in a given market, and any expenditure, for example a certain input like energy, have their own riskiness. Yet, for measurement it is useful to find a small number of typical distributions that can describe the different classes of the riskiness of the future cash flows that comprise the assets and the liabilities. Such an approach is presented in section 4 below.

\(^4\) These liabilities can be to employees, (future wages and other compensation packages), suppliers, service providers, government, etc. These liabilities are often ignored or they appear only in a partial way in a standard accounting balance sheet. The internal liabilities are derived directly from the arrangements that the firm has with its suppliers, including the suppliers of labor and human capital. Once the firm arranges these, there are other financial needs that are met by issuing external liabilities. Structuring these liabilities that is whether to issue debt or equity, borrow money from the bank, or issue any derivatives is a managerial decision given the total needs of the firm. This decision is not independent from the nature of the assets and the nature of the derived, (internal), liabilities.
Value Based Balance Sheet of firm i  
2011-2016 
(Millions of $)

<table>
<thead>
<tr>
<th>ASSETS</th>
<th>LIABILITIES AND NET WORTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales of Product A in Market 1</td>
<td>Liabilities to Workers</td>
</tr>
<tr>
<td>150</td>
<td>90</td>
</tr>
<tr>
<td>Sales of Product A in Market 2</td>
<td>Liabilities to Suppliers</td>
</tr>
<tr>
<td>80</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Liabilities to Providers of Services</td>
</tr>
<tr>
<td></td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Liabilities to Bondholders</td>
</tr>
<tr>
<td></td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Liabilities to Shareholders</td>
</tr>
<tr>
<td></td>
<td>65</td>
</tr>
</tbody>
</table>

Total Assets 230 Total Liabilities 230

The assets are the present value of the cash flows to be derived over the planning horizon, (2013-2018) plus the computed residual value from there on of the future sales of the relevant products in the relevant markets. Assume that the future cash flows over time are normally distributed with an expected value $E(CF)_t$, and a standard deviation $\sigma(CF)_t$. The derived liabilities are divided into two parts; wage is fixed and is treated as a riskless bond issued by the firm to the employees. The other derived liabilities, (to suppliers, service providers, and such like) are contingent on the sales, and thus are assumed to be normally distributed with a lower expected value and an identical standard deviation$^5$. Assume farther that the markets estimate the distributions$^6$ in the same way as the firm. Given the riskless bond that the firm issued to its employees, the capability of the firm to issue another riskless bond given the assumed distribution of the future cash flows, is estimated at 20MM$ (in present value terms). Therefore, in the VBB, the discretionary financial liabilities are 20MM$ of riskless debt, and 65 MM$ of equity, (also in present value terms). For simplicity

$^5$ It is so only for simplicity. The VBB restricts the Total variation to be the same for the assets side and the liabilities side. Each and any asset/liability can have a different distribution with different moments.

$^6$ The markets in this case represent the loaners. They estimate the risks concerning the cash flows of the sales, assets, expenditures, and the derived liabilities.
assume that both riskless bonds and equity are held by the same investors. The measurement of the assets and the liabilities of the firm in the example above are similar in nature to using Level 3 data in terms of IFRS 13. In this case internal data of the firm is used to form the value of the assets and that value is reflected in the liabilities. The above is a simplistic example to show how the VBB of a specific firm is measures. In the empirical part of this paper we actually estimate the VBB for a specific group of firms and derived a valuation. This valuation is consistent with both IFRS 13 and with the financial economics valuation model.

3. VBB and the Financial Economics Valuation Model: From Modigliani-Miller to Agency and Imperfect Competition

Fama and Miller argue that “In the two-period model the basic objects that must be priced in the capital market in period 1 are the probability distributions on the total market values of individual firms at period 2. The fragmentations of these distributions made possible by financial opportunities represent ways of subdividing the risks of any given distribution among investors.”, (The Theory of Finance, (1972), pp. 157).

The VBB is consistent with the financial economics valuation model. The classic financial economics valuation model is built on the assumption of complete and perfect markets where all assets and liabilities are continuously traded in public markets. This situation is referred to as Level 1 data in IFRS 13 and is relevant in limited cases. The VBB makes it possible to use a similar model using the firm's or others like auditors and external valuators as sources for the needed data to build up the valuation.

The basic valuation model is derived from the State-Preference approach, (Arrow, (1964), Debreu, (1959), Hirshleifer, (1965)). As Goldstein et al (2001) show, the sum of the present value of the claim to funds during solvency and the present value of the claims to funds in bankruptcy is equal to the present value of the claim to EBIT of the value.

Hence, value is neither created nor destroyed by changes in the capital structure.
Assume that the basic conditions of the State Preference approach hold\(^7\), and that there is a pricing functional \( P \in M \) such that:

\[
p(1), p(2), \ldots, p(S) \quad \forall p(s).
\]

Where \( p(s) \) is the price at period 1 of $1 at period 2 iff state \( s \) occurs.

An asset \( x \) of the firm \( (1, 2, \ldots, x, X) \) can be described as:

\[
V_a(x)(1) = \sum_{s=1}^{S} P(s) \cdot V_a(2, s) \text{ at period 1}
\]

Following the State-Preference approach, there is a finite number of states of the world that together describe fully the distribution of the cash flows that comprises the asset.

The value of the sum of the assets in the VBB of the firm, (the value of the firm), is:

\[
V_A(1) = \sum_{x=1}^{X} \sum_{s=1}^{S} P(s) \cdot V_a(2, s)
\]

The firm issues liabilities against its assets. The value of any given liability \( y \) \((y = 1, 2, \ldots, y, Y)\) is:

\[
V_{I,y}(1) = \sum_{s=1}^{S} P(s) \cdot V_{I,y}(2, s)
\]

The value of the liabilities of the firm given the information contained in the VBB is:

\[
V_I(1) = \sum_{x=1}^{X} \sum_{s=1}^{S} P(s) \cdot V_{I}(2, s)
\]

The identity between the assets and the liabilities in the VBB means that in period 1

\[
V_A(1) = V_I(1)
\]

In a world of complete and perfect markets there are markets for all types of liabilities including derived securities like wage contracts and other internal securities issued by the firm\(^8\). In such a world the separation principle holds. In this world the famous

\[7\] At period 1 suppose that investors agree that there are a finite number \( S \) of mutually exclusive possible states of the world at period 2 and that for a given set of decisions made by the firms (at period 1) the market value of firm \( i \) if a certain state “\( s \)” occurs is \( V_i( t=2, s) \)

\[8\] A perfect market world means that an employee who has an implicit promise of the firm to pay him a certain sum contingent on the success of the business plan of the firm, can sell such an implicit liability in the market today,
Modigliani-Miller, (1958), result hold, and the value of the firm is independent of its financing decisions as they are interpreted in a broad sense in the VBB. As Fama and Miller concluded their discussion of the independence of the financing from the investment decisions:

“Thus the period 1 market value of the firm is the same under all three different assumptions about financing decisions and in fact is always equal to the period 1 values of the total resources generated by the firm in each possible future state.” (The Theory of Finance (1972), pp. 159-160).

The total resources generated by the firm in each possible state of nature is exactly the sum of the assets in the VBB. Extending the basic two period model of Modigliani and Miller to a multi-period framework like the VBB, is straightforward.

The contingent value of the debt and equity at time T can be represented as

\[ V_D = \begin{cases} W(T) & \text{if } W(T) < F \\ F & \text{if } F \leq (W(T)) \end{cases} \]

\[ V_S = \begin{cases} 0 & \text{if } W(T) < F \\ W(T) - F & \text{if } F \leq W(T) \end{cases} \]

Where \( V_D \) is the value of the debt at time t and \( V_S \) is the value of stock at time t. The value of the firm \( W \) at time t is \( W(t) = V_D(t) + V_S(t) \)

Let F be the repayment of the debt upon maturity. If \( W(T) \) exceeds F, the firm can redeem its debt as promised. If \( W(T) \) is less than F the firm is in default and all the value of the firm goes to the bondholders. This is true if the firm issues shares and bonds only. In a more general case the firm issues N claims to shareholders, bondholders, managers, workers, suppliers, and providers of services.

Let the claims be \( V_1, V_2, \ldots, V_N \).

Some of the claims are inclusively defined by the functional \( w \) and \( t \), such as simple debt to be matured at a certain time \( T \). Some claims such as future salaries, taxes etc. are not defined directly by \( t \).
The primary problem is identifying the forms of the contingent value function, or identifying how these claims are valued. In the two-claims world ($V_S$ and $V_D$) the illustration is simple:

Exists a pair of contingent value functions $f_1$ and $f_2$ and their arguments $t$ (time) and $W$ - the value of the firm. The $i$-th security (or claim) at time $t \leq T$ can be stated as

$$ V_i(t) = f_i(W(t),t) \quad \forall \quad i = D,V $$

For the simple MM case in which we have only common stock and pure debt, for time $t=T$ we can draw:

$$ f_D(W,T) = \min[W,F] $$

$$ f_S(W,T) = \max[0,W-F] $$

Once other claims are introduced, particularly claims that are not independent of the EBIT produced by the assets of the firms, the valuation is not as simple as in the MM case. This is because $F$ is dependent on the structure of the claims held by some claimants. Two major groups of claimants that belong to this group are providers of human capital, managers and workers, and providers of inputs to the firm where the inputs are traded in a market of monopolistic competition. In these two cases we cannot use the general equilibrium approach that was developed by several authors following the MM approach, (see for example Garbade$^9$), rather we have to look for different approaches.

The extensive literature on agency cost, and financial distress, and the economic literature that use game theory approach are the natural place to look for models that are based on imperfect and incomplete markets. A good summary of the different approaches and the implications of the imperfection is in Brennan and Trigeorgis (2000). Brennan and Trigeorgis distinguish between three stages in the development of valuation models by the degree of control that various stakeholders in the firm have upon the cash flows of a given project over its lifetime. The first stage models are consistent with the Modigliani- Miller 1958 model of the value of the firm. Capital

$^9$ Pricing Corporate Securities as Contingent claims, MIT press, 2001
structure does not matter because no stakeholder exercises any control on the future cash flows of any given project\textsuperscript{10}.

The second stage models, often referred to as “Agency Cost” models, focus on the top management of the firm as a specific group of stakeholders, “agents” of the shareholders, who can affect the future cash flows by their activities. They are motivated by their contracts with the shareholders. Here one can assume that the markets are incomplete, especially where management contracts are concerned. In cases in which liabilities to top management and other professionals are an important part of the liabilities issued by the firm, the design of the liabilities to the providers of human capital (presented later in this paper as Financial Congruence) have an effect on the value of the firm. Seed and early stage hi-Tec firms is a special case of such a class.

The third stage models assume that a number of external stakeholders have the ability to affect the future cash flows of investment projects taken by the firm. These may be suppliers, external service providers, but also competitors who may have an indirect effect on the EBIT of the firm through price competition and similar factors. Similar situations are discussed in the Industrial Organization and New Trade Theory. Hotelling initiated the use of spatial analogies in assessing market differentiation. Cromley and Hanink (2002) follow this line to analyze differentiated international markets. The continuum of demand points is partitioned into homogeneous segments by use of a classification algorithm that minimizes within-group variation. The criteria used for classifying are two indicators of market overlap that have been suggested as important by the new trade theory, proximity of gross national product (GNP), and proximity of per capita GNP. Such models lead to a world of multiple equilibria\textsuperscript{11}. The design of the liabilities issued by the firm becomes

\textsuperscript{10} This is a direct outcome of how the perfect and complete projects undertaken by the firm determines its value. The capital structure is just a way to allocate the value generated by the firm among the suppliers of capital. All other factors of production are paid at the going market rate, and the firm faces an infinitely elastic supply curve of such factors.

\textsuperscript{11} The analysis of various possible values of the market values as Multiple Equilibria, is based on Lintner’s equilibrium of the firm market value.
a part of a strategy based on stochastic dominance and backward induction approach with its advantages and disadvantages as a framework for an economic analysis and managerial application.

The VBB approach provides a framework for such an analysis and for specific solution. By dealing with a single firm we avoid the need to specify which of the multiple equilibria will occur. Suffice is to say that there is an equilibrium solution in the market. The VBB framework can be regarded as a game where the decision makers within the firm have to decide on the type, and the nature of the liabilities of the firm given the assets of the firm and market conditions. The rules of the game, are the firm’s valuation function, such that the total value of the firm is maximized.

\[
V_{i0} = \frac{V_{i1} - \gamma \sum_j \pi_{ij}}{1+\gamma},
\]
whereas the end-of-period value of firm i is denoted by \( \tilde{V}_{i1} \) and it is normally distributed with mean \( \tilde{V}_{i1} \) and standard deviation \( \sigma_i \). The market value \( V_{i0} \) simultaneously determines the rates of return, the standard deviation and the covariance of returns, the proportion of each firm in the market portfolio and the beta, as the outcome of this equilibrium.
4. Risk Class and Financial Congruence

Once accounting moves from using only past data to allow estimates done by the management of the firm and/or external professionals we have to measure and to account for the risk profile of the assets and the liabilities. In general in the VBB measurement the current value and the risk profile of the assets is identically equal to the current value and the risk profile of the liabilities. We name this requirement as "financial congruence".

Financial congruence measures the changes in the value of a given liability where the value of the asset against the liability was issued changes. In the context of a firm, the financial congruence measures the change in the sum total of the liabilities where the value of the sum total of the assets changes. Financial congruence is an ex ante concept. Ex post The value of the assets is always identically equal to the value of the liabilities (including equity). The concept of financial congruence is related to the notion of a risk class. Fama and Miller introduced the notion of a risk class as a way to discuss risk in the MM model. To see this consider the following example:

Two firms $i$ and $j$ are in the same risk class iff for all $t, t \in T$

$$A_i(t) = P_i A_j(t)$$

and

$$L_i(t) = P_i L_j(t)$$

$\forall \ 0 \leq P_i \leq 1$

Let $A_i(t)$ be the cash flows of asset A of firm $i$ at period $t$ and $L_i(t)$ be the cash flows of liability L of firm $i$ at period $t$. $P_i$ is a proportionality factor which is the same for all $t$. Note that in periods before $t$, cash flows are uncertain, but for the firms $i, j$ to be in the same risk class their cash flows are always proportional by the factor $P_i$ and hence perfectly correlated. In the same manner we can perfectly correlate the firms’ cash earnings (Assets) and cash outlays (Liabilities)

Such that at any given $t, t \in T$

$$A_i(t) = P_i L_i(t)$$

4.3
\( \forall 0 \leq P_i \leq 1 \)

A sufficient condition for complete financial congruence is that relation (4.3) is true for every asset \( A_i \) at any given time \( t \).

A necessary condition for a complete financial congruence is that the sum total of the assets is in the same risk class as the sum total of the liabilities in the same risk class. The condition holds where \( P_i \) is less than one. In this case the relationship between assets and liabilities is given by:

Such that: \( A \equiv L \)

\[
A = \sum_{t=1}^{T} \sum_{n=1}^{N} a_n(t) = L = P \sum_{t=1}^{T} \sum_{m=1}^{M-1} l_m(t) + (1 - P) \cdot L \cdot M
\]

4.4

Proposition 4.4 implies the possibility of a value maximizing diversification within the firm. This is not surprising as financial congruency is important only where there are no complete and perfect markets. In a world of an imperfect competition it is likely that firms (and managers) will decide to diversify as a way to reduce their risk, as they often do.

The LHS of the equation above is the sum of all the assets, \((n=1,2,3,\ldots,N)\), owned by firm \( i \). Assets are represented by cash flows over time. The RHS is composed of two parts:

1. Future cash flows of the expenditures, (liabilities) minus one which is proportional to the cash flows of the assets but in proportion which is less than one.

2. The last liability (\( M \)) is the liability to the shareholders who are defined as the residual claimants. Shareholders receive whatever is left after all other claims were paid. As \( 0 \leq P \leq 1 \), from proposition 4.4 follows that the firm is always solvent and the financial congruency is complete.

What makes the firm solvent at all states is the constraint on \( P \). This is not always the case. Assume that a firm issues a bond that promises to pay the same amount regardless of the states of nature, and that this amount is equal to the expected value of the cash flows at any given period. In a complete and perfect market world, this will not alter the value of the firm. In such a world there is a market price today to any
contingent claim. The market knows how to unpack securities that are comprised of a number of basic claims that pay $1 given a certain state of the world in a given period. Although the bond issued by the firm promises to pay the same amount in any state of the world, and thus it appears as it is a riskless bond, the market will acknowledges the embedded option that prices the market risk. Hence, the market will price it according to the riskiness of the underlying assets. Where markets are incomplete, and in particular where the current and future actions of some security holders may affect the value of the liabilities of the firm, the constraint on the value of P does not hold. The firm may find itself insolvent in a certain period even if it has a positive net present value over time. In such a situation, the absence of financial congruency has an effect on the value of the firm.

Deviations from the perfect and complete markets are obtained where agency cost is introduced. Maurer and Ott show that were there are costs of financial distress equity holders will underinvest in an option to expand the business. Once we deviate from the elegant, but rather restrictive risk class model with its assumption of perfect and complete markets there is a need to specify the probability distribution of the cash flows that generate the assets. This is so because financial congruency requires that the probability distribution of the liabilities will be congruent with the probability distribution of the assets. Agmon and Whilborg provide a simple but effective way to classify uncertain outcomes that can be applied to the risk associated to the assets in the VBB of a given firm.

In order to do so the information about the past behavior of the cash flows of a given asset is collected. This usually consists of past sales records. The information is then supplemented by any relevant data about the market, competition, regulations, and such like. The data is then classified into three categories: Consensus, No-Information, and Either-Or. The three categories is then summarized as specific distributions. The

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12 In a complete market with full information it is assumed that this adjustment is costless.
13 See Brennan and Trigeorgis “Project Flexibility, Agency, and Competition”
14 Underinvestment is measured in relative to ARGMAX (Investment) that maximizes the value of the firm. If as shown, underinvestment is a result of the agency cost of the debt, the agency cost of the debt is the result of the decision of management to maximize the value of the shareholders rather than the value of the company.
Consensus category is fitted as a normal distribution, the No-Information category is fitted as a uniform distribution, and the Either-Or category into a binomial distribution.

The procedures is summarized in the following table.

<table>
<thead>
<tr>
<th>Type of Information</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consensus</td>
<td>Normal</td>
</tr>
<tr>
<td>No-Information</td>
<td>Uniform</td>
</tr>
<tr>
<td>Either-Or</td>
<td>Binomial</td>
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</tbody>
</table>

While issuing liabilities, explicit or implicit, the firm considers the distributional nature of its assets. For instance, the sum total of the assets of firm i is represented by a binomial distribution, then financial congruency means that the maximum value of a riskless bond that firm i can issue is bounded by a payment that is congruent with the low branch of the binomial tree. Such a situation calls for embedding an option in the liability. 15 This is just one simple example. An actual design of liabilities to accomplish financial congruency and maximizing value requires much more data. For instance, measuring not only the 1\textsuperscript{st} and 2\textsuperscript{nd} moments but also the 3\textsuperscript{rd}, (Skewness). Let us consider an asymmetric shift in the terminal payout probability profile. The assumption that costs are distributed normally produced a symmetric distribution of project values. Equity holders would prefer instead that this distribution were skewed to the right, which is to say that upside potential was enhanced without sacrificing the financial stability of the firm. We can observe then, that positive Skewness is valuable. 16 The specification of the underlying distribution is an important input in Level 1 data valuations for IFRS 13 fair value estimates as they give relevant information to the readers of the financial reports and may explain differences among different valuators.

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15 In firms where employees compensation comprises the lion’s share of the liabilities, and the assets cash flows are represented by binomial distributions, it is likely that financial congruency means combining fixed wages (liabilities) with bonuses (options).
16 Rode et at. (2003) show that projects that promote upside potential benefit the equity holders directly -even if variance is unchanged. More significantly for our purposes however, is the observation that Skewness is often invisible to conventional best case/base case/worst case assessments of projects because such analysis gives insufficient attention to probabilities, and the representation of projects via only discrete stylized outcomes admits a virtual continuum of possible outcomes, all of which could share the same points yet remain vastly different.
5. Estimating the VBB as a Valuation Instrument

In order to see how the VBB can be used in a real situation we conduct an empirical test for the VBB as an instrument of valuation. We chose to do that on a data base of small innovative firms who were backed by venture capital funds and went through what is known as an "exit" through an IPO. The VBB frame is ideal for valuation of such firms as their balance sheets are very similar in the composition of the assets and liabilities and they all went through a similar path of growth from the first round investment to the IPO.

The empirical work on "Fair Value" implementation is yet scarce. Scheibel (2007) compares between the German GAAP method (that ceased to exist after 2004) and IFRS. The results of the study show that German GAAP is significantly more value relevant statistically than IFRS. Ernstberger (2008), using the same database a different selection criteria, reports the opposite: "comprehensive income under IFRS provides more incremental value relevant information than comprehensive income under US GAAP". Florou and Pope (2012), using an international database show that enforcement of IFRS creates a stronger demand for equities.

We focus on a simple question. Can we utilize the VBB as an effective measurement tool. We use a dataset of firms from the software industry. All the firms are venture capital backed start-ups that had an IPO at either at NASDAQ or at TASE (Tel Aviv Stock Exchange), during the period 2000-2007. We use only software firms because their relative simple assets and liabilities. We use three years pre-IPO data provided in the prospectus as a part of the IPO as well as post IPO public data.

In table 1 we provide some detailed statistics about the dataset. For each of the firms in our data set we obtain the last private valuation that was done before the IPO. For each firm in the data set we compute the VBB value based on

A. Projected (expected) sales for 5 years discounted with normal distribution.

The sales growth

B. Projected (possible) value of patents and other IP, discounted with Binomial distribution.
C. Other assets, which are typically insignificant in our case, are discounted with a uniform distribution.

Graph 1 shows the average breakdown of the valuation.

We compute the VBB at two points in time:

A. At the last Venture Capital round. At this point we match the VBB with the Accounting-based value of the balance sheet and the "Market Value", taken from the valuation of the VC fund.

B. At the IPO. At this point, which is either 1 year or two years after the 1st valuation, we match the VBB against the balance sheet and the market price taken at:
   a. The IPO
   b. Average 6 months post- IPO price

We run several types of VBB valuations at each point of time, we present a method that is based on a GA (Genetic Algorithm) software package – Evolver\(^\text{17}\).

This method allows us to reach a set of plausible solutions to the multi-dimensional problem of many distributions, creating countless discount factors.

In table 2 we provide the leading (in terms of fitness) solution and the underlying distribution assumptions.

The goal seeking function is matching the value of the whole portfolio of firms with a single set of plausible discount factors that will yield a VBB value that can be compared to the value of the portfolio as per the investment of the VC funds. This measure was done twice, to review the robustness of the mechanism.

---

\(^{17}\) In a genetic algorithm, a population of strings which encode candidate solutions (called individuals, creatures, or phenotypes) to an optimization problem evolves toward better solutions. The evolution usually starts from a population of randomly generated possible solutions and happens in generations. In each generation, the fitness of every individual solution in the population is evaluated, multiple individuals are stochastically selected from the current population (based on their fitness), and modified (recombined and possibly randomly "mutated", as we use the Genetic phrase) to form a new population. The new population is then used in the next iteration of the algorithm. Commonly, the algorithm terminates when either a maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population. If the algorithm has terminated due to a maximum number of generations, a satisfactory solution may or may not have been reached.
First, we run the model without barriers on the matching of two valuation of a single firm. E.g. we allow the VBB of a single firm to differ from the VC valuation as long as the total value of the portfolio match.

Second, we run the same evolving model, when the VBB value of each specific firm is set to match the VC valuation with a suppleness of ± 5%.

The results of the two valuation are reported in table 3. As we can see, when the optimization is unconstrained, the values that the firms receive are inconsistent with their actual valuations. When we limit the degrees of freedom, we receive multiple solutions. The most plausible one when focusing on the DF factor of expected cash flow from future sales, involves a corner solution on the intellectual property of the firms. This is an thought-provoking point, as this solution hints that the patents and other property rights of software firms are small. Kief and Paredes (2011) suggest in a comprehensive legislative framework, that patents and other intellectual property rights in general may well be overpriced in book value compared to their economic value. The overpricing is especially likely in highly competitive segments where the entrance barriers are low. The software industry are like that.

We use Latin Hypercube Simulation with the "@Risk" software package to simulate the range of accepted discount factors.

The discount factor we receive is in the range of 22.1%-24.5%, only slightly lower the market's "thumb figure" of 25%.

---

18 Latin hypercube sampling (LHS) is a statistical method for generating a distribution of plausible collections of parameter values from a multidimensional distribution. In the context of statistical sampling, a square grid containing sample positions is a Latin square IFF there is only one sample in each row and each column. A Latin hypercube is the generalization of this concept to an arbitrary number of dimensions, whereby each sample is the only one in each axis-aligned hyperplane containing it. The maximum number of combinations for a Latin Hypercube of divisions and variables (i.e., dimensions) can be computed with the following formula: 

\[ \left( \prod_{n=0}^{M-1} (M - n) \right)^{N-1} = (M!)^{N-1} \]

For example, a Latin hypercube of divisions with variables (i.e., a square) will have 24 possible combinations. A Latin hypercube of divisions with variables (i.e., a cube) will have 576 possible combinations. The difference between Latin Hypercube sampling and random sampling ("Monte Carlo") can be explained as follows:

1. In random sampling new sample points are generated without taking into account the previously generated sample points. One does thus not necessarily need to know beforehand how many sample points are needed, while In LHS one must first decide how many sample points to use and for each sample point remember in which row and column the sample point was taken.

2. In LHS, the sample space is divided into equally probable subspaces. All sample points are then chosen simultaneously making sure that the total ensemble of sample points is a LH sample and that each subspace is sampled with the same density. Thus, LHS ensures that the ensemble of random numbers is a very good representative of the real variability and that the ensemble of random numbers is representative of the real variability whereas traditional random sampling is just an ensemble of random numbers without any guarantees.
In the next stage we repeat the same calculation at the post IPO stage. Here we match the VBB figures with the 6-months average firm's trading value.

The results are reported in table 4. Again, the unconditioned measure yielded discount factors that were too dispersed to have statistical meaning. When we apply the conditioned measures we receive discount factors in the range of 20.4% -23.1%. Note that because of the size of the data base we did not split the database over time.

Another remarkable result is the ability of the VBB to capture correctly the increase in valuation. Table 5 and graph 2 shows the unconditional VBB valuations deltas, computed as the "return over the holding period" compared to the deltas in market price computed as the "6 Months Avg. PRICE" over "VC VALUATION". The results support our main theoretic hypothesis: VBB is an effective tool to value young firms with minimal tangible assets and which provide limited financial information by using simple statistical measures and by doing so, bridging between finance and accounting.

7. Conclusions

The advent of Fair Value Measurement introduces the potential use of future estimates as data for valuation. This brings together the classic MM financial economics valuation model with the data presented in the financial reports. We present, discuss and test an instrument called Value Based Balance Sheet (VBB) which provides a measurement of the value of both the assets and the liabilities (including equity) of the firm in a consistent way with both the financial economics valuation model and the IFRS Fair Value measurement. The VBB highlights the need for risk congruence, particularly where markets are incomplete. This is of particular relevance in a world where labor contracts become more flexible and involves risk taking by labor. We show that the VBB can be actually estimated given available data following the Level 1 data distinction in IFRS 13. As time goes by and managers, analysts, and auditors will use future estimates of revenues and expenditures in a commonly agreed way the
VBB and VBB like measurement instruments will become a common instrument of financial analysis.
Table 1– Descriptive statistics

<table>
<thead>
<tr>
<th># of firms in data set</th>
<th>Average VC valuation (after the money) M$</th>
<th>min VC valuation (after the money)</th>
<th>Max VC valuation (after the money)</th>
<th>Average Post IPO value</th>
<th>Min(per firm) Post IPO value</th>
<th>MAX (per firm) Post IPO value</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>43.1</td>
<td>22.1</td>
<td>94.4</td>
<td>107.3</td>
<td>53</td>
<td>273</td>
</tr>
<tr>
<td>34</td>
<td>Median VC valuation (after the money) M$</td>
<td>STD of VC valuation</td>
<td>Skewness of VC valuation</td>
<td>Median POST IPO value</td>
<td>STD of market value</td>
<td>Skewness of market value</td>
</tr>
<tr>
<td></td>
<td>18.7</td>
<td>1.2</td>
<td>94</td>
<td>48.3</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>1,551</td>
<td>Total Portfolio Value M$ (VC valuation)</td>
<td>Total Portfolio Value M$ (Market valuation)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 provides some descriptive statistics about the data set. The average value of the firm increases slightly more than the median, hinting of the long right tale of the distribution, as some of the firms had successful IPO. Note also the increase in STD and Skewness.
Table 2 panel A – Solution Fitting – unbounded

<table>
<thead>
<tr>
<th>Factor</th>
<th>Expected Sales</th>
<th>Intellectual Property</th>
<th>Miscellaneous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underlying distribution</td>
<td>Normal/Log-normal</td>
<td>Binomial</td>
<td>Uniform</td>
</tr>
<tr>
<td>Factors (Range)</td>
<td>STD (0.3 – 0.6), R (0.1-0.4)</td>
<td>P (0.001 – 0.999)</td>
<td>A, B (A&lt;B) (0.001-V/10)</td>
</tr>
<tr>
<td>Solutions (1)</td>
<td>STD = 0.4123, R=0.189</td>
<td>P=0.323</td>
<td>A=0.001, B= V/38.85</td>
</tr>
<tr>
<td>Solutions (2)</td>
<td>STD = 0.4541, R=0.212</td>
<td>P=0.544</td>
<td>A=0.001, B= V/12.34</td>
</tr>
<tr>
<td>Solutions (3)</td>
<td>STD=0.532, R=0.271</td>
<td>P=0.001</td>
<td>A=0.001,B=0.002</td>
</tr>
</tbody>
</table>

Table 2B panel B – Solution Fitting – bounded

<table>
<thead>
<tr>
<th>Factor</th>
<th>Expected Sales</th>
<th>Intellectual Property</th>
<th>Miscellaneous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underlying distribution</td>
<td>Normal/Log-normal</td>
<td>Binomial</td>
<td>Uniform</td>
</tr>
<tr>
<td>Factors (Range)</td>
<td>STD (0.3 – 0.6), R (0.1-0.4)</td>
<td>P (0.001 – 0.999)</td>
<td>A, B (A&lt;B) (0.001-V/10)</td>
</tr>
<tr>
<td>Solutions (1)</td>
<td>STD=0.462, R=0.236</td>
<td>P=0.001</td>
<td>A=0.001,B=0.002</td>
</tr>
<tr>
<td>Solutions (2)</td>
<td>STD=0.494, R=0.249</td>
<td>P=0.001</td>
<td>A=0.001,B=0.002</td>
</tr>
<tr>
<td>Solutions (3)</td>
<td>STD=0.418, R=0.218</td>
<td>P=0.001</td>
<td>A=0.001,B=0.002</td>
</tr>
</tbody>
</table>

Table 2 panels A and B shows the Evolver’s top 3 solutions to the unbounded and then the bounded portfolios. A solution is reached once all the parameters (together) reach a local optimizing point. Given the complexity of the analysis, multi-solution frame can be expected. The bounded portfolio’s solutions tend to be corner solutions for the binomial and the uniform distributions.
Table 3 shows the single 3 valuations for each firm in the database: The Venture capital funds after the money valuation, the Bounded VBB and the Unbounded VBB. Though the unbounded valuations vary significantly from the VCF, they capture the fundamental value.
Table 4  VBB & Post IPO Valuations

<table>
<thead>
<tr>
<th>Firm # (ranked by VC valuation)</th>
<th>VBB Unbounded Valuation (M$)</th>
<th>VBB Bounded Valuation (M$)</th>
<th>6 months average post IPO Valuation (M$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>77.17</td>
<td>64.1</td>
<td>65.6</td>
</tr>
<tr>
<td>2.</td>
<td>85.51</td>
<td>76.8</td>
<td>74.9</td>
</tr>
<tr>
<td>3.</td>
<td>76.43</td>
<td>59.1</td>
<td>60.0</td>
</tr>
<tr>
<td>4.</td>
<td>53.2</td>
<td>58.9</td>
<td>57.4</td>
</tr>
<tr>
<td>5.</td>
<td>74.22</td>
<td>77.0</td>
<td>78.5</td>
</tr>
<tr>
<td>6.</td>
<td>98.24</td>
<td>96.3</td>
<td>97.8</td>
</tr>
<tr>
<td>7.</td>
<td>94.67</td>
<td>105.3</td>
<td>105.6</td>
</tr>
<tr>
<td>8.</td>
<td>53.2</td>
<td>61.9</td>
<td>63.8</td>
</tr>
<tr>
<td>9.</td>
<td>111.96</td>
<td>115.1</td>
<td>115.4</td>
</tr>
<tr>
<td>10.</td>
<td>92.33</td>
<td>87.8</td>
<td>88.8</td>
</tr>
<tr>
<td>11.</td>
<td>71.2</td>
<td>73.6</td>
<td>75.4</td>
</tr>
<tr>
<td>12.</td>
<td>78.6</td>
<td>52.5</td>
<td>54.1</td>
</tr>
<tr>
<td>13.</td>
<td>86.92</td>
<td>93.0</td>
<td>93.0</td>
</tr>
<tr>
<td>14.</td>
<td>111.13</td>
<td>119.1</td>
<td>118.3</td>
</tr>
<tr>
<td>15.</td>
<td>73.26</td>
<td>95.7</td>
<td>95.2</td>
</tr>
<tr>
<td>16.</td>
<td>108.8</td>
<td>114.0</td>
<td>112.7</td>
</tr>
<tr>
<td>17.</td>
<td>97.21</td>
<td>90.4</td>
<td>88.5</td>
</tr>
<tr>
<td>18.</td>
<td>58.54</td>
<td>53.8</td>
<td>53.5</td>
</tr>
<tr>
<td>19.</td>
<td>53.2</td>
<td>88.9</td>
<td>90.6</td>
</tr>
<tr>
<td>20.</td>
<td>139.57</td>
<td>110.3</td>
<td>110.5</td>
</tr>
<tr>
<td>21.</td>
<td>112.3</td>
<td>97.0</td>
<td>95.2</td>
</tr>
<tr>
<td>22.</td>
<td>77.21</td>
<td>104.6</td>
<td>103.8</td>
</tr>
<tr>
<td>23.</td>
<td>148.02</td>
<td>82.4</td>
<td>84.0</td>
</tr>
<tr>
<td>24.</td>
<td>84.03</td>
<td>109.4</td>
<td>107.7</td>
</tr>
<tr>
<td>25.</td>
<td>124.4</td>
<td>92.2</td>
<td>90.8</td>
</tr>
<tr>
<td>26.</td>
<td>106.55</td>
<td>67.3</td>
<td>66.9</td>
</tr>
<tr>
<td>27.</td>
<td>153.11</td>
<td>175.7</td>
<td>174.2</td>
</tr>
<tr>
<td>28.</td>
<td>122.79</td>
<td>88.7</td>
<td>87.5</td>
</tr>
<tr>
<td>29.</td>
<td>57.22</td>
<td>166.4</td>
<td>165.7</td>
</tr>
<tr>
<td>30.</td>
<td>122.7</td>
<td>158.7</td>
<td>156.8</td>
</tr>
<tr>
<td>31.</td>
<td>199.8</td>
<td>128.4</td>
<td>126.7</td>
</tr>
<tr>
<td>32.</td>
<td>262.11</td>
<td>212.7</td>
<td>211.3</td>
</tr>
<tr>
<td>33.</td>
<td>238.6</td>
<td>207.1</td>
<td>205.6</td>
</tr>
<tr>
<td>34.</td>
<td>239.72</td>
<td>82.2</td>
<td>81.6</td>
</tr>
<tr>
<td>35.</td>
<td>178.8</td>
<td>272.1</td>
<td>273.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4,068</strong></td>
<td><strong>3,851</strong></td>
<td><strong>3,864</strong></td>
</tr>
</tbody>
</table>

Table 4 shows the single 3 valuations for each firm in the database: The market’s value, the Bounded VBB and the Unbounded VBB. Though the unbounded valuations vary significantly from the market’s value, they capture in most cases the value and the increase in value since the prior valuation.
Table 5 shows the annual returns of the unbounded VBB model vs. the real returns on the same holding period (last VC round to Average IPO+6 months). The VBB returns are less volatile, as they are still based on the firms' expectations.
Table 6: Summary

<table>
<thead>
<tr>
<th></th>
<th>VBB Unbounded</th>
<th>VBB Bounded</th>
<th>VC</th>
<th>VBB Unbounded</th>
<th>VBB Bounded</th>
<th>MARKET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Value</td>
<td>43.89</td>
<td>43.15</td>
<td>43.10</td>
<td>113.01</td>
<td>107.59</td>
<td>107.34</td>
</tr>
<tr>
<td>Median Value</td>
<td>35.54</td>
<td>34.70</td>
<td>34.00</td>
<td>97.73</td>
<td>94.48</td>
<td>94.08</td>
</tr>
<tr>
<td>STD</td>
<td>21.00</td>
<td>18.27</td>
<td>18.73</td>
<td>53.76</td>
<td>48.40</td>
<td>48.35</td>
</tr>
<tr>
<td>Skew</td>
<td>1.50</td>
<td>1.31</td>
<td>1.16</td>
<td>1.36</td>
<td>1.67</td>
<td>1.71</td>
</tr>
<tr>
<td>Correlation</td>
<td>0.920</td>
<td>0.990</td>
<td>0.98</td>
<td>0.62</td>
<td>0.98</td>
<td></td>
</tr>
</tbody>
</table>

Table 6 summaries the findings. A significant increase in the average and median values is accompanied by a similar increase in the volatility. The focal observation is the significant correlation between the VBB new valuations and the actual increases in value.

Chart 1: Value breakdown

Chart 1 shows the assigned value of the firms to the three categories: future sales, IP and other. Note that as these are early stage software firms, they have few if any tangible assets.

Chart 2A: Last private round valuation and VBB valuations
Chart 2A graphs the single 3 valuations for each firm in the database: The Venture capital funds after the money valuation, the Bounded VBB and the Unbounded VBB. Though the unbounded valuations vary significantly from the VCF, they capture the fundamental value.
Chart 2B: Market's (6 month post IPO average) price vs. VBB valuations

Chart 2B graphs the single 3 valuations for each firm in the database: The market’s value, the Bounded VBB and the Unbounded VBB. Though the unbounded valuations vary significantly from the market’s value, they capture in most cases the value and the increase in value since the prior valuation.

Chart 3

Chart 3 shows the Bounded VBB return and Unbounded VBB return over time.
In chart 3 we plot the bounded and unbounded VBB models against the actual return on the firms. The bounded model provides as expected a "thin" cloud. Yet more important is that the unbounded model holds a significant correlation with actual return.
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