On to this quarter’s edition. When we introduced Review of Financial Markets (RoFM), our Chief Executive Simon Culhane, Chartered FCSI, stated that a key objective was to publish articles that were academically robust but also of sound practical value to market participants. While the last word on this will always be left to you the reader, this issue certainly scores strongly on both points. Banks have a need to update constantly their market prices and cost of funds, as these are such important parameters in customer loan pricing. A recurring conundrum is ‘joining the dots’ of the term structure of interest rates, in a way that produces a smooth and accurate curve. So it is great to be able to bring you a high quality article from Dr Ken Kortanek, Visiting Professor at the University of Pittsburgh, and Vova Medvedev who is with HED Inc., that solves just this conundrum. They show the results of applying a geometric programming technique using posynomial equations, and the output is indeed smooth and accurate. I have observed even some large banks still employing an unscientific and incoherent approach to extracting the yield curve; with RoFM Issue 5 in their hands there is now an elegant and tractable method for such banks to adopt.

Readers will recall the controversy surrounding the Government’s privatisation of Royal Mail. From what one reads in the media, when the authorities were obtaining valuations of the business from their preferred list of investment bankers, the estimates received were almost 100% apart from the lowest to the highest. This is not uncommon in corporate finance project appraisal, because there are so many assumptions involved. A key input parameter is the discount rate, and a common one used is the weighted average cost of capital (WACC). Professor Pablo Fernandez who is at IESE Business School, University of Navarra has written an excellent critique on the WACC concept and how it is often misunderstood and even misused. His template should be required reading for all investment bank corporate finance departments.

Our final article is from Professor Ben Jacobsen at University of Edinburgh Business School. He writes on the intriguing concept of using ‘gradual information diffusion’ to forecast market prices. It’s certainly a new take on the issue of financial market forecasting, or rather I should say a not-well-known take: the basic tenets have been in the financial literature space for over ten years now. So we are grateful to Professor Jacobsen for highlighting the potential benefits of this technique to us.

Enjoy the issue.

Professor Moorad Choudhry FCSI, Editor

ABOUT THE EDITOR

Moorad Choudhry FCSI FIFS is Professor at the Department of Mathematical Sciences, Brunel University and was latterly Treasurer, Williams & Glyn plc at the Royal Bank of Scotland. He is also Honorary Professor, Kent University Business School and Visiting Teaching Fellow, Department of Management, Birkbeck, University of London.

Professor Choudhry is Managing Editor of the International Journal of Monetary Economics and Finance and on the Editorial Boards of Qualitative Research in Financial Markets and American Securitization.

He is also a member of the CISI Editorial Panel, which chooses key content for the Securities & Investment Review. He is author of The Principles of Banking (John Wiley & Sons Ltd 2012). moradchoudhry@gmail.com

Extracting the benchmark yield curve from market prices: a practical approach - K. O. Kortanek, Visiting Professor, Department of Industrial Engineering, University of Pittsburgh, US and V. G. Medvedev, staff software engineer, Ph.D, HED Inc, Hartford, US

The WACC: Definition, misconceptions and errors - Pablo Fernandez, Professor of Finance, IESE Business School, University of Navarra, Madrid

Forecasting financial markets: cross-asset return predictability and gradual information diffusion - Professor Ben Jacobsen, Chair in Financial Markets, University of Edinburgh Business School

Submission guidelines/ list of journal panel members

EDITORIAL

These are always interesting times in finance. Mohammed El-Erian coined the term ‘The New Normal’ to signify the era of much lower growth rates in western economies, but I think the new normal is something else entirely, although related: the ongoing and seemingly permanent public sector underpinning of western economies by central banks, with near-zero interest rates and something we choose to call ‘quantitative easing’ (QE). Irrespective of whether one agrees with QE or not, and one could certainly see its benefits back in 2009, at least the logic of its rationale was understandable. The economy is in recession, so provide a stimulus by printing money. An age-old technique.

But with the formal adoption of QE by the European Central Bank (ECB), I confess I am now at a loss to follow its logic. Last year the ECB introduced a negative interest rate for deposits placed with it by eurozone banks. This suggests that the ECB thinks there is surplus liquidity in the system; one wouldn’t penalise banks with a negative rate on deposits if one thought there was a shortage of funds in the market. Certainly no observer should be surprised if there was surplus, given all the other monetary policy support that has been forthcoming from the central bank ranging from very low interest rates to long-term funding facilities in the form of the long-term refinancing operation.

The ECB’s introduction of QE suggests that the central bank thinks there is a shortage of liquidity in the system: one wouldn’t print more money if there was already a lot of it about.

So which one is it? Is the eurozone long or short of funds? If Lewis Carroll wrote a story about monetary policy it would probably look like this, setting negative rates and also embarking on QE.

One appreciates that the former policy is designed to ‘force’ banks to lend money, but actually the one thing corporate entities don’t want to do in a recession is borrow, rather the contrary: they are much more keen on paying down debt. So where can banks place the cash? Simple: buy eurozone sovereign debt. The same debt that the ECB has committed to on paying down debt. So where can banks place the cash? Simple: buy money, but actually the one thing corporate entities don’t want to do.

One appreciates that the former policy is designed to ‘force’ banks to lend money, but actually the one thing corporate entities don’t want to do in a recession is borrow, rather the contrary: they are much more keen on paying down debt. So where can banks place the cash? Simple: buy eurozone sovereign debt. The same debt that the ECB has committed to on paying down debt. So where can banks place the cash? Simple: buy money, but actually the one thing corporate entities don’t want to do.
ABSTRACT

In many countries there is a lack of a benchmark yield curve in spite of attempts to experiment with sovereign bonds which have sufficient liquidity. Referred to as 'on-the-run' Treasuries, they are the most frequently traded Treasury security of its maturity whose prices trade at a premium and are typically chosen by the media for reporting. It is not known whether avoiding less liquid instruments generates the 'true' underlying yield curve. Using an optimisation method we developed over the last ten years, we have obtained a benchmark yield curve from its application to all US Treasury bills, notes and bonds published on 19 December 2014 in the 'Treasury Quotations' section of The Wall Street Journal. For comparison purposes, we have performed an extraction on a subset of 31 T–Bills and 35 notes and bonds for a yield curve which appears reasonable, based upon a visual comparison between the two extracted yield curves. Finally, we demonstrate the application of this technique to an emerging market that exhibits a lower range of observable prices than that experienced in the US Treasury market.

1. RECOMMENDED MODUS OPERANDI FOR EXTRACTING FORWARD-INTEREST RATE FUNCTIONS

The problem one faces in this project is how to convincingly promulgate a method for extracting the forward-rate function and the zero-rate function from published sovereign fixed-income data. Ours is an addition to the list of forward-rate curve fitting procedures at 12 international banks kept by the Bank for International Settlements [3]. We know of no other extraction method whose computations apply to the full set of published data – for example, all US Treasury bills and all Treasury notes and bonds on a given day. In every published case of which we are aware, any particular extraction applies to a significantly reduced set of instruments from the full available set. The generally accepted belief is that extracting from an appropriate reduced set of instruments will faithfully reflect the true unknown yield curve. The problem one faces in this project is how to convincingly promulgate a method for extracting the forward-rate function and the zero-rate function from published sovereign fixed-income data. Ours is an addition to the list of forward-rate curve fitting procedures at 12 international banks kept by the Bank for International Settlements [3]. We know of no other extraction method whose computations apply to the full set of published data – for example, all US Treasury bills and all Treasury notes and bonds on a given day. In every published case of which we are aware, any particular extraction applies to a significantly reduced set of instruments from the full available set. The generally accepted belief is that extracting from an appropriate reduced set of instruments will faithfully reflect the true unknown yield curve function.

However, this may well be a fallacy. As yet no universal extraction method has emerged to justify this belief. It is not yet known what an 'appropriate reduced set of instruments' really is. It is our subjective experience that many authors recognise this open problem, which one can, in particular, infer from reading literature such as [7] and [1].

The preface of Kortanek–Medvedev [15, xi-xii] gives a description on the methodology we are following in a treatment of uncertainty quantification. A shorter and more elegant description appears in Gusev and Romanov [11, 299-300], which we quote:

"A conventional approach to the study of uncertain systems relates to the assumption that uncertainty may be described as a random process with known characteristics. In many applied problems, however, there may be a limited number of observations, incomplete knowledge of the data, and no available statistics whatever. An alternative approach to the uncertainty treatment, known as guaranteed, is based on set-membership (unknown but bounded) error description. In the problems considered here the set-membership of uncertainty is employed."

This encapsulates perfectly the problem we identified above. Thus, we have embodied this logic in our initial approach to the problem of extracting the forward-rate function from sovereign fixed-income data, see [14] and [16].

1.1 MEASURES FOR THE SIZE OF THE UNDERLYING POSynomIAL PRIMAL PROGRAM MODEL [8, 5]

In the first instance we set the posynomial form that we wish to fit market prices to, given by (1):

\[
\inf g_0(t) = \sum_{m_0} c_i t_1^{a_{i1}} \cdots t_m^{a_{im}}
\]

subject to

\[
g_k(t) = \sum_{m_k} c_i t_1^{a_{i1}} t_2^{a_{i2}} \cdots t_m^{a_{im}} \leq 1 \quad k = 1, \ldots, p \quad (1)
\]

where \(a_i\) terms are arbitrary real constants, but \(c_i\) are positive. The expressions \(g_k(t)\) are termed posynomials. Should the \(c_i\) be arbitrary, one uses the terminology signomials.

The standard statement about the size of the primal program is that (a) there are \(m\) primal variables, (b) there are \(n\) terms in \(g_0\), \(n - n_0\) terms in \(g_{n_0}, \ldots, n - n_p\) terms in \(g_p\), so there are \(n\) total terms in the primal program, (c) the number of (only inequality) constraints is \(p\), and (d) the degree of difficulty is \(n + m - 1\).

The zero-curve function and the forward-rate function are outputs from solving the primal geometric program (GP), see [17], [31, Forward rates via geometric programming]. The zero (ie, yield) curve is equivalent to the discount function which addresses the following question: what is the value today from receiving \(D\) dollars at a future time \(T\), where you receive no coupon payments nor any other cash flows?

A common accuracy measure we use for the fitted yield curve is defined as follows, [16, Section 5].

**Definition 1.1** For an observed bond price time series \(P_t\), \(t = 1, n\) and a computed price series, \(\hat{P}_t\), the mean absolute percentage error, MAPE, is

\[
\text{MAPE} = \frac{100}{n} \sum_{i=1}^{n} \left| \frac{P_i - \hat{P}_i}{P_i} \right|
\]

The units are percentages, so 0.05 means 5 basis points.

Other research employing the set membership of uncertainty includes: [22; [6]; [19]; [20]; [9]; [21]; [10]; [30]; [23]. Major contributions in computer implementation of the set-membership approach to uncertainty occurred by the second author: [24, 25, 26, 27].
2. APPLICATION USING WSJ US TREASURY QUOTES DATA

2.1 THE DATA SET

The full scope of Treasury Quotes is illustrated with data published on 19 December 2014. There are 33 bills and 293 notes and bonds. For all of these instruments, ‘Ask Yields’ are computed by certain rules and conventions, which are conveniently reviewed in standard textbooks, eg, [12, 6.1 Day Count and Quotation Conventions]. The key observation is that any Ask Yield is an annual percentage interest rate.

We shall develop two zero-curve extractions using Treasury quotations data for the date specified.

- Run #1: 282 Instruments MAPE = 0.00696

For a given day, mm/dd/yyyy, we include data for all bills and notes and bonds unless there is an obvious abnormality. Only those notes and bonds which have maturity at least as great as the maximum maturity of all the bills are admissible.

The extracted zero curve will be in black or green upon printing. Run #1 will usually involve a large primal geometric program. For our benchmark yield curve extraction on 19 December 2014 data we found: (a) 505 primal variables; (b) 5163 terms; (c) 1070 constraints; so (d) the degree of difficulty is 4657.

- Ancillary Run #2: 66 Instruments MAPE=0.00696

All bills are included, unless there is an obvious abnormality. For each note and bond we compute a Newton–Raphson internal rate of return, IRR annual %, to compare with the WSJ published AskYld annual % for the instrument. To accomplish this we select a number, such as 0.015. If the absolute value of the difference between the two percentages, Newton-Raphson IRR % and WSJ AskYld %, is greater than 0.015, then the instrument is ignored. Clearly from this arithmetic, 0.015, as the difference of two percentages, is also a percentage, ie, 0.015%, or in financial parlance, 1.5 basis points. The choice of this cut–off figure needs to be called ‘ad-hoc’ simply to indicate that its choice is up to the user. The guiding goal is to choose a cut-off value so that enough notes and bonds are included from which, upon an extraction of the zero curve, the result significantly reflects the unknown but ‘true’ zero curve. The size of the geometric program is represented by: (a) 505 primal variables; (b) 1865 terms; (c) 638 constraints; so (d) the degree of difficulty is 1359.

For both runs we need to select certain accuracy-of-fit values which correspond to γk appearing in the relaxed inequality [16, (32)]. The reason for this selection is explained upon reviewing the notion of ‘reversed constraints’ needed for approximately solving a signomial geometric program through a sequence of solved posynomial geometric programs. Fortunately, our empirical experience over a respectable number of years has shown that such sequences with only up to five members are sufficient.

We often take γk to be 0.99999 for Bills and 0.99999 for notes and bonds, conveniently denoted as 0.9(5)(4).

2.2 THE ZERO, NO–COUPON CURVE EXTRACTIONS

The extracted benchmark yield curve and the ancillary yield curve are shown in Exhibit 1.

3. CONCLUSIONS

Some of the countries in Asia–Pacific where there are ongoing efforts to develop benchmark yield curves are reported in [2]. We are familiar with some of the efforts in Indonesia, particularly with the work of Handy Yunianto at Mandiri Sekuritas.

In this paper we have proposed that the full extraction illustrated with Run #1 serve as a benchmark yield curve for the US on a given day. It will serve for a comparison between it and any extraction made from a subset, however chosen, of the full set of instruments. Clearly, limiting the number of instruments will yield a smaller MAPE, and by that measure it gives a more accurate fit of published instrument prices. But any significant departure of the extraction from a reduced set, from the benchmark extraction will be suspect and call for more analysis.

We have selected a subset of 66 instruments and achieved a better MAPE accuracy. In addition, the extraction from the reduced set of instruments has provided a yield curve which appears reasonable, based upon a visual comparison between the two extracted yield curves.

EXHIBIT 1: THE BENCHMARK YIELD CURVE

Exhibit 1: Benchmark & Ancillary Curves Run1 N=282 MAPE= 0.0069 Run2 N=66 MAPE= 0.0069 12/19/14

4. CASE STUDY: COMPARING ENSS AND GP YIELD CURVE COMPUTATIONS FOR INDONESIA

Handy Yunianto, now at Mandiri Sekuritas in Jakarta, and the author implemented the GP method to extract a benchmark interest-rate function from Indonesian market data and presented our results in June, 2004, [18]. Our study began with a comparison between the Extended Nelson-Siegel-Svensson (ENSS) extraction method [28, 29] and our GP method. The structure of the Indonesian Government Bond market is described by Kahlil Rowter, appearing in [13, Chapter 7], where the importance of a long–term interest rate benchmark is emphasised. The forward rate function of ENSS has six parameters, where t represents time.

\[
FR(b_0,b_1,b_2,b_3,t_1,t_2,t) = b_0 + b_1 e^{t_1 t} + b_2 (t_1)^e t + b_3 (t_1^2 e t) - t_1 + b_3 (t_2^2 e t) - t_2. \tag{2}
\]

Market practitioners also note a preference for the ENSS method as it produces smoother forward curves compared with other approaches, for example see [32]. A smooth forward curve is essential when used for market pricing.
Bolder and Stréliski [4] emphasise that determining optimal ENSS parameters by seeking the minimum of a measure of the pricing errors is a global optimisation problem, but they suggest constraints on them to “avoid ‘strange’ local optima.” We stopped an optimisation procedure realising a MAPE ranging from 0.20 to 0.60. A typical example of the extracted curves appears in Exhibit 2 below, with MAPE = 0.274.

Our computational experience with GP, upon setting \( \gamma_k \) to 0.999 for both bills and bonds, see [16, (32)], has consistently yielded a MAPE ranging from 0.07 to 0.09. This is sufficiently accurate for most market transaction applications.

Exhibit 2: Spot(ZRsvn.txt) & Forward Rate(FRsvn.txt) Svensson from 2 Bills & 18 Bonds

Exhibit 3: Spot(ZRgp.txt) & Forward Rate(FRgp.txt) GP from 2 Bills & 18 Bonds

REFERENCES


There are two basic methods for valuing companies by discounted cash flows:

**Method 1:** Using the ECF and the required return to equity ($K_e$).

Equation [1] indicates that the value of the debt ($D$) plus that of the shareholders’ equity ($E$) is the present value of the expected FCFs that the company will generate, discounted at the WACC:

$$\text{(1) } D_0 + E_0 = \text{PV}_0[K_d; \text{FCF}_t]$$

Equation [4] indicates that the value of the equity ($E$) is the present value of the expected equity cash flows (ECFs) discounted at the required return to equity ($K_e$): 

$$\text{(2) } E_0 = \text{PV}_0[K_e; \text{ECF}_t]$$

**Method 2:** Using the FCF and the WACC.

The FCF is the hypothetical equity cash flow when the company has no debt. The expression that relates the FCF with the ECF is:

$$\Delta D_t = \text{PV}_t[K_d; \text{CFd}_t]$$

The WACC is the rate at which the FCF must be discounted so that the WACC is just the rate at which the free cash flows (FCF) must be discounted to obtain the same result as the valuation using equity cash flows (ECFs). The WACC is neither a cost nor a required return: it is a weighted average of a cost and a required return. To refer to the WACC as the ‘cost of capital’ may be misleading because it is not a cost. This article presents seven valuation errors caused by incomplete understanding of the WACC. We conclude with an assessment of the errors made in corporate valuation by an investment.

1. **DEFINITION OF WACC**

Consequently, the valuation is an iterative process: the free cash flows are discounted at the WACC to calculate the company’s value ($D+E$) but, in order to obtain the WACC, we need to know the company’s value ($D+E$).
To refer to WACC as 'cost of capital' is misleading because it is not a cost. Between a cost and a required return. So the WACC is neither a cost nor a required return: the required return to equity ($Ke$), a cost: the cost of debt, and a market risk premium ($Pm$). In other words, the WACC is a weighted average of two very different magnitudes:

- a cost: the cost of debt, and
- a required return: the required return to equity ($Ke$).

Although $Ke$ is often called cost of equity, there is a big difference between a cost and a required return. So the WACC is neither a cost nor a required return, but a weighted average of a cost and a required return. To refer to WACC as 'cost of capital' is misleading because it is not a cost.

### 2. SOME ERRORS DUE TO MISUNDERSTANDING THE DEFINITION OF WACC

I describe below some common errors that arise in corporate finance appraisal due to a misunderstanding of the real meaning of WACC.

2.1. Using a wrong tax rate $T$ to calculate the WACC. The correct tax rate ($T$) that should be used every year is the $T$ that relates the ECF and the FCF in equation [3].

2.2. Calculating the WACC using book values of debt and equity. The appropriate values of debt and equity are the ones resulting from the valuation.

2.3. Calculating the WACC assuming a capital structure that is neither the current one nor the forecasted one: the debt to equity ratio used to calculate the WACC is different than the debt to equity ratio resulting from the valuation. This error appears in at least one valuation undertaken by an investment bank. Current debt was 125, the enterprise value was 2180, and the debt to equity ratio used to calculate the WACC was 50%.

This is wrong because the outstanding and forecasted debt should be used to calculate the WACC. The equity value of a firm is given by the difference between the firm value and the outstanding debt, where the firm value is calculated using the WACC, and the WACC is calculated using the outstanding (market value of) debt. Alternatively, if the firm starts with its current debt and moves towards another round of financing, then a variable WACC (different for each year) should be used, and the current debt should be deducted from the enterprise value.

2.4. The Enterprise Value ($E + D$) does not satisfy the time consistent formulae. Fernández (2002, page 401) shows that the relationship between the enterprise value of different years is:

$$E_t + D_t = (E_{t-1} + D_{t-1}) (1 + \text{WACC}_t) - \text{FCF}_t.$$

#### 2.5. Considering that WACC/(1-T) is a reasonable return for the company’s stakeholders. Some countries assume that a reasonable return on a telephone company’s assets is WACC/(1-T). Obviously, this is not correct. And the error is still higher if the return is multiplied by book values.

#### 2.6. Using the wrong formula for the WACC when the value of debt ($D$) is not equal to its book value (N). Fernández (2002, page 416) shows that the expression for the WACC when the value of debt ($D$) is not equal to its book value ($N$) is $\text{WACC} = (EKe + DKd – N r T) / (E + D)$.

The valuation is provided in lines 1 to 7, and states that the WACC was calculated assuming a constant Ke of 13.3% (line 5) and a constant Kd of 9% (line 6). The WACC was calculated using market values (the equity market value on the valuation date was 1,490 million and the debt value 1,184 million) and the statutory corporate tax rate of 35%. The valuation included the equity value at the end of 2002 (3,033; line 8) and the debt value of 2002 (1,184; line 10). Table 2 provides the main results of the valuation according to the investment bank.

### Table 1 Valuation of a broadcasting company performed by an investment bank

Data provided by the investment bank in italics

<table>
<thead>
<tr>
<th>Data provided by the investment bank in italics</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 FCF</td>
<td>-290</td>
<td>-102</td>
<td>-102</td>
<td>354</td>
<td>459</td>
<td>496</td>
<td></td>
</tr>
<tr>
<td>2 ECF</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>34</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>3 Interest expenses</td>
<td>107</td>
<td>142</td>
<td>164</td>
<td>157</td>
<td>139</td>
<td>112</td>
<td></td>
</tr>
<tr>
<td>4 Effective tax rate</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>12.0%</td>
<td>35.0%</td>
<td></td>
</tr>
<tr>
<td>5 Ke</td>
<td>13.3%</td>
<td>13.3%</td>
<td>13.3%</td>
<td>13.3%</td>
<td>13.3%</td>
<td>13.3%</td>
<td></td>
</tr>
<tr>
<td>6 Kd</td>
<td>9.0%</td>
<td>9.0%</td>
<td>9.0%</td>
<td>9.0%</td>
<td>9.0%</td>
<td>9.0%</td>
<td></td>
</tr>
<tr>
<td>7 WACC used in the valuation</td>
<td>10.0%</td>
<td>10.0%</td>
<td>10.0%</td>
<td>10.0%</td>
<td>10.0%</td>
<td>10.0%</td>
<td></td>
</tr>
<tr>
<td>8 Equity value ($E$)</td>
<td>3,033</td>
<td>3,436</td>
<td>3,436</td>
<td>4,410</td>
<td>4,997</td>
<td>5,627</td>
<td>6,341</td>
</tr>
<tr>
<td>9 $\Delta D = ECF - FCF + Int (1-T)$</td>
<td>397</td>
<td>244</td>
<td>-86</td>
<td>-197</td>
<td>-303</td>
<td>-389</td>
<td></td>
</tr>
<tr>
<td>10 Debt value ($D$)</td>
<td>1,184</td>
<td>1,581</td>
<td>1,825</td>
<td>1,739</td>
<td>1,542</td>
<td>1,239</td>
<td>850</td>
</tr>
<tr>
<td>11 $D/(D+E)$</td>
<td>28.1%</td>
<td>31.5%</td>
<td>31.9%</td>
<td>28.3%</td>
<td>23.6%</td>
<td>18.0%</td>
<td>11.8%</td>
</tr>
<tr>
<td>12 WACC using lines 4,5,6,8,10</td>
<td>12.0%</td>
<td>11.95%</td>
<td>11.93%</td>
<td>12.08%</td>
<td>12.03%</td>
<td>11.96%</td>
<td></td>
</tr>
</tbody>
</table>
Table 2 Valuation using the wrong WACC of 10%

Present value in 2002 using a WACC of 10%
Present value in 2002 of the free cash flows 2003-2008 647
Present value in 2002 of the residual value (g=2%) 3,570
Sum 4,217
Minus debt -1,184
Equity value 3,033

The valuation has two major errors:

a. Wrong calculation of the WACC. To calculate the WACC, we need to know the evolution of the equity value and the debt value. We calculate the equity value based on the equity value provided for 2002. The formula that relates the equity value in one year to the equity value in the previous year is
\[ E_t = E_{t-1} (1+K_e) - ECF_t. \]
To calculate the debt value, we may use the formula for the increase of debt, shown in line 9. The increase of debt may be calculated if we know the ECF, the FCF, the interest and the effective tax rate. Given line 9, it is easy to fill in line 10.

Line 11 shows the debt ratio according to the valuation, which decreases with time.

If we calculate the WACC using lines 4, 5, 6, 8 and 10, we get line 12. The calculated WACC is higher than the WACC assumed and used by the investment bank.

b. The capital structure of 2008 is not valid for calculating the residual value because in order to calculate the present value of the FCF growing at 2% using a single rate, a constant debt to equity ratio is needed.

To perform a correct valuation, assuming a constant WACC from 2009 on, we must recalculate Table 1. Tables 3 and 4 contain the valuation after correcting the WACC. To assume a constant WACC from 2009 on, the debt must also increase by 2% per year (see line 9, 2009). This implies that the ECF (line 2) in 2009 is much higher than the ECF in 2008.

Simply by correcting the error in the WACC, the equity value is reduced from 3,033 to 2,014. This is, as one would agree, a significant difference.

Table 3 Valuation calculating the WACC correctly

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 FCF</td>
<td>-290</td>
<td>-102</td>
<td>250</td>
<td>354</td>
<td>459</td>
<td>496</td>
<td>505.9</td>
<td></td>
</tr>
<tr>
<td>2 ECF</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>34</td>
<td>35</td>
<td>473.2</td>
<td></td>
</tr>
<tr>
<td>3 Interest expenses</td>
<td>107</td>
<td>142</td>
<td>164</td>
<td>157</td>
<td>139</td>
<td>112</td>
<td>76.5</td>
<td></td>
</tr>
<tr>
<td>4 Effective tax rate</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>12.0%</td>
<td>35.0%</td>
<td>35.0%</td>
<td></td>
</tr>
<tr>
<td>5 Ke</td>
<td>13.3%</td>
<td>13.3%</td>
<td>13.3%</td>
<td>13.3%</td>
<td>13.3%</td>
<td>13.3%</td>
<td>13.3%</td>
<td></td>
</tr>
<tr>
<td>6 Kd</td>
<td>9.0%</td>
<td>9.0%</td>
<td>9.0%</td>
<td>9.0%</td>
<td>9.0%</td>
<td>9.0%</td>
<td>9.0%</td>
<td></td>
</tr>
<tr>
<td>7 WACC used in the valuation</td>
<td>10.0%</td>
<td>10.0%</td>
<td>10.0%</td>
<td>10.0%</td>
<td>10.0%</td>
<td>10.0%</td>
<td>10.0%</td>
<td></td>
</tr>
<tr>
<td>8 Equity value (E)</td>
<td>3,033</td>
<td>3,436</td>
<td>3,436</td>
<td>4,410</td>
<td>4,997</td>
<td>5,627</td>
<td>6,341</td>
<td></td>
</tr>
<tr>
<td>9 ∆D = ECF - FCF + Int (1-T)</td>
<td>397</td>
<td>244</td>
<td>-86</td>
<td>-197</td>
<td>-303</td>
<td>-389</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>10 Debt value (D)</td>
<td>1,184</td>
<td>1,581</td>
<td>1,825</td>
<td>1,739</td>
<td>1,542</td>
<td>1,239</td>
<td>850</td>
<td>867</td>
</tr>
<tr>
<td>11 D/(D+E)</td>
<td>37.0%</td>
<td>40.9%</td>
<td>41.4%</td>
<td>37.2%</td>
<td>31.7%</td>
<td>25.0%</td>
<td>16.9%</td>
<td>16.9%</td>
</tr>
<tr>
<td>12 WACC calculated with 4,5,6,8,10</td>
<td>12.09%</td>
<td>11.95%</td>
<td>11.93%</td>
<td>12.08%</td>
<td>12.03%</td>
<td>11.96%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Line 7 is deliberately left out

Table 4 Valuation using the corrected WACC from Table 3

Present value in 2002 using the WACC calculated in Table 3 588
Present value in 2002 of the free cash flows 2003-2008 3,727
Present value in 2002 of the residual value (g=2%) 4,187
Sum 4,271
Minus debt -1,184
Equity value 2,014

3. Conclusions

The WACC is a discount rate widely used in corporate finance. However it is just the rate at which the FCFs must be discounted to obtain the same result as the valuation using ECFs.

The WACC is neither a cost nor a required return: it is a weighted average of a cost and a required return. To refer to the WACC as the ‘cost of capital’ may be misleading because it is not a cost.

• Tables and figures are available in excel format with all calculations at http://web.iese.edu/PabloFernandez/Book_VaCS/valuation%20CaCS.html
Exhibit 1. Calculating the WACC

The intertemporal form of equations [1], [2] and [4] is:

\[ E_{t+1} = E_t (1+K_{et+1}) - ECF_{t+1} \]
\[ D_{t+1} = D_t (1+K_{dt+1}) - CF_{d_{t+1}} \]
\[ (E_{t+1} + D_{t+1}) = (E_t + D_t) (1+WACC) - FCF_{t+1} \]

The sum of [1] and [2] must be equal to [4]:

\[ (E_t + D_t) + E_t K_{et+1} + D_t K_{dt+1} - (ECF_{t+1} + CF_{d_{t+1}}) = (E_t + D_t) (1+WACC) - FCF_{t+1} \]

As CF_{d_{t+1}} = D_t K_{dt+1} - (D_{t+1} - D_t) and ECF_{t+1} = FCF_{t+1} + (D_{t+1} - D_t) - D_t K_{dt+1} (1-T)

\[ ECF_{t+1} + CF_{d_{t+1}} = FCF_{t+1} + D_t K_{dt+1} - D_t K_{dt+1} (1-T) \]

\[ (E_t + D_t) WACC_{t+1} = E_t K_{et+1} + D_t K_{dt+1} (1-T) \]

The WACC is:

\[ WACC_{t+1} = \frac{E_t K_{et+1} + D_t K_{dt+1} (1-T)}{E_t + D_t} \]

T is the effective tax rate applied to interest in equation [3]. \( E_t + D_t \) are not market values nor book values: in fact, \( E_t \) and \( D_t \) are the values obtained when the valuation is performed using formulae [1], [2] or [4]. WACC is a rate that may be multiplied by market values \( E + D \), but it is not appropriate to multiply the WACC by book values.

REFERENCES


ABSTRACT

Professional investors use a large number of strategies based on academic studies. However, to date a very promising strand of the literature focusing on market timing seems to remain largely undiscovered by practitioners. This strand is known as the Gradual Information Diffusion or Cross-Asset Return Predictability literature - the notion that not all information reaches all investors at the same time and this may lead to predictability in financial markets. I discuss some of the findings in this area and illustrate how these models can be applied in quantitative trading strategies and automated trading systems.

INTRODUCTION

The academic focus on forecasting financial markets has shifted in the past 25 years from the question whether financial markets are predictable to how these markets can be best predicted. At the end of the 1980s most academics still felt that markets were informationally efficient. Investors, so the theoretical models assumed, would process all information so fast that prices would immediately reflect all information. As a result, market prices would follow a random walk. Only new information would change prices and because new unanticipated information is unpredictable by definition, it will have an unpredictable or random effect on prices. However, since the eighties so many studies documented that financial markets were to some extent predictable that even most academics no longer believe markets are completely unpredictable. What was known as the Efficient Market Hypothesis and its empirical cousin the ‘random walk’ model are no longer considered to be full accurate descriptions of financial markets. Nowadays, they serve as a first approximation or a benchmark to measure how well we can predict.

Academics now assume that investors are not always rational, cannot process all information instantaneously and sometimes collectively go wrong. This can lead to some predictability in financial markets. For instance, some stocks often do better than others even though the previous theory dictates that they should not. Well-known results are the relatively good performance of growth stocks versus value stocks (stocks with a high earnings to price ratio perform better than stocks with a low E/P), and momentum effects (stocks that do well, tend to keep doing so for six months to a year). Professional investors have implemented many of the stock selection criteria in their stock selection process or use these in their so-called ‘Factor investing’ - strategies to manage risk.

To date most professional investors seem to focus on the academic stock picking results. Surprisingly, a very promising strand of the literature focusing on market timing seems to remain largely undiscovered by practitioners. This is a pity because this strand is not only intuitively appealing but it also has a huge potential to deliver good investment strategies. This part of academic research is known as the Gradual Information Diffusion or Cross-Asset Return Predictability literature. Here I give a quick overview of the main concepts used in that strand of the literature and how these might be applied in forecasting strategies.

SECTION 1: Gradual Information Diffusion, an example

In 1990 the first empirical evidence on Gradual Information Diffusion appears (before there even was a theory of Gradual Information Diffusion). Two well-known stock market researchers, Lo and MacKinlay, document that stock returns of big firms forecast stock returns of smaller companies. Large firms respond to news instantaneously as they are followed by many investors and analysts. Moreover, as they are part of the main index all important macro-economic information that will affect stock markets in general will through index trading most likely be immediately reflected in these big firms as well. The smaller firms receive less attention and may respond to the same news with a delay. As a result returns on large firms tend to predict the returns of smaller firms. This is exactly what Lo and MacKinlay (1990) find.

Would this result still hold today? To test whether big firms still lead the smaller ones I use some well known indices (like the S&P500, DAX and FTSE100) for a number of countries and test whether these forecast the movements of smaller stocks in that country. Lo and MacKinlay considered only the US market. However, if it is a Gradual Information Diffusion effect, it should, of course, be present in most countries. I measure (using a simple linear regression) how far the movements of big stock returns forecast the returns of the small firms in the next month. For the small firms I use the MSCI Small Cap indices for each country. The table below has the results. Overall the ‘big leading small’ effect is indeed positive: if stock market prices of big firms go up this month, on average stock market prices of small firms will go up in the next month (all else equal). The effect is strong. The column ‘Effect’ (the coefficient alpha from the regression denoted as a percentage) shows to what extent returns of the well known large cap index affect the smaller firms in the next month. For instance, for the UK, an increase in the FTSE by just 1% will in the next month lead to higher return on average of smaller firm by 0.263%. A 5% return change (not exceptional as for stock markets as it is roughly one monthly standard deviation) will change next month small cap returns by more than 1%. This generally holds for all countries. In fact, all results are statistically significant, with all the p-values below 10% and mostly close to zero (the probability that this is just coincidence is very low). Moreover, last month’s big firms returns explain the effect is variation of the monthly returns of small firms. For Brazil even more than 10%. To an untrained eye, these numbers may not look like much but keep in mind that in any month a lot of unexpected news will come out. If only one indicator explains this part of variation in small cap returns in the presence of all that unpredictable news, that is relatively a large amount. Generally, it is enough to up the odds in one’s favour.

1 These all start in February 1993 onwards with the exception of the Brazilian market. There our analysis starts in June 1994. End date is April 2013 for all series.
Table 1. Big firms leading small firms: February 1992- April 2013. Based on the regression:

\[ r_{t \text{Small}} = \mu + \alpha r_{t-1 \text{Big}} + \epsilon_t \]

It is easy to derive simple market timing trading strategies from these results. For instance, invest in small caps if the FTSE has gone up more than x%. Or, if the FTSE has gone down, short the small caps or invest risk free. With many trackers and exchange-traded funds around, trading strategies like these can be executed relatively easily and at relatively low cost. Of course, nothing prevents us from incorporating more variables based on gradual information diffusion. The empirical results on cross-asset return predictability go much further.

SECTION 2: Gradual Information Diffusion: literature review

Nowadays, academic researchers consider Lo and MacKinlay from 1990 to have found the first evidence of a theory that has become known as Gradual Information Diffusion. In 1999 Hong and Stein published their theory on Gradual Information Diffusion in the *Journal of Finance*. They showed that when information travels slowly across investors and markets, it can generate price under-reaction, momentum effects and more general predictability across financial markets. Rather than assuming that all information is available and can be easily processed by rational investors, gradual information diffusion requires ‘bounded rationality’. If we are willing to assume that investors cannot see all information at the same time.

Exhibit 1: An example of Gradual Information Diffusion

Since the theory on Gradual Information Diffusion was published, a large number of academic studies have found strong evidence of this cross-asset return predictability. Interestingly, we find it exactly where the theory tells us we should be able to find it.
In line with the example above, Driesprong, Jacobsen and Maat (2008) find that oil price changes significantly predict returns in stock markets around the world. Note that given their impact on the world economy, oil prices seem a natural candidate. Roughly speaking, a 10% increase in the oil price in one month (not unusual as it is only one standard deviation) predicts 1% lower stock market returns one month later. In line with gradual information diffusion, the effect is particularly strong in non-oil-related industries. In fact, their results confirm the example above. There is no evidence of return predictability for the resources, industrial and basic materials sectors, but predictability for the IT sector and the banking industry is significant. Norway presents another nice example of collective forecasts by investors. One reason why cross-asset return predictability effects may work so well is that in a way these methods use the collective forecast of investors in one market to predict another. Moreover, as financial market returns can be observed continuously; we can update predictions faster in comparison to macro-economic variables, which typically have a frequency of quarterly, or at best monthly and tend to be backward looking.

That said, there are a large number of issues to be addressed. The first problem is that like many other quant strategies, gradual information diffusion models had a difficult time predicting stock market returns during the recent financial crisis. There are also some down-to-earth questions like how long does it take for information to diffuse into prices – can we rely on monthly data or should we focus on shorter or longer intervals? Moreover, as the oil price example above illustrates, changes in oil prices may convey information about the future of the economy. However, not all changes necessarily mean the same thing all the time. For instance, a price increase in copper might be a good signal in a recession (stronger demand) but bad news during an expansion (higher inflation). A new strand of the literature is emerging that investigates time-varying return predictability in the context of gradual information diffusion (Jacobsen, Marshall and Visaltanachoti, 2014).

There is no reason why it should not work in other financial markets. However, in real time experiments I find that in automated trading strategies, which include gradual information diffusion variables, so far it works best for forecasting stock markets.
CONCLUSION

Gradual Information Diffusion is a promising and practical area of predictability research currently available in academic literature. Empirical research would appear to support that the effect is indeed present in financial markets. What makes it interesting from a practitioner’s point of view is that this has received little attention in automated trading systems to date.

REFERENCES


ACADEMIC JOURNAL PANEL MEMBERS

Prof Moorad Choudhry  FCSI Brunel University
Prof Carol Alexander University of Sussex
Dr Edward Bace, Chartered MCSI CISI, Middlesex University
Dr Paul Cox University of Birmingham
Scott Dobbie FCSI(Hon) Deutsche Bank
Peter Land, Chartered FCSI Brewin Dolphin
Gino Landuyt Luxembourg Financial Group
Prof Donald Lawrence MCSI University College London
Sian Lloyd, Chartered FCSI CISI
Gregor Logan MCSI Family Investment, Nutmeg
David Moskovic Royal Bank of Scotland
Prof Jim Steeley Aston Business School
Nigel Sydenham, Chartered FCSI CCL Academy

SUBMISSION GUIDELINES

CISI members are invited to submit to the Institute for consideration papers on any aspect of wealth management, capital markets and banking.

Articles must be:

• Original work and previously unpublished
• Between 1,500 and 3,500 words in length and accompanied by an Abstract of 80-150 words.

All papers submitted will be refereed by the journal editorial panel or its recommended reviewers. For further details about the Review of Financial Markets and how to submit articles, see cisi.org/academic

HAVE YOUR SAY

If you would you like to comment on any of the articles in this issue, contact CISI Communications Editor Richard Mitchell: email richard.mitchell@cisi.org or call +44 20 7645 0749

REVIEW OF FINANCIAL MARKETS

cisi.org/academic