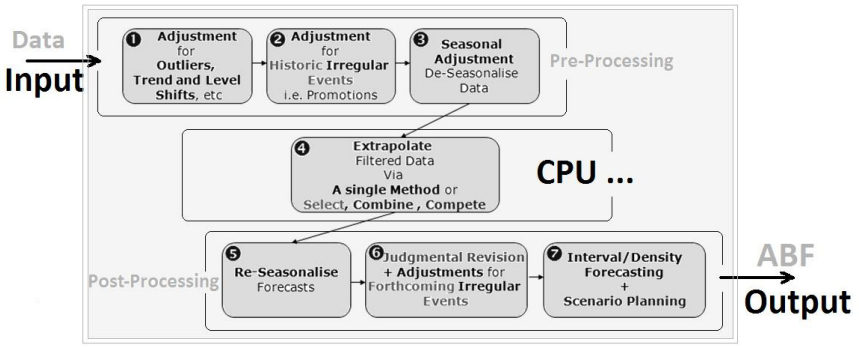
*"Of course, **there is no accurate forecast**, but at times this shifts the focus for ... If **there is no** perfect plan, is **there such thing** as a good enough plan? …"* K.D. Zylstra

Applied Business Forecasting



Kostas Nikolopoulos

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What's in this Book?

>>

Forecasting in Practice; Time-series; Judgment; IS/ICT/Oraganisational issues; ABF Process; Uncertainty; Scenarios; Forecasting Support Systems; e-Forecasting;

CONTENTS

6. **Seasonal Adjustment**
   Classical Seasonal decomposition, Deseasonalising series – Reseasonalising Forecasts, Alternative seasonal adjustments procedures, What if the history is not long enough?

PART III. FORECASTING

7. **Simple Extrapolative Methods**

   Naïve methods, Moving Averages, Exponential Smoothing(Simple, Holt, Double, Damped, Holt Winters), Trend extrapolation/Robust Trend.

8. **Causal methods**

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9. **Intermittent Demand**

   Methods, tactics and metrics especially for intermittent and lumpy demand data

10. **Advanced Extrapolative Methods**

    Box – Jenkins, Theta model

11. **Computer Intensive Methods**

    Artificial Neural Networks, Data mining techniques

12. **Method Selection**

    Selecting, combining or Competing methods. Holdout or within sample – BIC/AIC. Evaluate accuracy levels competing methods with multiple (and relative) metrics. On the choice of accuracy metrics

PART IV. POST-PROCESSING

13. Judgmental Forecasting

Unaided Judgment, Delphi Method, Structured Analogies

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15. Special Events – Special Actions

Semi and Fully-automated Methods so as to estimate the impact of special event respectively to similar events in the past Adjust for Special Events **[xls]**

16. Strategic Forecasting. "What-if" analysis

Density forecasting, Building sets of projections

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17. Forecasting and Decision Sciences

Forecasting as a key function for both Operations Research and Operations management – the hard and soft parts of Management Science. Forecasting and stock control

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Efficient Design and Use of Forecasting Support Systems. Essential features of FSS, Guidance on the choice of an FSS. A prototype FSS

21(st Century)**… e-Forecasting**

The efficient use of the Internet/www in business forecasting

∞. The Future

Epilogue

*"Of course, **there is no accurate forecast**, but at times this shifts the focus for ... If **there is no** perfect plan, is **there such thing** as a good enough plan? …"*[1]

Preface

Applied Business Forecasting…

Applied … as this is not really a text written for researchers in the field; it is however research-driven, meaning that the ready-made 'forecasting recipes' contained in the following 21 chapters are direct results from more than 15 years of research and consultancy projects in forecasting.

Business … as focus is primarily on business and operational forecasting methods and applications, rather than problems from economics and finance. The rather more advanced techniques required for the latter are introduced in the last part of the book.

Forecasting … as who doesn't want to know what the future will bring…?

Business Forecasting is a crucial function in any 21st century company. A bad forecast can be translated into:

either

… *lost sales*, thus poor service and unsatisfied customers!

or

… *products left in the shelves*, thus high inventory and logistics costs!

Wait a minute… this sounds like a *lose-lose* situation! If you don't get it exactly right, you will lose money - one way or another. What's more, as you might of guessed, you won't ever get it exactly right! Even the most advanced forecasting system, only by pure chance, will give you a perfect forecast…

[1] by Kirk D. Zylstra - 2005 - Business & Economics - John Wiley and Son

Thus, the angle of this book, and our sincere advice to the reader would be to:

"…make sure you do your best to get an as-accurate-*forecast*-as-possible[2], and learn to live with the *uncertainty* that inevitably comes with this forecast…[3] "

, exactly as the introductory quote wisely suggests…

In practice[4], although forecasting is a key function in operations, it is usually very poorly performed. This text aims to shed light on the practical aspects of everyday business forecasting, by adopting some well-informed, academically-evidences and easily–implementable processes; which, in most cases are just simple heuristics.

This text also aims to provide managers/executives as well as managers-to-be (PG/MBA students), with the necessary background knowledge and software tools to run a successful business forecasting function. As a result, state-of-the-art business forecasting software plus MS Excel templates are disseminated freeware with this book.

Ok … but there must be at least fifty titles out there in business forecasting! ... why do we need another one? …….

……..This book is not about all the things you could possibly do when you are faced with a forecasting task. It is not about guiding you through a methodology[5] tree, where all possible options are given, and it's up to you to decide where to go. If this is what you're looking for, then the best place to go is www.forecastingprinciples.com lead by Prof. Scott Armstrong and the International Institute of Forecasters, where you get a gateway to the amazing world of forecasting - and free of any cost.

Furthermore, this book is not about giving you all the underlying theory and mathematics of the discipline. In fact, maths & stats, theorems & axioms are kept to the absolute minimum. Everything is kept as simple as possible, … but not simpler![6] So, there will be a few formulae, but expressed in a way that does not require a mathematical background to follow. If you were looking for the maths of forecasting then the leading textbook of the field - Makridakis, Wheelwright and Hyndman (1998)[7] – is your reference point.

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[2] to take into account all available *Information* that is relevant to the specific forecasting task – usually referred as *Marketing Intelligence* -

[3] This is the line also taken from Makridakis, Hogarth and Gaba, in their recent book "Dance with Chance: Making Luck work for you", One World Publications

[4] Armstrong, S. (2001), *Principles of Forecasting*, Kluwer Academic Publishers

[5] www.forecastingprinciples.com

[6] A famous quote attributed to Albert Einstein

[7] Forecasting Methods and Applications, 3rd Edition, Wiley, New York

For engineers like me, that prefer the 'do it yourself' approach, the second edition of the latter book is particularly useful as most of the forecasting algorithms are presented in such a way that their implementation is very straightforward in a standard programming language.

Now if you don't believe in numbers, and Judgmental forecasting is your weapon of choice when approaching forecasting tasks, then my friend Paul[8] Goodwin along with George Wright, is probably the way to go.

So what is this book all about? In essence this book is severely biased by my personal research findings and results from a series of research and consultancy projects. I try to give a ***One-Stop Forecasting Solution*** **to your business forecasting needs**. By-and-large it is an MBA book…

ABF, the *forecasting-process introduced in this text* - I strongly believe will significantly enhance the forecasting performance in your company/private or public organization; a process that consist roughly of two basic elements:

a) A fairly accurate set of *forecasts*, and
b) A good estimate of the *uncertainty* around them

Of course it would be up to you, once faced with real-life problems, how to use these forecasts, and more importantly how to take counter-measures and back-up-policies as to cope with the predicted **uncertainty**.

Leading & Living with scenarios built around this uncertainty, is the key to your business success…

This book could also work as the starting point for PhD students that enter the field of forecasting, as to get a good look & feel for the discipline and the practical aspects of the profession. For research students, in addition to the aforementioned texts , the subsequently logical steps would be to go for Theil[9], Diebold[10], Box Jenkins[11] and my all-time-favorite forecasting book – Bob Brown's 1957 masterpiece[12] – "Smoothing, Forecasting and Prediction of Discrete Time Series", that I have revisited so many times.

So what's in the book? Introductory material, Data management, Data and Information Filtering, Basic forecasting approaches, Advanced forecasting Approaches, Forecasting with Judgement and finally a section on how forecasting is used in other disciplines and application areas such as Decision Sciences, Finance, Economics, Policy, Information Systems and the Web. This later material is slightly more advanced and mostly 100% research driven,

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[8] Wright, G. & Goodwin, P. 1998. *Forecasting with Judgement*. Chichester and New York: John Wiley and Sons , and Goodwin, P. 2006. *Decision Analysis for Management Judgement,* 3rd Edition Chichester: Wiley

[9] by Henri Theil , *Principles of Econometrics*, Wiley; 1st edition (June 15, 1971);

[10] Diebold, F. X. "Elements of Forecasting" …

[11] by George Box, Gwilym M. Jenkins, Gregory Reinsel, Time Series Analysis: Forecasting & Control (3rd Edition) 1994; Publisher: Prentice Hall;

[12] Original version 1957, Reprint 2004, Dover Publications

hence serves more for the research audience in the field. However it is also a good indicator for the practitioners as to realize that more advanced tools are required in order to forecast efficiently in certain application areas – and thus seeking for consultants to support them in such situations, is probably a good idea.

In this book there are a few innovations, in the form of topics never discussed in mainstream forecasting texts, including:

- *Data management issues*

Although the hierarchy of products in a company necessitates the use of techniques like top-down and bottom-up forecasting in practice, these are very rarely discussed in textbooks. Guidance as to how to organize your data will be given in great detail - a very important aspect for practitioners

- *Large Case studies*

Four case studies are discussed and analyzed gradually throughout the chapters, illustrating the ABF process in the companies under examination. These cases include:

1. a Vehicle-Hire company in the U.K.,
2. a Cosmetics company operating in Greece,
3. a Tobacco-Distribution company in Europe, and
4. Health Service data from a EU country, so as to give a public sector perspective as well.

By studying these examples, the readers will be able to replicate the suggested processes using their own data, and eventually build a successful forecasting function for their company.

- *Intermittent demand*

Although 60% of most inventories present lumpy, intermittent and irregular demand, this topic and methods tailored to such data, are very rarely discussed in textbooks.

- *Theta model*

Theta model was the most successful academic model in the last major forecasting competition - the M3 competition - run in 2000 by professor S. Makridakis and M. Hibon. How it could be used in practice has, as of yet, not been demonstrated.

- *Software*

A freeware version of **forTANK[13] Oracle**, a specialised forecasting software plus continuous guidance on how to use Microsoft© Excel[14] in forecasting tasks is given throughout the text

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[13] This software have been developed from experts in the forTANK, the forecasting Think-TANK **www.fortank.com**

[14] Microsoft and Microsoft Excel are both terms and products copyrighted by Microsoft Corporation

- *Forecasting Support Systems (FSS)*

Guidance on the choice of the appropriate FSS in a company, as well as essential features that should be included in such systems are extensively discussed

This book also aspires to serve as a textbook at various taught levels. For this purpose, we provide all the relevant academic material in the companion website **www.fortank.com/abf**. Suggested syllabi are presented in the following paragraph:

- Undergraduate (12 x 50min sessions + Seminars – 10 credits)
  - Focus is given on the steps of the forecasting function

  -> 1, 2, 3, 5, 6, 7, 7, 8, 12, 13, 21, Revision

- Postgraduate (12 x 100min sessions + Seminars – 15/20 credits)
  Primarily aiming for taught programme like MSc in Operations Research/ Decision Sciences/Analytics/Marketing Modeling/Strategy
  - Focus is given on extrapolation methods as well as applications

  ->[1/2],[3/4], [5/6], [7], [8], [12/10], [9/18], [11],[13/14/20], [15/16], [18],[21]

- MBA module (or MSc in Strategic Management) (10 x 150min sessions – 15/20 credits)
  – The book is especially designed with the MBA audience mind, thus apart from the advanced techniques, everything else should be covered.

  -> [1/2], [3/4], [5/6], [7/12], [8], [9/18], [11], [13/14/20], [15/16], [21]

- Executive Education – 1 day crash-course (4 x 100min sessions)
  – Focus is given in the forecasting function.

  -> [1/2/3/4], [5/6/15], [7/8/12], [13/16/17/20]

Kostas has contributed this preface and chapters 1,2,3,4,5,6,7,12,13,14,15,20,21, while partially involved in chapters 9,18,19. Prof Aris Syntetos[15] has significantly contributed in chapter 9. Prof. and lead a team among. Prof. Dimitris Thomakos[16] has edited and contributed in chapter 17. Dr. Nicolas Domingo Savio[17] has provided most of chapters 13 and 18, and edited all of my chapters. Contributions span between many people in this text, and unavoidably writing style is often changing from chapter to chapter, as we decided to preserve each other's personal style of expression, at the slight expense of consistency throughout the book.

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[15] Dr Aris A. Syntetos is Professor of Operations Research and Operations Management at Salford Business School, United Kingdom

[16] Dr. Dimitrios Thomakos is Professor in Applied Econometrics at the Department of Economics in the University of Peloponnese, Greece

[17] Dr Nicolas D. Savio is my best ever PhD student

Many thanks for the time you will devote in reading my text

Kostas

"Any astronomer can predict just where every star will be at half past eleven tonight; he can make no such prediction about his daughter… …"[18]

Chapter 1:
Applied Business Forecasting

What's in this chapter?

Basic definitions in Forecasting; Time-series; Judgment; IS/ICT/Organizational issues; Forecasting in Practice; Basic steps in forecasting; ABF Forecasting Process; Introduction to forecasting models and methods, Forecasting Competitions;

[18] This quote comes from James Truslow Adams, famous American historian and writer. I have first read it in one of my favorite forecasting books, "Forecasting in Business and Economics" by Nobel laureate Professor Clive W.J. Granger, and it sarcastically points out the difficulty in forecasting …

1.1. Forecasting: let's define the field…

I am great fun of web and especially Wikipedia. Whenever I want to find a definition for ###, I always Google "###" and here it comes a humanly-understandable definition of whatever was I searching in the first place! In fact, I always get a much better quote than in most of the academic books I've read. I am a man of no-changing habits, so I Googled … 'forecasting' and here is what I got:

> *"Forecasting[19] is the process of estimation in unknown situations. Prediction is a similar, but more general term, and usually refers to estimation of time series, cross-sectional or longitudinal data. In more recent years, Forecasting has evolved into the practice of Demand Planning in everyday business forecasting for manufacturing companies. The discipline of demand planning, also sometimes referred to as supply chain forecasting, embraces both statistical forecasting and consensus process."*

I know… too many undefined terms for an introductory paragraph. So let's take everything from scratch; the first sentence of the quote is the most important: forecasting is more-or-less about *estimating in unknown situations* - thus your only weapon is the past and how much this later resembles to the former.

This wiki quote continues with nicely distinguishing between *forecasting* and *prediction*. In this text, although acknowledging that these terms may mean slightly different things across various disciplines, we will use them interchangeably[20]

The next sentence, fully aligns with the beliefs of the authors of this text: *Forecasting has evolved into the practice of Demand Planning in everyday business forecasting for manufacturing companies …* sometimes referred to as **supply chain forecasting**. This is exactly what this book is about; everyday business forecasting - given to the audience in the most applied way: via cases, tools and ready-made examples.

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[19] From Wikipedia, the free encyclopedia @ http://en.wikipedia.org/wiki/Forecast

[20] Among other similar terms like: projecting, extrapolating, forseeing, etc. In a business context all these terms could be used .

The world of everyday business forecasting, comes with the assumption that some kind of regularly-observed quantitative information will be available for the products under consideration. In other words *time-series* data will be available.

A time-series (Figure 1.1), is just a series of observations over a long-period of time; those observations are usually taken in equally distanced periods e.g. months, week, quarters etc. That is typically how data look like in business and operational forecasting; in most cases, observations for more than three years per product are available, while these are recorded quite frequently (every month or less).

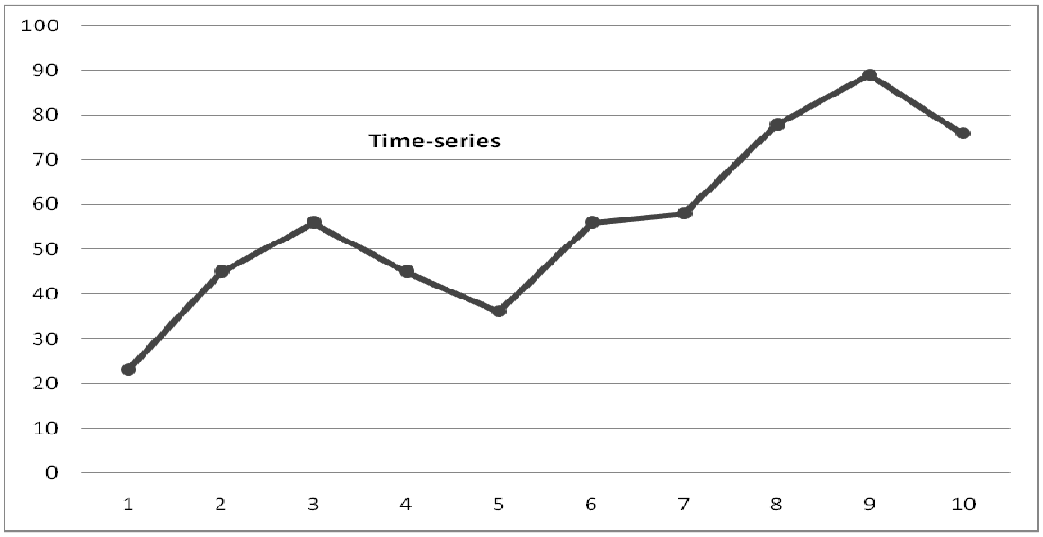

Figure 1.1. A time-series

But this is not always the case as:

- You may have *cross-sectional* data, data referring to the same point of time but for different product/services etc. – e.g. sales for 10 different car make in a given day
- You may have *no data* at all – so you end up using entirely your judgement as to make some forecasts

In this book, focus is basically given in time-series forecasting and how this integrates efficiently with judgmental adjustments. These adjustments are driven from all sources of marketing intelligence[21].

[21] Marketing intelligence or market intelligence - http://en.wikipedia.org/wiki/Market_Intelligence

Analysis and forecasting of cross-sectional data are partially covered in chapter 8, but still remain out of the core scope of this text.

Ok, let's start by seeing what is needed as to prepare a good set of forecasts. First of all you need the data; you need to get in place the time-series for the product(s) you are interested in. Is this something easy?

Not at all! Imagine yourself having to forecast for a Retailer in UK, with more than 200 stores across the country, and more than 50.000 products on sale in each store. Many of these products would be dairy products and groceries that need to be replenished very fast, thus necessitating setting orders on a weekly or more frequent basis.

Ordering should not be made at a local/store level, and sales/orders will have to be accumulated at regional or national level as to achieve better prices from the suppliers.

The problem as described above would require sales data to be collected from the Point-Of-Sale (POS) – practically the tills, accumulated to store–level and then transferred via Local Area Networks (LANs), Wide Area Networks (WANs) or the *Internet* to the Regional or HQ databases. There, these data should be aggregated per product as to create the total demand-series for each one, and then forecasting should take place for each and every of the products in the companies.

Doing this for 1000s of products on a daily basis is a very serious data management task, and would practically lead you to problematic time-series, typically with missing values, miss-measured values, inconsistencies etc. It should become obvious by now, that very consistent and robust DBMS are needed (DataBase Management Systems) … just to get the data in the first place. And all these before you actually start the projections of those series in the future.

In figure 1.2, the aforementioned process would be to …:

"… get the *thick-black-line* right in the first place… !".

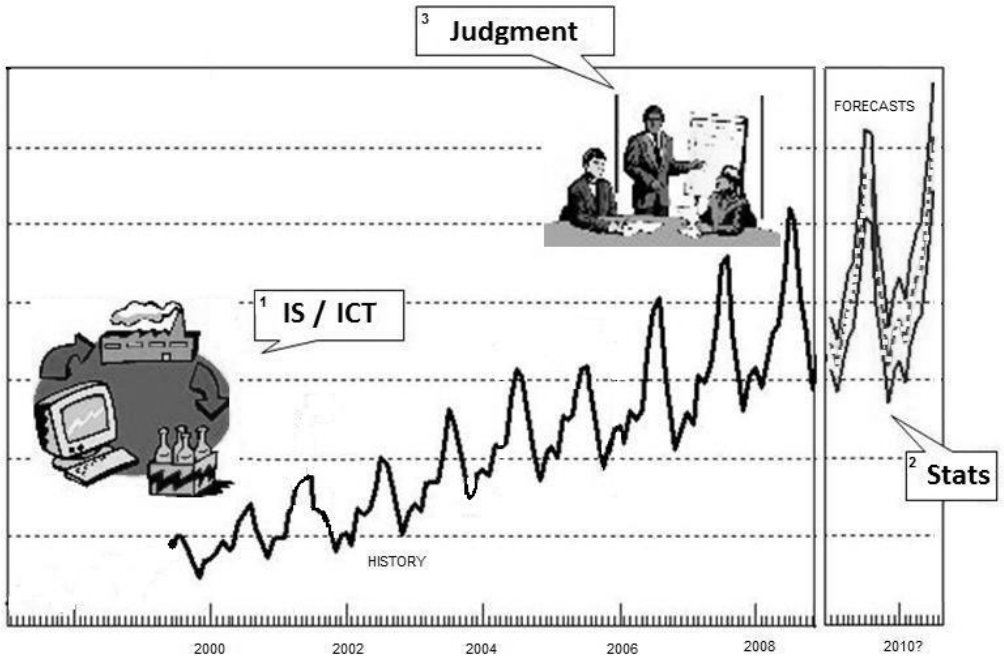

Figure 1.2. What's needed in order to prepare a good set of forecasts?

This thick-black-line stands for the history of the specific product you are interested to forecast. More details on how to organize your database as to efficiently forecast, will be discussed in chapters 3 and 4. In real life, you would be very lucky to get a time-series looking that 'good' as the one in figure 1.2. Usually you get a series with tops 3 years worth of history, probably with some gaps, definitely with some strange values[22] and no obvious repetitive patterns (we will soon call theses *cycles* and *seasonality*). Concluding, Information Systems (IS) and Information Communication Technology (ICT), abbreviated as **IS/ICT,** both play an essential role as to get the data right; that is the first critical part of the forecasting process.

[22] … Too low or too high values; the so-called outliers… just because they lay out of the rest of the…herd!

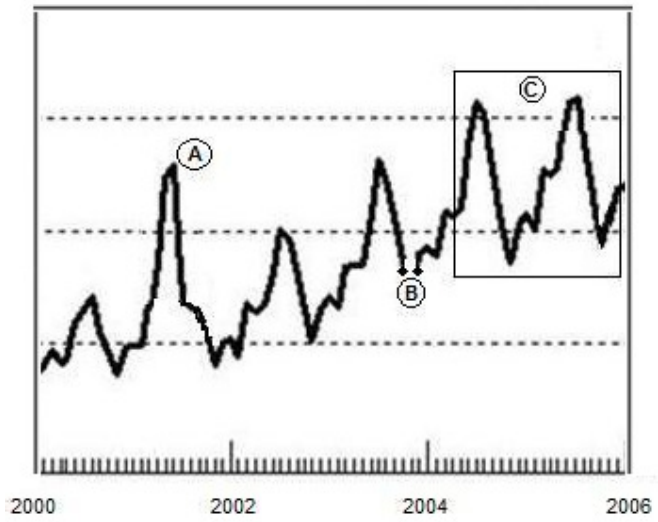

Figure 1.3. Series with problems that need to be treated before forecasting.

The next logical step would be to project this thick-line into the future: forecasting the available time-series. Time series- forecasting is based on the assumption that a particular variable will behave in the future in much the same way as it behave in the past[23]. Thus the dotted-line should be the 'natural' extension of the thick-black-line. Natural … in the sense that history repeats itself. This is the basic assumption of statistical forecasting; thus ***Statistics*** – abbreviated Stats - is the second fundamental part of the forecasting process.

If I had to use a color for this dotted-line, the natural choice would be red[24]. Red is the color for danger! You will soon realize that it is too risky to provide just a forecast - in the form a single number for a specific point of time in the future. We will call this a **point-forecast**. In most of the cases you will usually be interested in many points of time in the future, so forecasts for the full forecasting **horizon** as it is usually termed, and not just a single point-forecast.

In order to live with the aforementioned risk, we would like to have the *black-lines* as well as shown in figure 1.2. Those lines are the forecast/**prediction intervals** - in this case symmetric over and under the point forecasts -, and their very reason for existence is to give you a

[23] Chapter 2: Sarah Keast and Michael Towler, *Rational Decision Making for Managers, Wiley Chichester*

[24] This is the color-code used in the accompanying software TIFIS CM3, *black* for history, *red* for Point forecasts and *blue* for the prediction intervals.

sense of the **uncertainty** around your point forecasts. In essence they tell you (referring back to figure 1.2):

> "… if its not going to be the *dotted-line*, then with great confidence it would be something from the *lower black-line* up to the *upper black-line*!"

We would like to set these confidence levels around 95%, thus being 95% 'sure' that the future unknown demand will appear somewhere between those blue-lines. But in real life this results in something that managers totally dislike: the thin black-lines being far out from the dotted-one… And as a result managers go one step back and require only the point forecasts to be reported to them. This is the reason that most advanced forecasting software - **FSS** (stand for Forecasting Support Systems) usually do not report the prediction intervals at all.

Another critical part of the forecasting process, as presented in figure 1.2, is **Human Judgment**! Humans don't really like machines… They're afraid of them! They think they will get their jobs and eventually they will get fired! As a result they dislike ready-made solutions that do not require their intervention. They would like to have some ownership of the produced forecast. So ... they **Adjust**!

They basically adjust for two reasons:

a) Because they think that they are *better forecasters* than the FSS system in front of them! They believe they're better at selecting and/or optimizing, as well as calibrating the available forecasting models provided to them by the FSS … that is obviously wrong! FSS use advanced optimizers to select among thousands of values as to initialize, optimize, select, tune and fine-tune the 100s of models available to their forecasting engine. So when an FSS suggests a model, usually termed as the *Expert* or *Auto* forecast, a very serious optimization procedure has taken place, and a challenge is more often than not futile.

b) Because they think that they KNOW something that the FSS system in front of them doesn't! Now if they really know something, they would be correct to act. If the information is reliably sourced and they are confident they are doing the right thing, they should go for it. But be aware, there are certain rules of how these adjustments should be made. Rules and conditions that we will investigate in detail in chapters 14 and 19

Ok, before we move on, let's spend some more time on the conceptual differences between forecasting and Statistics. Time-series Forecasting used to be a part of Statistics – nowadays (thanks to Makridakis[25] et al.) it's a far more generic and multidisciplinary scientific field. Multidisciplinary should be already obvious as we have clearly identified a) Stats (so Math, Statistics), b) IS/ICT (so Information and Computer Sciences) and c) Human Judgment (so Psychology), being all essential parts of the discipline.

Form a methodological point of view, *forecasters* – in contrast to *Statisticians*, quest optimal model in a different way, so:

How do you define the 'best' forecasting method/model?

Statistics fundamentally makes the assumption that there is a *true underlying model* under the observed data-series i.e. the black-dotted-line under the noisy time-series in figure 1.3. If we identify that true underlying model, then all we have to do is project it into the future, in our case the grey-dotted line. But is this the best possible forecast?

[25] The true birth of the Forecasting discipline dates back to late 70s, early 80s at the hands of Prof Spyros Makridakis (at INSEAD), Prof Robert Fildes (then at Manchester Business School, now in Lancaster University) and Prof Scott Armstrong (Wharton). Benito Carbone also played a key role in the early stages. The result was to create two journals International Journal of Forecasting – IJF (Elsevier) and Journal of Forecasting – JoF(Wiley), a conference ISF (www.isf2010.org), an Institute IIF (www.forecasters.org), in a word ... a DISCIPLINE! Many have followed since then and are part of the forecasting community now, including the authors of these text, but history was written by those 3-4 men and their close associates … More details can be found in the interview of Spyros for IJF: Fildes, R. and Nikolopoulos, K. (2006) "Spyros Makridakis: An Interview with the International Journal of Forecasting". International Journal of Forecasting, 22(3): 625-636.

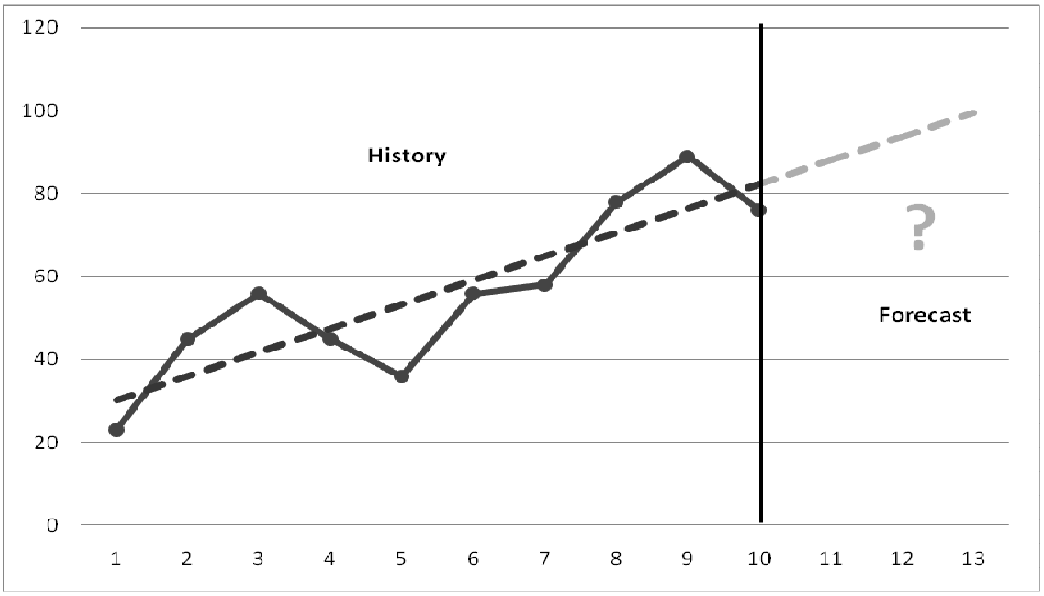

Figure 1.4. Forecasting, Extrapolation and … Statistics

In essence, in statistics we try to find the model that **best fits** the data. And since we expect history to repeat itself, we project it and we are happy. Thus the statistical forecasting recipe is: Find the best fit - > job done -> Sleep tight…!

However, in time-series forecasting, history very rarely repeats itself !

Forecasters instead focus on which model **forecasts best** rather than which model fits best! Hold on, we have an *oxymoron* here? How can we know which model forecasts best since we do not know the future?

To resolve this, we do our first forecasting *trick*: we hide a part of the series, usually the very recent one: A 20% of the most recent part of the series is usually enough. Others suggest we have to hide as much as the forecasting horizon we are interested in – thus if we have to forecast three months ahead we should hide the last three months of the available data.

We call this the **holdout** and we will use it to evaluate which model forecasts best. This process will become crystal clear in chapter 12, but you already understand what's happening: for example we hide the last year of our time-series, and we use the previous years to forecast this last hidden one, with a variety models, and the one model that goes 'closer' to the hidden values is the model that … forecasts 'best'.

And this of course is not necessarily the one that fits the whole available dataset the best (the standard technique used in statistics).

Unfortunately, our approach is not bullet-proof either…as:

> *There is no guarantee that the model that forecasts best, will keep on forecasting best…*

However, it still produces on average better forecasts that the model that fits best! At least, that's what most empirical investigations suggest.

1.2. ABF Forecasting Process

Forecasting in business is performed at an *Operational*, *Tactical* and *Strategic* level:

- At the *operational* level - where the focus of this text is, we are mostly interested in being "***roughly right within the limited available time***", given in order to prepare the forecasts. This involves short-term forecasting tasks; real life applications are usually a few weeks/months ahead. For some category of products (e.g. dairy) we may even need more frequent forecasts (every day or every other day).
- *Tactical* forecasting involves short to mid-term forecasting, usually 3-12 months ahead. Cumulative and individual point forecasts are needed for this period, as well as incorporating the effect of forthcoming events like promotions, supply interruptions etc
- At the *strategic* level we usually look into forecasting horizons that go beyond a year and involve the impact of rare events (like major international crises as the recent one regarding energy prices and the global credit system), new product development, product withdrawals, capacity amendments, scenario planning.

The aforementioned *forecasting horizons* are only indicative, and often met in supply chain forecasting. There are many forecasting applications where a strategic forecast is just for a few months ahead! So, in order to avoid any confusion, we use the terms: 'forecast for x steps ahead' or 'forecast for x periods ahead', without specifying what steps/periods stand for. These steps could be anything from minutes to

years depending on the application area. Typically *short-term* forecasting involves 1-3 steps ahead; *medium-term* or mid-term is for 4-12 steps ahead and *long-term* anything over 12 steps ahead[26].

This book proposes a simple *7–step* forecasting process tailored for operational forecasting tasks. This process is illustrated in figured 1.5, and is abbreviated as "*ABF forecasting process*" or just **ABF** for short – named after the title of this text (Applied Business Forecasting).

ABF provides detailed guidance on how to prepare operational forecasts for a single product. This process should be:

a) Repeated for every product in your inventory, and

b) Re-run each time new demand/sales data becomes available

Thus, if we observe our inventory of 100 products on a monthly basis, we should run ABF every month for each of the hundred products we manage.

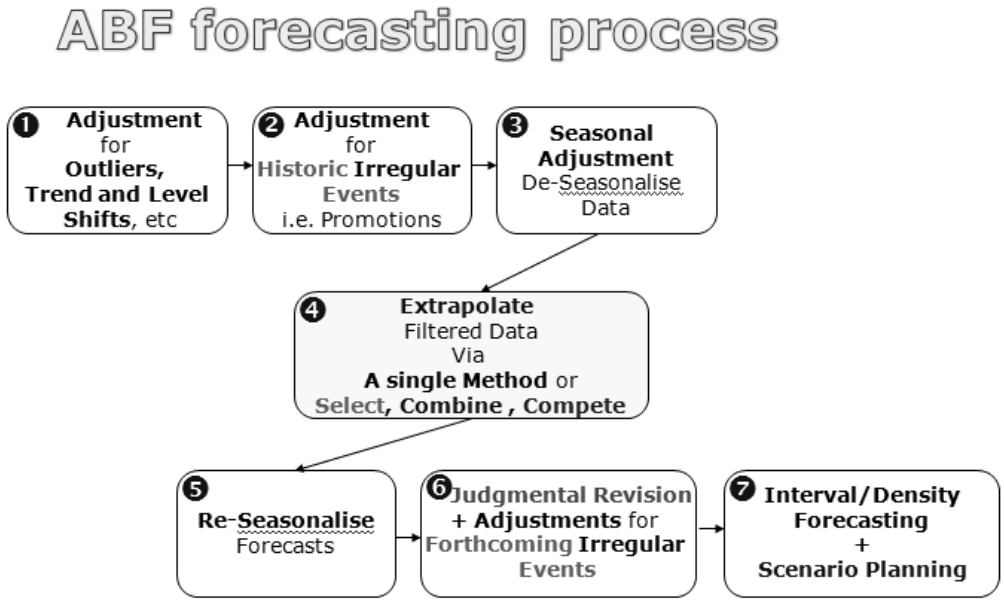

Figure 1.5. ABF Forecasting Process

[26] For this and other types of forecast classifications, see Hibon M. and Makridakis S. (2000) "The M3 Competition: results, conclusions and implications". International Journal of Forecasting 16, 451-476.

Let's start decoding what these boxes stand for; there is one box for each of the *7–steps* of the ABF process. The upper three form the *pre-processing* phase, the one in the middle the *main-forecasting-task* and the latter three the *post-processing* phase (Figure 1.6)

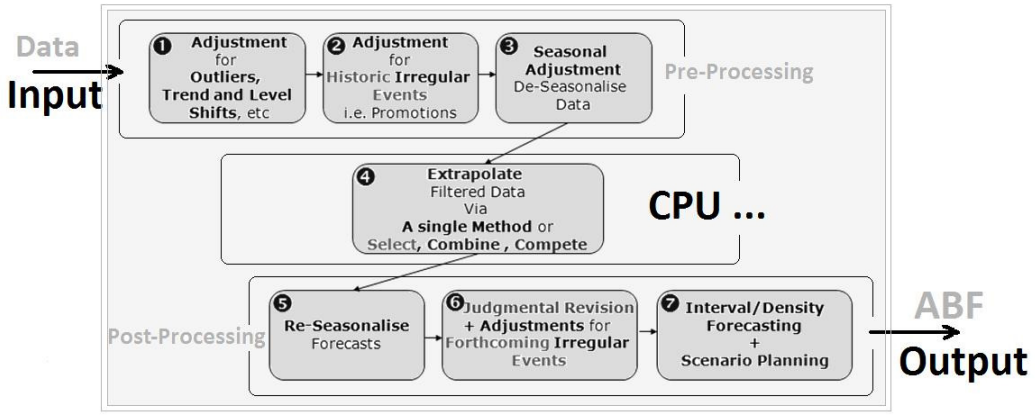

Figure 1.6. I/O and CPU… of the ABF forecasting process!

It looks like a typical Black-Box approach[27]. However, we believe it's more like a 'Grey-Box' approach! A situation where you will be able to understand most of the things that are happening throughout ABF, however rely on automated tools to deliver for you! It look like a typical computer system – I am probably still haunted by my engineering background; Input/Output and Central Processing Unit; the latter is consists of the pre-processing and post-processing unit as well as (obviously) the CPU (Central Processing Unit). I will hint here that the ABF output is actually much much more than a single numeric forecast. But this will become clear in the next few pages.

Let's explore the ABF process as illustrated in figure 1.5:

- First Box: the BAD things…

  Each single time-series comes with a number of problems. Some of these are dead-obvious but some are well hidden. We have made a brief introduction of such problems in figure 1.3. To cut

[27] A standard engineering expression, for a situation or a solution where something seems to work fine, but we are not sure why and definitely do not know for how long it will keep on working!!

the long story short, we must deal with all these 'bad things' and prepare a series with no missing values, no extremely low/high values (outliers), no level or trend shifts; this would involve automated detection algorithms for such problems and suggested solutions in order to adjust the original series into new series, filtered for all the aforementioned problems. This algorithms and processes will be discussed in detail in chapter 5.

- Second Box: the GOOD things…

  In time-series forecasting it is often very difficult to tell good things from bad ones … just like in real life! A 'good thing' in a time series is a *special event* (SE), often termed in literature as *irregular*, *infrequent* or *rare* event; it could be a promotion, a production interruption, news, regulation, etc… in general anything that could make demand deviate substantially from regular levels! But why is something irregular good? Simply because it is an information-rich period, a period with special interest where an external/exogenous event has driven excess or limited demand respectively. So, it would look exactly like an outlier, but we will know what exactly happened. From a mathematics perspective, the way you detect and subsequently adjust periods with special events, is identical to the one used to treat outliers. We will deal with SE extensively in chapters 4 and 15.

- Third Box: the REGULAR things…

  In forecasting, finding regularities and patterns in a series is an essential task; usually termed *periodicity*, things that repeat themselves on a regular basis. If the regularity, the repetition happens within a year then we will call this phenomenon *seasonality*; for less than a year *mini-cycles*, while for more than a year, big *economic/financial-cycles*. In any case, removing the effect of these cycles at this stage of the ABF process (and re-introduce them later on), has been empirically proven to work very well, as argued in various empirical investigations[28].

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[28] For more information please visit http://www.forecastingprinciples.com/ , or read "Principles of Forecasting: A Handbook for Researchers and Practitioners, J. Scott Armstrong (ed.): Norwell, MA: Kluwer Academic Publishers, 2001". Also a very helpful lecture and slides are provided by Prof Scott Armstrong: http://mediasite.wharton.upenn.edu/mediasite/Viewer/?peid=875bbd02-c634-41c9-8b16-23e5d4b92154

After successfully completing these three steps of the Pre-Processing phase of our time-series, we should by now have a nice *filtered*[29] - *smoothed* series, that will look almost[30] like a straight *line*, either entirely flat or with a constant-*ish* trend (upward or downward). Now, it is about time to extend this line into the future… Now we are ready to forecast!

- THE (fourth) BOX: FORECASTING…

  This is where all the fun is… Let's try forecasting: extrapolate the series in the future. We won't just choose a method - and that's it! (where would the fun be after all…?).

  We basically employ three fundamental strategies … the "three forecasting tricks" as I fancy calling them:

  - "**Select**": my mother always says that "Experience is all that matters…"; and she is probably right. Thus if a method worked well in the past, we should probably stick to it, and keep on selecting that same one for the task of extrapolation. Furthermore, some methods may have been proven to work better for some products while other methods better for other products; so there are 'horses for courses' and once again we're better off sticking to them. In essence, we could build a nice table – a *selection protocol* (SP) as we will call it more formally, where in one column there is a list of our products, while in the other column the forecasting methods and models that have worked well in the past for the respective products. An illustrative example is shown in table 1.1

Company X	
'Best' FORECASTING methods over the last 2 years	
Product 1	**Method A**
Product 2	**Method B**
….	…

Table 1.1. Forecasting Selection Protocols

[29] A term often used in engineering applications.
[30] Of course there would still be some *noise* over this line

- '**Combine**':

"***When in doubt … combine!***"

, a very good piece of advice I dare say. When a method has worked well in the past for a certain product, but the new Statistician on the block… insists that method *X* is the new panacea in time-series forecasting, then why not combine those two? So get a set of forecasts from your trusty chosen method, get another set of forecasts from the new highly-promising method, and then average these to get a final set of forecasts. If you believe more in the former (or the later) you could easily differentiate the weights respectively as to express your belief e.g via a 30% weight to the experience-based method and 70% to the new one. We will dig further into the concept of combining in chapter 12 but until then, remember: "*Combining always works!*" (in other words: Combining, most of the times outperforms the individual performance of the methods being combined…)

- '**Compete**', the true reason forecasters exist: (empirical) **Forecasting Competitions**! We do not trust anything, and from all the available methods and models, applied on all the available history, we will find the one that forecasts 'best '. We will discuss our criteria for defining 'best' forecasts in detail in the next chapter, while the process of empirically conducting forecasting competitions will be further detailed in chapter 12

Sometimes we even apply these tricks simultaneously – e.g. a) we compete only among methods that have performed well in the past, or b) we combine the winner of the competition and the top performing method in the past as described in a selection protocol, or …

- Fifth Box: Superimpose regular patterns

By now, our forecasts should look like a straight line, either *flat* or with a certain *slope*. If we have identified regularities in step three, then we need to bring them back into the game, in other words we superimpose these patterns onto the extrapolation. Once this step completed, our forecasts will have *ups* and *downs,* and will look like a natural extension of the cycles and

seasonality observed in the history of the series; more on this process in chapter six.

- Sixth Box: Human Judgement

  This is where humans come into the game. No matter how sophisticated the process so far, people – usually referred to as *forecasters* or *experts* - want to intervene at this stage; primarily to introduce market intelligence? This is usually performed in two phases: a) an initial phase, where experts roughly revise all provided forecasts by changing[31] them by a percentage x% e.g. increase all monthly forecasts for the full next year by 10%, and b) a more targeted one, where some specific forecasts in the future are adjusted for the potential impact of special events like promotions, e.g increase by an extra 1000 units the sales forecast for next September due to an expected advertising campaign.

- Seventh (Last) Box: Density forecasting + SCENARIOS; living with Uncertainty!

  In this final step, we try to cope with the *uncertainty* that comes with the produced forecasts. Firstly, we usually provide a set of *confidence* or *prediction* intervals, associated with the point forecasts for the full forecasting horizon, as shown in figure 1.2; this is also known as *density* forecasting. There are theoretical as well empirical ways so as to produce these intervals, which will be discussed in detail in chapters 7-11. The most popular way to deal with the uncertainty around the provided forecast is by building scenarios. These practically derivate from the produced forecasts, but we will treat them as an indispensible part of the ABF process. We will discuss the art of Scenario planning in chapters 16 and 17.

We have seen the *input*; we have roughly seen the *steps* within the 'grey-box'; let's stay a bit more on the *output* of ABF. When you started reading this book, you probably thought it would all be about a *number* or a few *numbers* - if forecasts for more periods ahead were required. By now, it should have become obvious that far more output - in numerical and narrative form - will be available. Practically every step of the ABF process is producing some output, which is consisted by-and-large of what is contained in table 1.2. (Of course this table is not exhaustive)

[31] Usually increasing the forecasts, due to an optimism bias (more on this and other types of bias in chapter 13)

ABF Output
- A list of *adjustments* made to the original data due to problems - A list of *adjustments* made to the original data due to Special Events - A set of *Seasonal Indices* if seasonality was identified - Sets of *Cyclical indices* if min-cycles or major economic cycles were identified - A set of statistical *point-forecasts* (each one fore each respective forecasting horizon) - A set of judgmentally *revised* forecasts plus *Notes* explaining the reasons for adjustment - Two sets of *prediction intervals*, under and over the provide forecasts - An estimation of the *Bias* of those forecasts: a tendency to consistently under/over forecast or over-forecast - An estimation of the *expected accuracy* of those forecasts: in the form of past errors - An estimation of the *uncertainty* of those forecasts: in the form of the standards deviation of the forecasts - An estimation of the *endogenous difficulty* of the forecasting task; in the form of the *noise*[32] existing in the original time-series. In statistical and mathematical sciences we believe that under any observed phenomena (time-series in our case), there is an underlying signal where whatever is not explained and captured from it, is described as noise in the series. - *Statistical significance*[33]of the forecasts: in the form of comparisons with standard forecasting benchmarks - *Economics significance*[34]of the forecasts: in the form of the financial implications of our forecasts as in stock holding costs[35], or trading financial results[36]

Table 1.2. ABF output

[32] Noise is a term met in many sciences. I prefer the electrical engineering definition of it where Noise can block, distort, or change/interfere with the meaning of a message in both human and electronic communication. For a good definition of absent of any sci-jargon, you may visit http://en.wikipedia.org/wiki/Noise

[33] Armstrong, J. Scott (ed.) (2001). Principles of forecasting: a handbook for researchers and practitioners (in English). Norwell, Massachusetts: Kluwer Academic Publishers.

[34] Timmerman, A. and Granger, C. W. J. (2004), "Efficient market hypothesis and forecasting", International Journal of Forecasting 20: 15-27.

[35] Syntetos, Nikolopoulos and Boylan 2010 IJF forthcoming

[36] Maris, K., Nikolopoulos, K., Giannelos, K. and Assimakopoulos V. (2007) "Options trading driven by volatility directional accuracy". Applied Economics 39 (2): 253-260. Bozos, K., Nikolopoulos, K. and Bougioukos, N (2008). "Forecasting the Value Effect of Seasoned Equity Offering Announcements", 28th International Symposium on Forecasting ISF 2008, June 22-25 2008, Nice, France.

In the rest of the book we will give all the necessary details and tools to efficiently use ABF for your operational forecasting needs. However, there are many other forecasting applications, where ABF cannot be applied as it is. These applications are beyond the main scope of this text, and are discussed roughly in the next section.

1.3 A few more interesting FORECASTING applications.

So what are we really fascinated to forecast?

Whenever I say outside my inner academic circle that I am a forecaster, I typically get three responses:

What's going to be the weather tomorrow?

Can you forecast the numbers for the lottery?

Can you forecast the stock market?

My answer in all these is: … "Unfortunately NO". And this brings us back to the fundamental question: "what can realistically be forecasted, and what can not?" Maybe more interestingly, is what people are really interested in forecasting…

The aforementioned questions are clearly beyond the scope of this book… particularly the weather! (which by the way this is quite an issue in Britain!). The following list is not exhaustive, but we believe captures most of the things people are interested to forecast:

- Gambling / Individual and team performance in sports
- Weather forecasting
- Transportation forecasting
- Economic forecasting / Major Economic shocks
- Technology forecasting
- Earthquake prediction/ Major catastrophes
- Land use/Real estate forecasting
- Long term/Strategic forecasting/Foresight