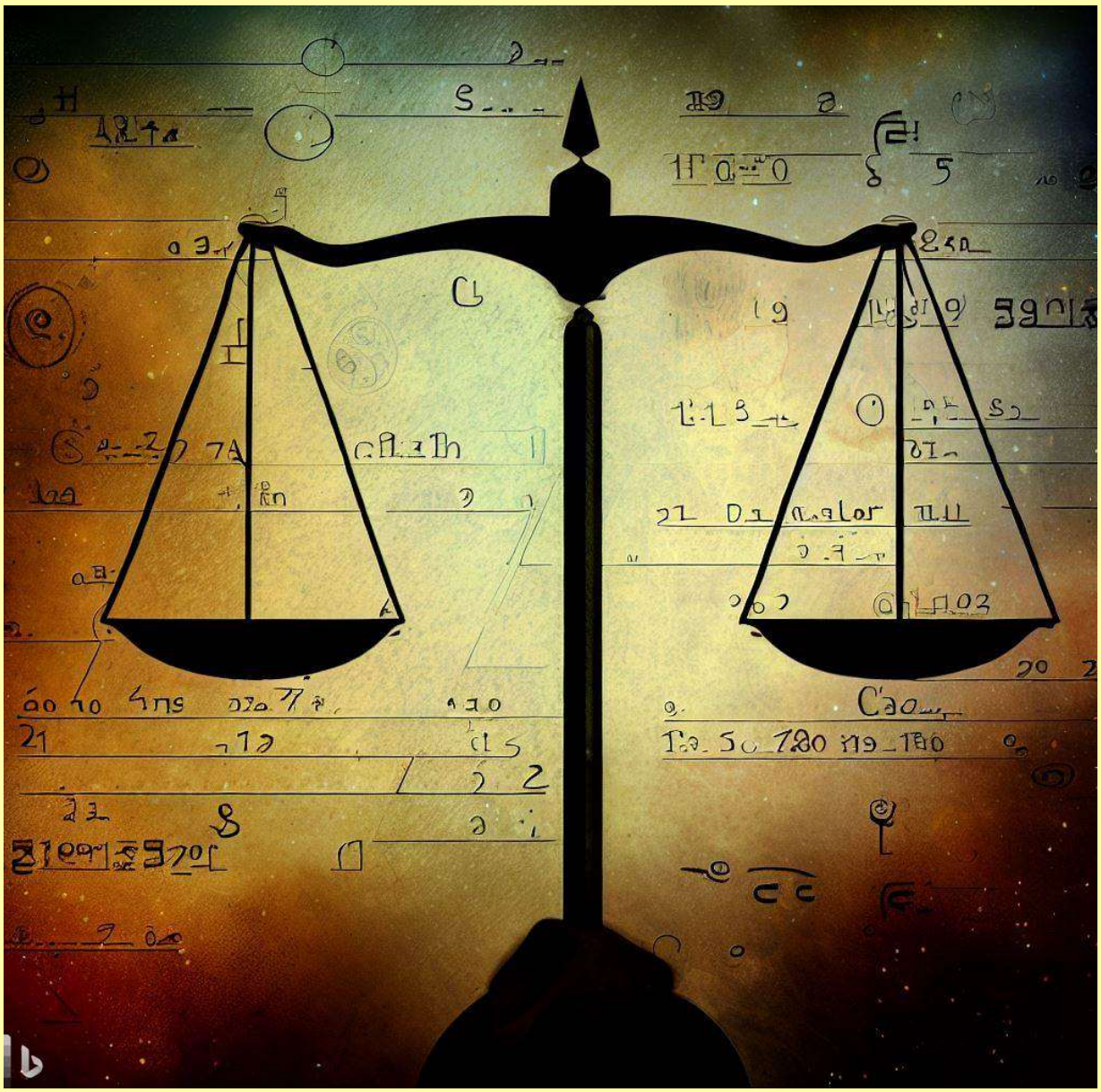
# All/other things being equal

## Ceteris Paribus



***Making numbers make sense***

**Neil Higgs**

# All/other things being equal

## Ceteris paribus

***Making numbers make sense***
***(with stories, anecdotes and some history)***

Neil Higgs, SAR, CMRS, RRSS

April 2023

Somerset West, South Africa

*'Twas brillig, and the slithy toves*
*Did gyre and gimble in the wabe:*
*All mimsy were the borogoves,*
*And the mome raths outgrabe*

*"Beware the Jabberwok, my son!..."*
*...*
*One, two! One, two! And through and through*
*The vorpal blade went snicker snack!*

*(Alice slays the dragon)*
*[of maths!]*

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Title Page picture: Alice slays the dragon of math

Cover: Bing AI image

## About this monograph

This book is about finding the stories that numbers can tell us just by using a few simple Rules of Thumb that you can make second nature. It is also about curiosities and stories to do with numbers – a rich history to be had.

Who is this little book aimed at?

You.

You, like many people, may feel a bit at sea with the numbers, charts and graphs that surround us these days. You may feel that others are better than you are in this area. This little book may help you – along with some anecdotes and stories to bring it to life. After all, this is supposed to be fun, not work.

Who wants to have fun?

You.

You may feel you have a good handle on this sea of numbers around us.

Great!

But how well can you tell others what the numbers mean?

Communication of issues that involve numbers is generally (not always, to be sure) awful. This is a direct observation of mine and applies to many journalists, media, PR people, CEOs of companies and spokespeople. Of course, there are people who are outstanding, but many are not. They miss the point, fail to challenge obvious nonsenses, and do not process the numbers into telling a story - they make our lives less easy. In some cases, the consequences are serious. Misconceptions arise quickly when numbers are indigestible or poorly presented.

Of course, there are those who set out to misrepresent the numbers to satisfy a particular agenda. We shall be on the lookout for these.

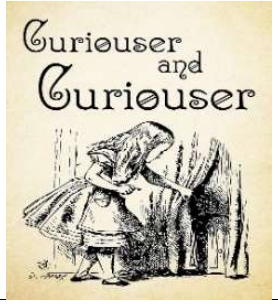
What you will find as you read is that you will no longer be discombobulated by numbers – just the reverse: you will revel in seeing through all the confusion. With a smile on your face. There will be "aha" moments.

We will look at common biases in the numbers around us - and in our own heads: we will quickly learn to cry "foul". We will discover when to say, "No way!".

> **So, yes, this book is quite definitely aimed at you, whoever you are. A reader, listener, or viewer, someone just going about their everyday lives. A journalist, a media person, a CEO or PR specialist, a spokesperson. Anyone involved in the communication of numbers that need to tell us something**.

This little book is about numbers, about being more comfortable with numbers, about finding the story they tell us, about finding it easily. Numbers are there to tell us stories. If they don't, the whole point of putting them out there has failed.

Talking of which – why Ceteris Paribus? Wait and see! Enjoy – that is what it is all about.




"The time has come," the Walrus said,
"To talk of many things:
Of shoes - and ships - and sealing-wax –
Of cabbages and kings –
And why the sea is boiling hot –
And whether pigs have wings."

(Alice)[1]

[1] Carroll, Lewis (1865), *Alice's Adventures in Wonderland*, Macmillan, 1865,
Carroll Lewis (1871), *Through the Looking Glass, and What Alice Found There*, Macmillan, 1871
Illustrator: Sir John Tenniel (We shall quote extensively from *Alice,* using this simple reference)

## Preface

Numbers.

Love 'em, hate 'em.

People tend to fall into one of these camps, it seems.

Where do you fall? Did you like maths at school or was maths literacy more your style? Did you hate both?

Do you equate numbers with indigestible mathematics, or maths, as we in South Africa say (not the American "math", please!). Do you feel the whole topic is just too complicated and completely irrelevant to your everyday life? Or do you just find numbers boring? Do they confuse you so that number ideas don't come easily to you?

Or do you find numbers fascinating, insightful, fun even? Do you see patterns in numbers easily? Can you see a news report and feel able to question some of the numbers - and, better, the conclusions – that you might find?

If you don't have a problem with numbers and what they tell you, this little book may not be for you – although you will find it useful in helping others who ***do*** battle. And if you are one who must **communicate** numbers to others, this little book will almost certainly make you think.

If numbers are not for you – whoa! **Stop** and think again.

In today's world, numbers are all around us. We probably don't even realise how often we use them, how familiar we actually are with them, how often we see them in the media or in discussions. Maybe you only ***think*** you are not good with numbers. Maybe you are much better than you think – I suspect you are. Maybe those who talk numbers at you could do a better job of that communication.

### Media and CEOs take note – this is also for you!

Teachers often tell kids at school that numbers (or maths) are/is difficult. But these subjects are often poorly taught, by teachers with inadequate maths' qualifications and an inadequate understanding of maths' ideas themselves. For many, the focus is on passing exams by rote learning, rather than on understanding basic ideas.

As a result, of the roughly 800 000 to 900 000 people who write matric these days, only about 220 000 write maths (that's around a quarter). And this number is declining. *Of these*, only about a half achieve a mark of 50% or more (I am not going to bother with those who achieve the minimum of 30% as that is just a joke). For maths literacy, 300 000 wrote the subject - but less than a half achieved even a 40% mark.

Taking both together, we have only around 250 000 people (a quarter of a million) who have some level of formal number training, even at a basic level, coming out of school every year.

And this does not tell the whole story – only about a half of those who start school (about 1,6 to 1,8 million) even get to Grade 12 to be a part of that 800 000 to 900 000. This is why South Africa comes pretty much last in most international studies of global maths abilities[2].

Utterly shameful.

> In 1992, Mattel released a talking Barbie doll that told young girls, "Math class is tough." There was a public outcry and affronted purchasers were given the option to swap the doll for one without the offending message. But the assumption that maths is a mysterious and uniquely difficult subject that is accessible to some but not all learners lives on. Young learners are quick to decide if they are good or bad at maths, and are likely to retain that mathematical identity for the rest of their lives.[3] [4]

[2] The sources for these numbers we give in the next chapter.

[3] News.vanderbilt.edu/2017/01/31/math-myths-researchers-debunk-common-misconceptions/ accessed 17 November 2022.

[4]The article also identifies some **myths** about maths: that not everyone is capable of learning maths, that maths is only about memorisation; that maths isn't supposed to be fun, and that maths is something you do alone. **These are all rubbish**.

There is no need for our poor abilities in handling numbers. Sometimes, those who give out - communicate - the numbers just don't do a very good job. Sometimes, we just close our minds and give up. But most of us are better than we think – we just need either a bit more confidence or a few simple pointers: ideas we can carry easily in our heads until they become second nature. It is a bit like learning to ride a bicycle.

Would you like to come and ride this bicycle with me?

Neil Higgs
Somerset West
April 2023


"…I only took the regular course." [said the Mock Turtle]
"What course was that?" enquired Alice.
"Reeling and Writhing, of course, to begin with," the Mock Turtle replied; "and then the different branches of Arithmetic – Ambition, Distraction, Uglification and Derision."

(Alice)

## Introduction – navigating this monograph

To some extent, this monograph can be dipped into wherever you feel the need. There are some references in later chapters to ideas from earlier chapters but the book does not follow a rigid sequence: it is rather a set of topics to make you feel more comfortable understanding, working with or communicating numbers, and ideas that depend on numbers or data (scary word!).

The first chapter is about simplifying and cutting through the detail to get the big picture without losing value. It is a good lesson for us all. Chapter 2 is about understanding scale and looking beyond the simple numbers to find the story, as well as getting know some useful numbers as signposts. The title of that chapter comes from an erstwhile boss who always told us to go beyond the obvious. Chapter 3 takes storytelling further to emphasise context and why that helps sort out fantasy from reality. Percentages are bandied about in much of what we see and communicate – but are surprisingly misunderstood, a subject addressed in Chapter 4. This segues naturally in Chapter 5 into understanding another ubiquitous topic: that of growth and how to understand – and use – it.

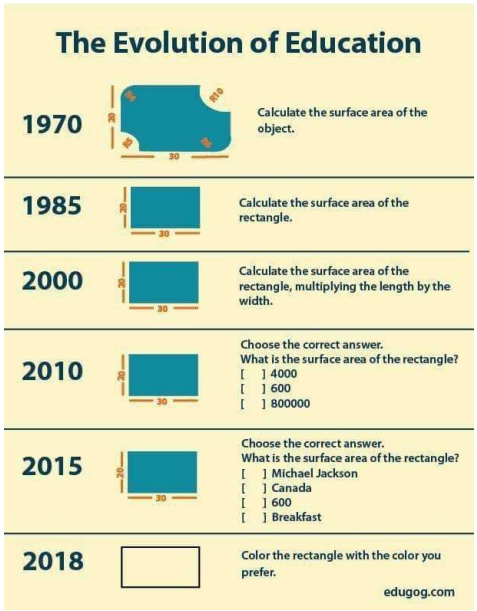
Chapter 6 looks into the field of chance, risk, probability and (in)justice, an important topic in these days of pandemics and DNA data. This is a useful precursor to Chapter 7: understanding the ins and out of polls and surveys, which we see daily in the press and which journalists generally communicate terribly – there are useful questions for you to ask in this arena. Such numbers often talk of averages but we also need to understand how people vary, both the subject of Chapter 8. Data is often portrayed using such summary numbers in graphs and infographics, which have their own set of dos and don'ts that can either inform or mislead – see Chapter 9.

An area of importance to us all is money, which drives how we shop and how we make decisions – for what numbers we can use to make this better for us, see Chapter 10.

Humans have an amazing ability to see patterns in numbers and events. Chapter 11 looks at how these can mislead us - or inform - us, leading naturally into Chapter 12 on predictions and forecasting, not in terms of the technicalities of how to do it, but what to look out for and when to challenge. Similarly, Chapter13 uncovers the biases that haunt all of what we see and what we do, and which can affect decisions and attitudes to an untoward degree – learn about these and how they might apply to you and the numbers all around us.

Finally, we bring it all together in Chapter 14 for a final round up (or down).

The Appendices go into more technical territory as well as providing answers to puzzles and exercises, and a database of conversions and key numbers. Look out for historical notes and stories to show the human side.



## Chapter 1 – A gentle art to get your balance ("Gently Bentley")[5]

***Today's lesson***

*Simplicate and add lightness – old aeronautical engineering maxim originating with the developer of the Ford Tri-motor aircraft, William Stout.*

***Simplicate***

In my opening remarks, there were a whole bunch of numbers. I approximated them quite a bit but they give a reasonable reflection of the current state of play for 2018 and 2019. The 2020, 2021 and even 2022 figures are rather different because of the COVID pandemic and do not reflect the normal state of affairs. Here is our first lesson: always check if things are EQUAL or NOT when doing any comparison – something we do every day.

Rule of Thumb 1 (RoT1): Are we comparing like with like or is it a case of apples and pears? Are all things equal? [*Ceteris paribus* means "*all (or other) things being equal*", from the Latin.]

Did you battle to understand those numbers at the beginning? By approximating them into round numbers, I made it easier – which was fine for the story I wanted to tell. You didn't need the detail for me to get my point across. And there is the second lesson – often the numbers around us are not presented with any thought, so they become indigestible. They are given to so many digits that our minds simply close them out. The story is lost.

For example, I could have told you that (for 2019, from the Dept of Basic Education's (DBE) press release about that year's matric results), it was reported as follows:

> A total of 787,717 candidates entered for the November 2019 NSC examination. This number was made up of 616,754 full time and 170,963 part-time candidates.
>
> A total of 790,405 candidates sat for 147 question papers in 7,416 examination centres nationwide. A further 212 learners wrote at correctional facilities.
>
> The minister said that 186,058 matric students achieved a bachelor's pass and 144,762 achieved a diploma pass.
>
> A further 78,984 achieved a higher certificate pass.
>
> She added that there are about 12m children in school [presumably just the DBE kids].

The figures for 2018 were a little higher, so, to give you the general idea of the past couple of (normal) years, I approximated by saying "roughly 800 000" sit for matric. It was good enough to get the general picture[6]

This press release is a prime example of poor reporting. The DBE may feel they have to give the numbers down to the last learner, but the reporter could have made the reader's life easier by saying "just under 790 000" learners sat the exam. And who knows what the 790 405 means? Somewhere we gained some 2 700 learners. But there is more: who separates thousands with a comma these days? No – we use a space, as I have done: the comma is for the decimal point. This whole press release simply confuses us all. Such detail should be in a footnote[7] or via access to the full press release via a web link. The other figures could have been rounded.

My eyes glazed over by the time I got to 787,717.

So, the next Rule of Thumb (RoT 2): Whenever you see lots of figures, drastically round the numbers in your mind. Simplify. *Imagine you had to tell someone else what the numbers said. Quickly. What is the story?*

[5] "Gently, Bentley" was a catchphrase of the post-WWII BBC radio show called *Take It From Here*, which starred the Australian comedians Dick Bentley and Joy Nichols, as well as English comedian Jimmy Edwards, who later had a series with that title. As such it entered the "pop culture" of British English.

[6] Update: in 2022, this figure reached 920 000, probably as a result of some catch-up after the COVID years. *Non ceteris paribus.*

[7] Footnotes are under-rated – they are good places for detail without disrupting the main story.

With this in mind, the release could have been more usefully reported as –

> 790 000 sat matric; 80% were full time. Just over 185 000 (a quarter) achieved a bachelor's pass with just over a half achieving a bachelor, diploma or higher certificate pass. (See link…)

Of course, depending on what the writer wants to achieve, more or less detail could have been given. The point is about clarity and throwing away numbers that just make one's eyes glaze over.

This is the fast-disappearing gentle art of approximation. It frightens some people.

Let's explore this a little more.

The art of approximation is being lost mostly because people have become lazy – they are given numbers to an unnecessary number of digits whenever they see a computer printout, or use a calculator. These are then simply spouted out regardless, without people properly absorbing what they mean. It is not the computer's fault or the calculator's fault – but a human interface that can intelligently process these outputs is still needed in today's world, to make sense of that world, to tell the story.

Think about the numbers you encounter every day without giving them much thought.

You know roughly how far it is to work or the nearest shops - if not in kilometres then in minutes. Maybe you factor in about 40 minutes or an hour (or two) to get to work, or ten minutes to the shops, or 30 minutes to someone in your family. You don't need to think, "It will take 42,5 minutes" or "I must allow 29,7 minutes". You know that there might be traffic, or some other problem such as the taxi being full or late - or you might just bomb through. A rough "40 minutes" or whatever is fine to plan your day well enough. Your experience tells you what to expect on most occasions.

It is the same with money. You probably have a good idea what an average shopping expedition will cost for a particular purpose. You will make sure you have enough money for that purpose. If the amount rung up does not fit more-or-less what you expect, you will more than likely sense it.

Depending on your circumstances, there will be other numbers with which you are quite familiar: your child's marks at school, that the days are longer in summer, that it gets hotter then, too, and that around 30ºC is quite hot. You know that 0ºC is freezing point.

This is none other than simple number sense. You don't think twice about it. You just do it.

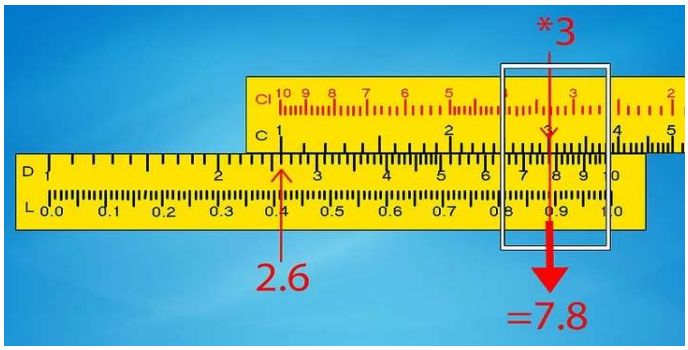
It is very easy to extend these ideas to other things and that is what this book aims to do. If you feel any apprehension about numbers, carry on reading – your apprehension won't last much longer. If you want to make a point using numbers, carry on reading.

Let's start with some war stories – stories about real events that helped to give *me* some number sense. Some of the stories are about the old days (so there is some historical interest) and some are about modern thinking that has become lazy.

> I was in Form II (that equates to Standard 9 in South Africa). It was the end of year and it was hot. Our Geography teacher had marked our exams and those of his other classes and was adding up all the class marks to get to class averages (we will explain averages later). He obviously felt the heat. I think we all felt a bit lazy after a year of work, and the Christmas holidays were close. We had finished our syllabus and our teacher decided we could help him add up the class marks. For each class for which he needed an average, he would call out the marks (they were in percentage form) and we all had to add them. Of course, it became a competition to see who could add them up the fastest and get the correct answer (defined as the answer most of us got!).
>
> I diligently wrote down all the numbers for the first class and started to add. But one of the others, Peter, got to the total well before I did. I was a bit miffed as I thought I was quite quick. No matter – a lucky fluke, I thought. But he did it again…and again…hmmmmm.
>
> He would not tell me how he did it – but later I closely questioned the person sitting next to him and found out his secret. As the numbers were called, he added each pair as he went along. When the time came to add from his list, he had half the numbers to cope with. No wonder he was faster.

I never forgot this little trick – and the lesson it taught me. It is easy to add two short numbers (percentages are in the form of two digits for class marks) in your head with even a tiny bit of practice, simplifying the final task considerably. And to add sets of just two numbers already begins to add to your sense of what looks right when you get the total.

> Our school days were very different from those of today when it came to handling numbers. In Junior school, we learnt how to multiply and divide three- and four-digit numbers on paper. It was slow and laborious so one did not want to get it wrong and have to redo the exercise. But one learnt to figure out roughly what the answer should be in advance so that any major error would be immediately apparent.
>
> By the time we reached high school, we had to work with bigger numbers or numbers with decimal points. To do this by hand was very tedious. But we had no calculators in those days, so what was the answer?
>
> We had two options: the first was to use logarithmic (log) tables (if you add two logarithms, it is equivalent to multiplying the two numbers whose logs they are). You will be relieved to hear that I won't go into the intricacies of logs here although we will talk about some of the ideas behind them when we get to understanding growth later. Another option, especially in the higher standards, was to use a slide rule. This is an analogue device that also uses logarithms but does it by adding two lengths on the rule together to do the multiplication. (Division was accomplished in either case by subtracting logs or lengths.) The diagram below shows the "addition" of lengths 2,6 (on the D scale) to 3,0 (on the C scale) to get 2,6 x 3.0 = 7,8 back on the D scale. The marks on the scales are not equidistant because both are logarithmic scales, but addition is so much easier than multiplication.




You will be very unlikely ever to use or even see either a real slide rule or log tables, which is a bit of a shame – of course, we must always use new technology where appropriate; if you are interested, there are some quite fun slide rule apps freely available (I still love my slide rule)[8].

> As an interesting snippet, a team of ladies under Dorothy Vaughan provided many of the calculations for the US space race: Katherine Johnson - who was awarded the Presidential Medal of Freedom in 2015 by President Barack Obama - joined the team in 1953. A physicist, space scientist and mathematician, she provided the calculations (by hand) for Alan Shepherd's first US flight into space, John Glenn's three orbits of the earth and the trajectory for Apollo 11's moon landing. Some of the Apollo astronauts said that they would not fly into space until "Katherine said it was ok", once she had checked the electronic computers of the time- not quite trusting them[9].

The key thing was that, in the both the cases of logs or slide rules, one needed to know roughly what the answer would be, *in advance*, so as to get the decimal point in the correct place.

Do we need to do that today – after all, we have calculators easily available? Most smartphones either come with a calculator already installed, or there are any number of good free apps that will do the job. Almost all come with a simple four-function (+ − x ÷) component as well as a scientific component that we explore later.

[8] By the way, there is a great book called *Slide Rule* by Neville Shute. It is his partial autobiography from his time in aviation. One of the major events it covers is that of the first British commercial airship, the R100, in 1929/1930. It was a very successful aircraft, designed by a team of people termed *calculators* who did all the stress calculations by hand, using slide rules. It was not this airship that crashed – that was the R101.

[9] Grace Murray Hopper (1906 – 1992), one of the first women to work on computers, became a rear admiral in U.S. Navy. She did significant work on the Harvard Mark II, where she discovered the first computer bug - a moth - and coined the term to mean a problem with a programme She developed the first compiler, A-0, and the programming language COBOL.

Let me give you an example, though, which suggests that this is still a useful art – the art of approximation, that is. Let's take a more complicated example than the one above. Say we had to multiply 7,21 by 9,87. Most people today would reach for a calculator – fair enough: if you have one, by all means use it.

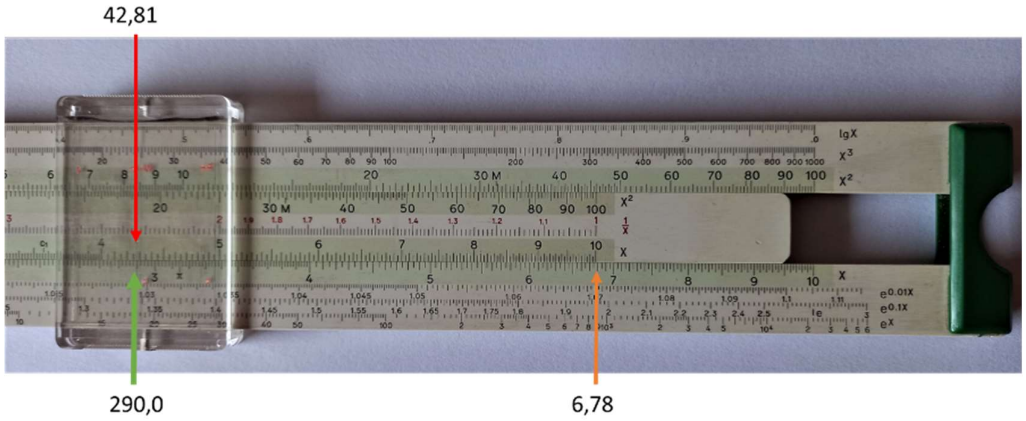
But first, just stop.

Look at the task.

You could **roughly approximate** this (I use both words for emphasis!) by saying this is roughly 7 x 10 = 70. Using a calculator gives 71,1627 - so 70 is not a bad first estimate. You can do it in your head.

How accurate do you need to be? Is 70 good enough, or perhaps 71? Do you need to go to all the decimal places? Unless you are designing something critical, probably not. But more to the point – if you happen to hit the wrong key on your calculator and get, say, 61,2927, if you have done the quick mental approximation, you would know immediately that you had made an error. If you have no idea what to expect, you might just end up writing down the numbers blindly.

Let's do an even more complicated example. Here, for historical interest, is a picture of my actual slide rule set up to calculate 6,78 x 42,81.




How would you do this quickly in your head first? As a very rough start, you could multiply 7 by 40 to get 280 (remember your times table? 7 x 4 = 28). Now you know *more or less* what to expect. When your calculator tells you the answer is 290,2518, you will probably be happy that you have not entered a number incorrectly. This very rough calculation is not foolproof, of course – had you entered 6,78 x 41,81, you would have obtained 283,4718 – still close to your rough in-the-head result. But this simple mental check will save you trouble surprisingly often.

Getting into the habit of doing this will teach you how to apply the gentle art of approximation in what you see around you every day, as we saw in our opening example. It will certainly help you to make sense of the numbers that you see around you, as well as help you to remember them if you need to.

The story will begin to stand out because you won't be lost in a sea of digits.[10]

Here is another example, taken directly from the annual Statistics SA mid-year population projections[11] giving the population estimates for mid-year 2020, one of many reports the organisation puts out every year[12], with a

[10] The English mathematician and clergyman Reverend William Oughtred and others developed the slide rule in the 17th century based on the emerging work on logarithms by John Napier. Many top scientists such as Galileo, Gunter, Newton, Gauss, Watt, Priestley, Fulton, Fuller, Einstein, Fermi, and Von Braun.developed and used slide rules routinely in various forms. Before the advent of the electronic calculator, it was the most common calculation tool in science and engineering. The slide rule's ease of use, availability and portability, and low cost caused its use to continue to grow through the 1950s and 1960s, even as electronic computers were gradually being introduced. The introduction of the handheld electronic scientific calculator around 1974 made slide rules largely obsolete. The Oughtred Society takes this history and the use of slide rules much further if you are interested.

[11] P0302, 9 July 2021, abbreviated to MYE.

[12] Much of the writing of this book took place during the various COVID lockdowns. Some of the examples date from that period. Any useful updates since then are given as necessary – but the same principles apply, *mutatis mutandis.* In addition, some of the later data is skewed by distortions induced by the pandemic and so is less useful as general example.

short summary. I have great respect for all that StatsSA does, on a restricted budget. The work they do is critically important for all South Africans in any kind of decision-making role, and in many research and related roles.

***Bear in mind that these figures are estimates, using various assumptions and models to arrive at the figures:*** they do not come from a Census – rather, they take the last Census (2011)[13] and use algorithms and models to project forward to today, taking into account fertility, mortality and immigration data.

**Table 1: Mid-year population estimates for South Africa by population group and sex, 2020**

| Population group | Male | | Female | | Total | |
|---|---|---|---|---|---|---|
| | Number | % distribution of males | Number | % distribution of females | Number | % distribution of total |
| Black African | 23 519 474 | 80,7 | 24 634 253 | 80,8 | **48 153 727** | **80,8** |
| Coloured | 2 555 204 | 8,8 | 2 692 536 | 8,8 | **5 247 740** | **8,8** |
| Indian/Asian | 787 662 | 2,7 | 753 451 | 2,5 | **1 541 113** | **2,6** |
| White | 2 266 535 | 7,8 | 2 413 235 | 7,9 | **4 679 770** | **7,8** |
| **Total** | **29 128 875** | **100,0** | **30 493 475** | **100,0** | **59 622 350** | **100,0** |

For 2020, Statistics South Africa (Stats SA) estimates the mid-year population at 59,62 million. Gauteng still comprises the largest share of the South African population, with approximately 15,5 million people (26,0%) living in this province. KwaZulu-Natal is the province with the second largest population, with an estimated 11,5 million people (19,3%) living in this province. With a population of approximately 1,29 million people (2,2%), Northern Cape remains the province with the smallest share of the South African population. About 28,6% of the population is aged younger than 15 years and approximately 9,1% (5,4 million) is 60 years or older. Of those younger than 15 years of age, the majority reside in KwaZulu-Natal (21,8%) and Gauteng (21,4%). Of the elderly (those aged 60 years and older), the highest percentage 24,1% (1,31 million) reside in Gauteng. The proportion of elderly persons aged 60 and older is increasing over time.

Given our discussion so far, what is your first reaction to the table?

Mine was – why so many digits?? There is no way the models and algorithms are accurate to the last person. Even the Census has some approximations and adjustments in it, for starters. Add in the various assumptions of estimated growth, fertility, mortality and flow patterns, and these MYE estimates become increasingly approximate. How approximate? I have no idea – and that is, in itself, a problem. We don't really have any idea how far we can take them – to the nearest ten, a hundred, a thousand? What is certain is that going down to the last person is nonsense.

I asked StatsSA why they use so many digits and never received a sensible reply. So, much as I respect them, I have to ask how much sense they made of the numbers. I suspect they came straight out of the computer and into the publication with no intermediate processing. The problem then is that there is an implied level of precision that arises by using so many digits – and that is rubbish. Unfortunately, I have seen these figures used by others exactly as they are without any questioning or thinking. This is not good and unnecessarily complicates things. It also leads to people's eyes glazing over.

The summary does give a better sense but, for me, the take out from the table is that our population then was a little less than 60m with 30,5 females and 29,1m males [51:49]. Blacks comprise 81%, coloureds 9%, whites 8% and Indian/Asians just under 3%. Boom, that's it.[14]

Before we leave this topic, I was struck recently by a question posed by a very good health journalist who was stuck by a simple estimation exercise. She wanted to refer to statistical experts for help. But there was no need: she was quite capable of doing the exercise, *to a good enough approximation*, herself.

[13] Census taking has a long history dating back to the 18th century. Census surveys in South Africa were conducted in 1911, 1921, 1936, 1951, 1960, 1970, 1980, 1985, 1991, 1996, 2001, 2011 and 2022. However, information collected during the Apartheid era is uneven and unreliable especially with regard to the African/Black population. Legislation such as the Native Areas Amendment Act and the Group Areas Act skewed official statistics and grossly underestimated the number of people living in cities, amongst other things.

[14] Update: the 2022 MYE estimates a population of 60,6m (also P302 and released 28 July 2022).

She wanted to estimate the size of the 2020 18+ population from Table 6 in the same publication, P0302, to estimate the number of adults eligible for COVID vaccinations. This is a very big table with lots of numbers, again to too many digits. I have drastically simplified it in the table below.

I used two decimal places as we use this table again later – but, for now, we could even have kept it to one decimal place.

The table can be summarised (as we see) as –

- 0 – 14: 17,1m
- 15 – 19: 4,8m
- 20 – 59: 32,4m
- 60 + : 5,4m

| Age group | Millions | |
|---|---|---|
| 0 - 4 | 5,74 | |
| 5 - 9 | 5,72 | 17,1 |
| 10 - 14 | 5,59 | |
| 15 - 19 | 4,77 | 4,8 |
| 20 - 24 | 4,82 | |
| 25 - 29 | 5,42 | |
| 30 - 34 | 5,64 | |
| 35 - 39 | 4,80 | |
| 40 - 44 | 3,73 | 32,4 |
| 45 - 49 | 3,17 | |
| 50 - 54 | 2,57 | |
| 55 - 59 | 2,21 | |
| 60 - 64 | 1,80 | |
| 65 - 69 | 1,41 | |
| 70 - 74 | 1,01 | 5,4 |
| 75 - 79 | 0,64 | |
| 80 + | 0,58 | |
| TOTAL | **59,62** | |

The journalist was stumped because there is no interval explicitly breaking down the 18 years and older group.

**As a first approximation**, we might simply spread the 4,8m in the 15 to 19 year group over five equal one-year portions of 0,95m, so that the 18/19 year-old element of the 15 – 19 group is 1,9m. Adding in the last two numbers in the summary, we quickly obtain 39,7m or ~ 40m for the estimated 18 years and older population size[15]. This would be good enough for most purposes[16].[17]

This illustrates the point that even quite drastic approximations can be very useful in finding the story we need to understand. There is nothing wrong with approximations if they help us find the big picture. And we need to understand that many of the figures we are fed are themselves estimates that are not exact – and nor do they need to be, very often.[18]

[15] Note that the "~" symbol means "roughly" and is a standard symbol in maths – sometimes also depicted as "≈" – and is pronounced "tilda".

[16] Of course, the simplifying assumption that we can spread the age group sizes equally is not exactly true (there are likely to be sligtlty more in the three younger groups, looking at the sizes of the groups below and above the 15 – 19 group), but, given that we are already working with estimates that have some level of approximation about them, we won't be far out and certainly good enough for broad planning purposes.

[17] As an aside, I could easily have set the number of people on those five single years at a round 1m to get 39,8m ~ 40m even faster.

[18] As another aside, as the COVID vaccination programme (very) slowly got underway in South Africa, those aged 60 + were prioritised. The media set this figure at around 5m – probably a bit too much of an approximation given that vaccines had to be ordered and distributed. Better that the authorities should have worked on 5,5m.

***Conversions***

Your will often see or need to use conversions from one set of units to another: miles to kilometres, litres to gallons, kg to lbs (kilograms to pounds), or whatever.

The less numerate will apply a conversion fator with no thought – say 50 miles = 80,47km, or 10lbs = 4,536kg. A common one is the Kármán line at 100km = 62,137 miles.[19]

This is nonsense.

The original distance in miles or lbs or km is clearly set to the nearest mile, lb, or km (or whatever). For everyday use, then, 50 miles = 80km, 10lbs = 4½kg, and Kármán is 60 miles.

The principle is the same: apply the gentle art of rounding!

***Useful numbers***

We also now have some useful reference numbers to keep in mind:

- Our population in 2020/2021 was around R60m.
- Around 80% is black.
- About 20m were under 18, 40m were 18years and over, and about 5,5m people were 60 years and over.
- There were about 12m children in government schools.
- About 800 000 to 900 000 write matric these days. About a half of those starting school (1,6m) make it to Grade 12.
- Less than half of those writing either maths or maths literacy pass; about 100 000 pass maths itself with 50% or more. We have about a quarter of a million people emerging each year with some level of numeracy – less than one in six of those kids starting school can be called "probably numerate".

Sobering.

"You are old, father William," the young man said,
"And your hair has become very white;
And yet you incessantly stand on your head –
Do you think, at your age, it is right?"

(Alice)

My Mum as a very experienced book-keeper was excellent with numbers. She would be responsible for the final stocktake figures for her company once a year. It was a big job and she would call on my sister and I to help. She had a big ledger which she would bring home. In it were listed all the items their outlet sold with their cost and selling prices. We had to multiply the number by the price to get a stock value.

As an aside, this was the days of £.s.d., or pounds, shillings and pence. Mum would always know if we were wrong as she knew roughly what our answers should be. Mum would then take the column of figures and add them up completely in her head from top to bottom - first the pence, then the shillings and then the pounds – and then do it in reverse (bottom to top) to check herself. She was never wrong.

[19] The altitude at which space is defined to begin as set by the Fédération Aéronautique Internationale (FAI).

To watch her pencil slide up and down the columns was a real revelation. She had real number sense.

Of course, the computer would do all this today – and stock-take numbers would need to be correct to the last penny/cent. But that is not how they would be reported in the Annual Shareholder's Report.

Maybe there is a lesson for StatsSA here.

***What have we learnt?***

As we leave this chapter, we have two Rules of Thumb – check that comparisons are like vs like **(all things are indeed equal)**; round the numbers you see to make them easier to absorb. Don't be afraid to round drastically. You may have to tell someone these numbers and be able to relate usefully the story that they are telling.

*Simplicate and add lightness*

This little trick alone will make numbers clearer to you, greatly aiding your number sense.

If you are a communicator, this approach will make your numbers so much easier for your audience to understand and buy into[20].

In a conversation Alice has with the White Queen:

"How old are you?" said the Queen.

"I'm seven and a half exactly"

"You needn't say "exactly" the queen remarked: "I can believe it without that. Now I'll give you something to believe. I am just one hundred and one, five months and a day"

"I can't believe that!" said Alice.

"Can't you?" the Queen said in a pitying tone. "Try again: draw a long breath, and shut your eyes."

(Alice)

Did you know?

Number systems date back to 30 000BC when the paleolithic people in Europe made marks on bones. The Babylonians (whom we shall meet often) in 2000BC (4 000 years ago) used a number system with base 60 We use base ten, the old shilling had 12 pennies (base 12) and there were 20 shillings in a pound (base 20). Go figure! We still have a remnant of base 60 in that we have 60 seconds in a minute, 60 minutes in an hour. There are 360˚ in a circle (a right angle is 90˚). Attempts to make 10 hours in a day and 100 minutes in an hour – and 100˚ in a right angle - have never taken off.

Today's number system stems from those Babylonians, as refined by the Hindus from 600AD onwards. The modern decimal system became recognisable around 1600AD. Of course, the Romans did their own thing – a system that required expert knowledge to manipulate to any degree. (See also the Appendix)

CCCDX ÷ IV = XC anyone?

## Activity Corner (answers in Appendix)

### Three quick puzzles:

1. Find a rough answer to 7.5 x 4.2 = ?
2. What is 37 + 19, roughly, just roughly!!?
3. EASY ONE: 360 ÷ 4 = ??? (see the box at the end of Chapter 1!)

## Games corner

1. What's next? 4, 8, 16, ??

[20] Don't be afraid to use footnotes to give the detail!

2. Here is a square of numbers. These are random numbers, all falling between 0 and 9. The first square is an example. The second one is for you to do.

   a. Find a path from the top to the bottom, moving one row downwards each time to a touching cell either vertically or at a corner, so that the path adds up to the smallest total. What is your total?
   b. Repeat going from left to right. What is your total?
   c. Feeling strong? Then repeat the exercise, this time looking for the highest total. Write down both totals.

| | | | | |
|---|---|---|---|---|
| 3 | 2 | 1 | 6 | 5 |
| 0 | 6 | 0 | 4 | 8 |
| 3 | 4 | 3 | 3 | 7 |
| 3 | 5 | 4 | 3 | 2 |
| 6 | 8 | 9 | 1 | 8 |

Top to bottom lowest is 7, left to right is 7. Now you do the highest paths (answers are 32 and 34).

Now your turn – answers in Appendix 2!

| | | | | |
|---|---|---|---|---|
| 1 | 8 | 4 | 4 | 6 |
| 9 | 5 | 1 | 7 | 3 |
| 2 | 0 | 4 | 3 | 4 |
| 3 | 3 | 9 | 1 | 7 |
| 8 | 5 | 3 | 8 | 1 |

## Chapter 2 – The big numbers are big and the small numbers are small (or when size matters)

***Today's lesson***

*All things bright and beautiful*
*All creatures great and small – Traditional hymn – He gave us eyes to see them,*
*And lips that we might tell…*

***Finding the story***

A good part of my career of 50 or so years has been spent doing surveys amongst ordinary people. These involved asking people about their usage of and attitudes to brands, how they felt about various ads, new packs and new products, as well as studies involving the media, socio-economic issues, how people live their lives, make decisions and interact with each other, and what different groups of people look like in terms of how and what they need to live. The categories we worked on ranged over most of the economy and much of the public sector. It has been a fascinating career with never a dull moment because of the variety, the challenges, the time and cost constraints, and more. Suffice to say, I have been very lucky to have had a thoroughly good time.

As you can imagine, most of these surveys involved the generation of reams of results - numbers. Whilst we shall talk about how to interpret surveys later – it is an important topic in today's society – my focus in this chapter is on some of the things I have learnt in communicating results to clients, as well as to the public at large on occasion.

In the early days, research companies simply sent 534 pages (or more!) of computer printout to their clients and left it at that. As a result, researchers gained a reputation of being boring and dull. It was not far from the truth.

When I started in research in the mid-70s, there was already an increasing need for researchers to make more sense of the numbers (though many old-school researchers resisted this as heresy) and the company I eventually joined for the majority of my career was big into interpretation. We were regarded as mavericks[21]!

What does this mean – this making sense of the numbers? It means sitting down with the numbers and finding the story to tell. *There is always a story to find and tell.*

However, for a neophyte researcher[22], it is much easier to say which numbers are big and which numbers are small. Of course, this is evident from the tables included with the report: there is no need to repeat the obvious.

Or is there?

Let's look at a few examples.

A common type of survey is one that monitors how brands are doing in the marketplace. One might ask what brands people have used in the last week or month. This would be reported simply as the usage percentages achieved: brand A is used by 23%, brand B by 27%, Brand C by 13% and so on. Here it might be acceptable simply to say which brands have achieved what. Even so, most researchers might add a little value by presenting the results in order of size in order to show which brands are big and which brands are small more easily. This is a first baby step in the *simplify* process we raised in Chapter 1.

There would almost always be analyses to show how this overall pattern changes for different groups of people: females vs males (if this is appropriate for the category being considered), different age groups, different areas, different levels of affluence or education and so on. Or we might look at changes over time.

One must not accept the set of results at face value: there will always be a story to find with even just a little digging. Does our brand appeal to younger or older people? Richer or poorer? Do we have a strength in certain areas and a weakness in others? How have things changed compared with last year? This is quick and easy to find and to weave into a simple story. This is also what you might ask (or expect) when reading such a report.

[21] and sometimes labelled "cowboys"!

[22] or for the neophyte writer/journalist.