Article

Science walks on two legs, but social sciences try to hop on one

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Abstract

Science walks on two legs. One leg consists of asking: How things *are*? This leads to observation, measurement, graphing, and statistical description. The other leg consists of asking: How things *should be*, on logical grounds? This leads to logical models that should become quantitatively predictive. Science largely consists of such models, tested with data. Developed science establishes not only connections among individual factors but also connections among these connections. As an illustration, I use laws about human activity I have found. But social sciences often take the lazy road of fitting raw data with a straight line or some fashionable format, unaware of the need to *think* and build models based on logic, as stressed by Karl Deutsch. As expounded in my *Making Social Sciences More Scientific* (2008) and *Logical Models and Basic Numeracy in Social Sciences*, www.psych.ut.ee/stk/Beginners_Logical_Models.pdf, I call for a major widening in social science methodology.

Introduction

This is a great and unexpected honor for me to receive the Karl Deutsch Award from the International Political Science Association. I became aware of Karl Deutsch's work as soon as I began to shift from physics to social sciences. This began with Deutsch's book on *Nationalism and its Alternatives* (Deutsch, 1969).

Most impressive was an article by Manfred Kochen and Deutsch (1969): 'Toward a rational study of decentralization'. This was an early example of what I call quantitative logical models. I will return to these models.

I have succeeded in discovering some relationships that qualify as laws about human activity. But my approach, which I took with me from physics, has met resistance.[1] This is why the Karl Deutsch Award is a happy surprise, indeed. This means I can raise a stronger voice to promote logical models. But first a few words on how I became a social scientist.

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How I became a social scientist

While herding cows at 11, during World War II, I passed time pondering the following. Suppose 100 soldiers face 50 soldiers in an open field. Everyone can shoot at everyone opposite. Assume equal weapons and skills. How many of the 100 would be left when the 50 are annihilated? I suspected that the losses of the superior force would be rather small. I did some calculations in my head, but it got too complex, and I had no paper with me. So I had to give up. But maybe this suggests it was in my bones to apply quantitative logical models to social issues.

Much later, I recalled this puzzle. I quickly set up a set of two differential equations and solved them. The result: A full 87 out of 100 survive. Did I publish this result? Tough luck. Some guy Lanchester had already devised these battle equations in 1916, way before I was born (Lanchester, 1956).

Like Karl Deutsch, my family fled totalitarian rule in Eastern Europe and eventually ended up in North America. On my way, I completed high school in Marrakech, Morocco. I got a Bachelor's degree in nuclear engineering at the University of Toronto, and a PhD in physics at the University of Delaware. I published in nuclear and solid state physics (Taagepera and Nurmia, 1961; Taagepera, Storey, and McNeill, 1961; Taagepera and Williams, 1966). But mainly I worked with textile fibers at an industrial laboratory (Pioneering Laboratory, DuPont de Nemours Experimental Station). Still, I also wondered about what happened to my family and my country, because of world politics. So I took evening courses in political science. This led to an MA in international relations.

During these studies I noticed the so-called cube law of Anglo-Saxon elections. This changed my life. This relationship applies to two major parties in single member plurality elections. It expresses the fact that the larger party gets a hefty bonus – its seat share is much larger than its vote share. But how much larger is it? Just saying, 'more votes, more seats' is primitive science. Direction of change is not enough. To qualify as science, we must make the relationship quantitative. This means we must ask specifically *how* large a seat share a party would receive with a given vote share.

The cube law of elections does this. It connects the *ratio* of seats of the two parties, A and B, to the *ratio* of their votes. The seat ratio is roughly the cube of the vote ratio: $S_A/S_B = (V_A/V_B)^3$. For instance, when the percentages of votes are as close as 60 to 40, the so-called cube law says that the percentages of seats are as far apart as 77 to 23.

This relationship is not linear. It is curved – and in a complex way, imposed by logic. Why do I stress this? Because all too many social scientists seem to believe that all quantitative relationships are linear. None of them believe in a flat Earth, but they do believe in straight lines. The hard reality is that linear relationships are quite rare in natural sciences, and don't tell me that social relationships are any simpler. This is where social sciences produce a lot of junk – lots of phantom linear relationships.

But back to the so-called cube law. This was not really a law. It was just an empirical regularity. To qualify as a law in the strongest scientific sense, we must also have an explanation, *why* the relationship *must* have the form it has, why it could not be any other form. This was what puzzled me. The answer came soon after.

The law of minority attrition

To explain a phenomenon, try placing it in a broader framework. Here the relationship is not always cubic. The outcome depends on the total number of seats. Indeed, when there is only one seat at stake, like in presidential elections, then a vote ratio 60 to 40 does not lead to seat ratio 77 to 23 but 100 to 0.

Hold it, some political scientists may holler. Don't you dumb physicist know that parliamentary and presidential elections are completely different beasts? You cannot put them into the same

model. I have met such misconceptions over and over, and this impedes political science becoming a science. Oh yes, I *can* apply the same model to parliamentary and presidential elections. If I were wrong, then the quantitative logical model simply would not fit. But my extension of the cube law does fit. This confirms that for *some* purposes, presidential elections by plurality are just an extreme case of parliamentary elections that use the single member plurality rule.[2]

I later published my model as the 'seat-vote equation' (Taagepera, 1973)

$$S_A / S_B = (V_A / V_B)^n \text{ where } n = \log V / \log S$$

Here *V* is the total number of votes and *S* the total number of seats. I now call this model the 'law of minority attrition' because it applies more broadly, beyond elections. For instance, it applies to female–male ratios among assistant and full professors (Taagepera, 1994). Turned around, this law also produces the pattern by which the European Union has allocated seats in the European Parliament to countries (Taagepera and Hosli, 2006).

Cube root law of assembly sizes

The law of minority attrition produces the so-called cube law only if the number of seats in the assembly is the cube root of the number of voters, which roughly reflects country population. To my surprise, I found that this is so in most democratic countries. Countries have discovered by trial-and-error that the cube root of population is the most efficient size for legislative assemblies. So a country of 8 million typically has a representative assembly of 200, given that 200 times 200 times 200 brings us to 8 million.

But why is this size the most efficient? Here we come to the Kochen and Deutsch model for optimal decentralization. Kochen and Deutsch (1969) asked how many warehouses would be optimal for a firm that services a region. If there is only one warehouse, delivery costs are high because of distance. If there are many warehouses, delivery gets cheaper, but the fixed cost of maintaining warehouses piles up. In other words, *capital* costs go up *proportional* to the number of warehouses, while *service* costs go down *inversely proportional* to that number. Kochen and Deutsch expressed this as an equation. They turned this equation into its differential form, and out popped the number of warehouses that minimizes total costs.

This is also the way to approach assembly sizes. Consider the communication load on a single member of the assembly.[3] With a larger assembly, her load of handling *constituents* goes down, but her load within the *assembly* goes up. When we apply Kochen and Deutsch type reasoning, we find that the total communication load on a single representative is minimized when the number of representatives is the cube root of the population (Taagepera 1972).

Recall that to have a 'law' in the strong scientific sense, we need not just an empirical relationship and not just a cute logical model, we need both.[4] For first or only chambers we do have both. So the relationship qualifies as the cube root *law* of assembly sizes

$$S = P^{1/3}$$

Cross-disciplinary or multi-disciplinary?

All this became more exciting than the physics of textile fibers. So I began to look for a job in political science. I sent out letters to some 120 departments. I told them to throw away my letter if

they thought political science was in good shape, as *science.* But if they thought political science still needed to *become* a science, I was the person to turn the whole discipline around. Only one university took the bait, the brand-new Irvine campus of the University of California. They wrote: 'You are an odd kind of a social scientist. We are an odd kind of School of Social Sciences. Maybe we are good for each other'. We have been so, indeed, over close to 50 years.

The Karl Deutsch Award emphasizes cross-disciplinary work of which Deutsch was a master. How does my work qualify? I have published in *American Anthropologist*, on expansion of civilizations (Taagepera and Colby, 1979), and even in *Linguistica Uralica*, on grammatical similarities in Eurasian languages (Taagepera and Künnap, 2005). I recently published a model of how world population growth interacts with technology and limited space (Taagepera, 2014), which neatly fits world population numbers during the last 1600 years. This past history projects to a sharp slowing down due to space squeeze, with a ceiling being hit at 10.2 billion people, yes, that precise, with little wiggle room.

I have also built and tested models of how a country's population affects its trade/GDP ratio (Taagepera, 1976) and the size of its cities (Taagepera and Kaskla, 2001). I have studied how communism interacts with culture and corruption (Sandholtz and Taagepera, 2005). Has this work been cross-disciplinary, inter-disciplinary or merely a multi-disciplinary smorgasbord of unconnected studies? The common thread is that I keep applying methods I took away from physics.

This may appear most clearly in my electoral studies research, becoming highly visible with the book *Seats and Votes* (Taagepera and Shugart, 1989) three decades ago. I wrote it together with a graduate student, Matt Shugart. Thereafter, I continued with a book on *Predicting Party Sizes: The Logic of Simple Electoral Systems* (Taagepera, 2007). Matt had his own highly visible book on *Presidents and Assemblies* (Shugart and Carey, 1992). We are now jointly completing a book with much deeper insights. The new Shugart and Taagepera (2017) *Votes from Seats* will totally supersede the former Taagepera-Shugart *Seats and Votes*.

But can these books offer anything to those political scientists who have no interest in electoral studies? They do, because they offer an example to emulate: connections among connections (Taagepera, 2008: 66–67, 130–136, 2015: ch. 10).

Connections among connections is the hallmark of science

Indeed, having connections among connections is the hallmark of developed science. It is nice to have separate equations to connect individual factors, such as *y* to *x* and *A* to *B*, and maybe *S* to *V*. But this would be like the railroad map of Africa: largely isolated tracks connecting ports to some points in the hinterland. The tracks do not interconnect. Compare this to railroads in Europe: You can go from Poznan (the location of the IPSA World Congress) to almost any other train station in Europe, hopping from one train to another. The tracks interconnect. This is what I mean by connections among connections: The equations that connect *y* to *x, A* to *B*, and *S* to *V* are themselves connected. Take electricity. Electricity offers a network of equations that connect factors such as electric charge, voltage, current intensity, resistance, force, and power (Taagepera, 2008: 66–70).[5]

Can such connections among connections also exist in social sciences? On philosophical grounds, one may express doubts. But, connections among connections now do exist in one corner of the social sciences, electoral systems.

Connections among connections in electoral systems

Consider a simple electoral system where a total of *S* seats in an assembly are allocated in districts of *M* seats each, using some Proportional Representation rule. When districts have only one seat

each, $M=1$, Proportional Representation amounts to Single Member Plurality. Yes, Single Member Plurality is just the extreme case of Proportional Representation, when district magnitude is gradually reduced toward 1. Remember presidential elections as an extreme case of assembly elections. Self-evident to physicists, such thinking by extremes meets tremendous resistance from political scientists, and this weakens the progress of the discipline.

How many parties would win seats, at least one seat, in such an assembly of S seats, allocated in districts of M seats? In the absence of any further information, it can be shown that our best guess is the fourth root of the so-called seat product, M times S (Taagepera, 2007: 116, 133–134)

$$N_0 = \left(MS\right)^{1/4}$$

For instance, if an assembly of 200 seats is elected in 10-seat districts, then the seat product is 200×10=2000. Its fourth root is 6.7. So, most likely about seven parties will get seats. From this guess, in turn, we can logically estimate the seat share of the largest party. From that, the so-called effective number of parties follows (Taagepera, 2007: 122–164). We have a sequence of interconnected equations.

Cute cat, but can it catch mice? Cute logical model, but does it fit reality? Yes, this model does fit the world average unbelievably well. This world average, in turn, supplies a *benchmark for country studies*. Indeed, if a country has markedly fewer parties than expected, then we should investigate which country-specific factors are at play, in addition to its assembly and district sizes.

Effective number of parties

The 'effective' number of parties I mentioned is the Laakso–Taagepera effective number. Markku Laakso and I devised it separately and then published it jointly (Laakso and Taagepera, 1979). This number is widely used to characterize the number of parties when some of them are large and some are small. The effective number discounts small parties by assigning weights to seat shares of parties, proportional to these very shares

$$N = 1 \,/\, \Sigma \, s_i^2$$

where s_i is the fractional seat share of the ith party. For example, suppose eight parties obtain seats, but to a very uneven extent: 30–30–30–2–2–2–2–2. Three parties have 30% each and five parties have only 2% each. Then any reasonable effective number must be at least three and at most eight. The Laakso-Taagepera number comes out as 3.68.

This effective number also has applications outside parties. I have measured the areas of historical empires and calculated the effective number of polities, worldwide, over 5000 years (Taagepera, 1997). An exponentially decreasing pattern results. If this pattern continued, how soon could we expect a single world state? Sorry, we would have to wait for another 2000 years.

Inverse square law of cabinet duration

Now consider the average duration of government cabinets over a long time spell. Logical considerations based on the number of communication channels tell us that this duration should be inversely proportional, not to the number of parties but its *square* (Taagepera 2007: 165–175).[6] This is so indeed, as shown in Figure 1. This figure graphs cabinet duration against the effective
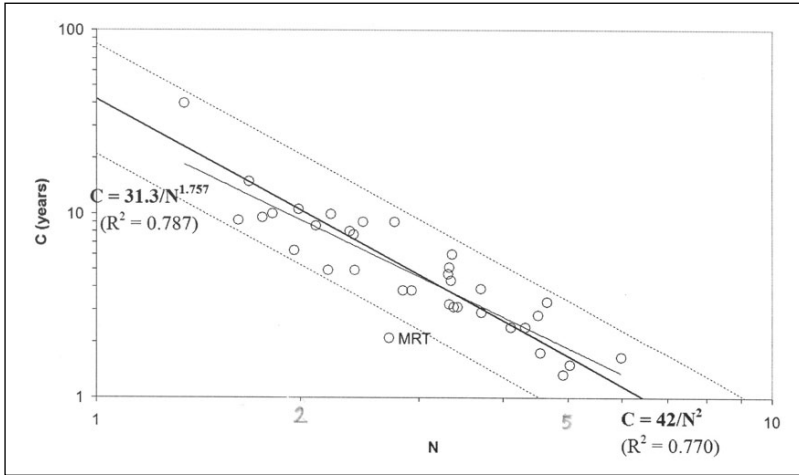
Figure 1. Mean cabinet duration vs. effective number of legislative parties: predictive model, regression line, and the range within a factor of 2 of the model (Taagepera and Sikk, 2007).

number of parties. Both scales are logarithmic. The *thin* central line is the statistical best-fit line (OLS, Ordinary Least Squares). The *thick* central line is the best-fit line with the logically predicted slope –2 (for logarithms). The two lines are visibly close to each other; this means the logical model fits reality.

The average cabinet duration is 42 years divided by the square of the effective number of parties (Taagepera and Sikk, 2010)
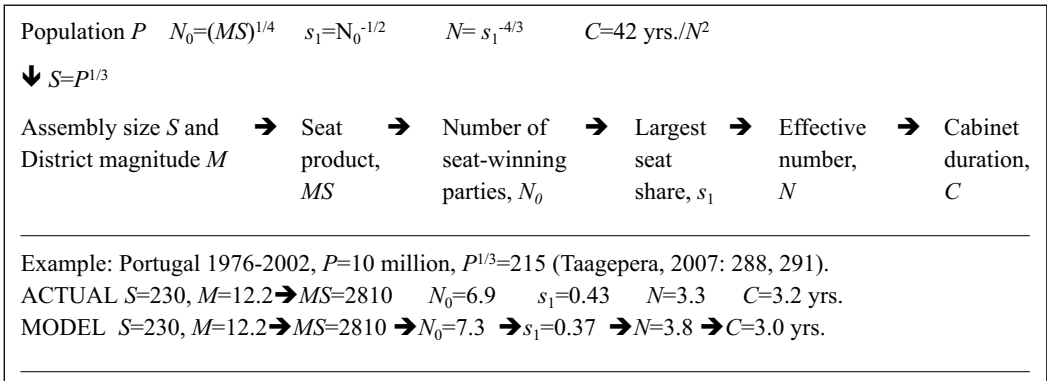
$$C = 42 \text{ years} / N^2$$

For instance, if there are two roughly equal-sized parties, then our best guess for average cabinet duration is 42/4=10.5 years. Of course, other factors besides the number of parties also enter. Figure 1 shows that, due to these other factors, the actual average durations can be as much as twice the average expectation, or only one-half of it ('off by a factor of 2'). For two parties this means that duration might be as much as 21 years, or as little as 5.2 years. The effective number of parties still accounts for 77% of the total variation in cabinet duration.[7]

Connections among connections in electoral and party systems

Let us return to my main point: connections among connections. Figure 2 shows them in electoral and party systems. The top line shows the successive links. Toward the left, we see how the number of seat-winning parties results from the number of seats in assembly and district: This number is the fourth root of the seat product – $N_0=(MS)^{1/4}$. At the right, we see that cabinet duration is 42 years divided by the square of the number of parties – $C=42 \text{ yrs}/N^2$. In between, other links connect them. Together, they form a long logical chain, as the center part of Figure 2 shows.[8]

The logical relationships in Figure 2 combine to

$$C = 42 \text{ years} / (MS)^{1/3}$$

Population P $N_0=(MS)^{1/4}$ $s_1=N_0^{-1/2}$ $N=s_1^{-4/3}$ $C=42$ yrs./N^2

⬇ $S=P^{1/3}$

Assembly size S and District magnitude M	➜	Seat product, MS	➜	Number of seat-winning parties, N_0	➜	Largest seat share, s_1	➜	Effective number, N	➜	Cabinet duration, C

Example: Portugal 1976-2002, $P=10$ million, $P^{1/3}=215$ (Taagepera, 2007: 288, 291).
ACTUAL $S=230$, $M=12.2$➜$MS=2810$ $N_0=6.9$ $s_1=0.43$ $N=3.3$ $C=3.2$ yrs.
MODEL $S=230$, $M=12.2$➜$MS=2810$ ➜$N_0=7.3$ ➜$s_1=0.37$ ➜$N=3.8$ ➜$C=3.0$ yrs.

Figure 2. Connections among connections in electoral and party systems.

This may be hard to believe, but once assembly size and district magnitude are given, the average cabinet duration is pretty much settled.[9] The lower part of Figure 2 offers Portugal as a typical example.[10] The logical model moderately overestimates its number of parties and moderately underestimates its largest seat share and cabinet duration.

This is how far I got ten years ago, in *Predicting Party Sizes* (Taagepera, 2007). On the basis of the number of seats in the assembly and in the districts, one could predict how the *seats* are distributed among parties. But what about the *votes*? This still defeated us. Now we have licked this problem, too.

The forthcoming book on *Votes from Seats* (Shugart and Taagepera, 2017) also predicts the world averages for vote distributions, nationwide and in the districts. It does so on the basis of just the number of seats in the assembly and in districts. The scatter of data is appreciable, but the world average pattern is uncannily close to the logical model. These world averages supply benchmarks for country studies. We are connecting an ever-widening range of connections.

Science walks on two legs, but social sciences try to hop on one

Superficially, I have done pretty well, given that I received the Karl Deutsch Award. Yet, I have failed. I have failed to fulfill my promise to make a science out of political science. If anything, political science, along with other social sciences, is now *less* scientific than it was half a century ago when Kochen and Deutsch (1969) published their decentralization model. This is so because mindless statistical data processing has crowded out logical model building, such as used by Kochen and Deutsch. From being *non*-scientific, political science has become more *pseudo*-scientific.

Forget about the pointless squabble between qualitative and quantitative approaches to the study of politics. Both are indispensable, and they interact. Both can be applied well or poorly. My concern is about misdirected quantitative approaches. They clutter the field. Not only are they rampant, but also some journals impose them, even on people who should know better.

Here's an example. Some time ago I read a nice study that expanded our understanding of politics, without using many numbers. But then it degenerated into pointless statistics. The resulting regression did not add anything. To the contrary, it blurred the message. The contrast was so blatant that I contacted the author. I said it looked as if the journal had required adding regression as a condition for publication. The author responded: 'You are absolutely right'. Does that sound familiar? If people who do sensible *qualitative* work are forced to add senseless statistical machinery, something is wrong.
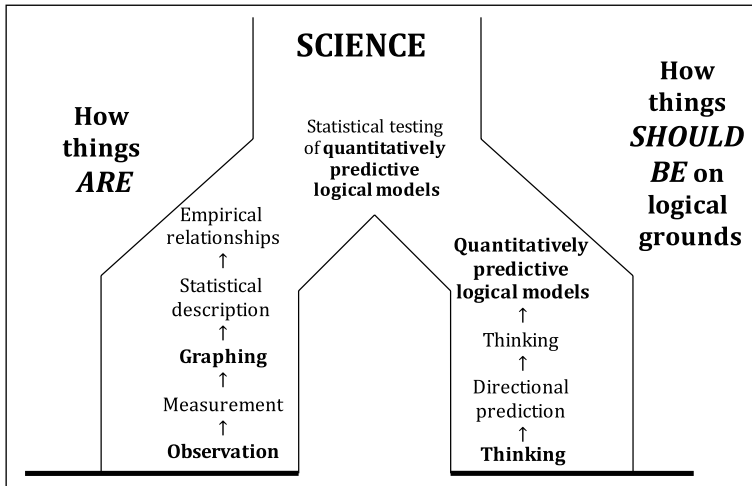
Figure 3. Science walks on two legs: Observation and Thinking (Taagepera, 2015 modified).

Here's a different case. Duncan Luce, a foremost mathematical psychologist, told me about his struggle to publish a paper (Folk and Luce, 1987). The nature of the problem called for logarithmic-linear data fit. The journal insisted on replacing it with a naive linear fit, which made no logical sense. As a compromise, the authors were allowed to keep the approach that made sense, as long as they also added junk (Taagepera, 2008: 4). If people doing logically grounded *quantitative* work are forced to add senseless linear fits, something is wrong.

Science walks on two legs

Science walks on two legs, as shown in Figure 3. One leg deals with the question: How things *are*? This involves observation, measurement, graphing data, and statistical description of data. The other leg deals with the question: How things *should be*, on logical grounds? This leads to logical models. That question guides the first one. The question 'How things are?' assumes that we know which aspects of things matter. But we largely see only what we look for. And it's the question 'How things *should be*?' that tells us *what* to look for. The two legs come together when models produced by thinking are tested with data, mostly using statistics.[11]

This is overly abstract. To show what this means I go through the discovery of the law of cabinet duration in more detail.[12] The first step is casual *observation*: Countries with many parties tend to have short-lived cabinets. The second step is *thinking* about this observation. This leads to a *directional prediction*: If there are more parties, the duration of government cabinets will become shorter. *Measurement* of cabinet duration and number of parties largely confirms this prediction.

But a merely *directional* prediction is not enough. Think of Galileo. Any Toscana peasant could have told Galileo in which direction things fall (Taagepera, 2008: 24). They fall down! What else do you need to know? But Galileo also wanted to know how fast they fall, and why. If we want to be scientists, we must ask similar questions about cabinet duration, and about every other directional relationship. Yet, when I do address such questions, all too many journal reviewers react like the Toscana peasant. They declare superfluous anything beyond the direction of the effect. By so doing they block inquiry at the very stage where Galileo's study of gravity began. Those peasants really do harm to social sciences.

An essential step is to *graph the data*.[13] Then really *look* at the graph and *ponder* what it tells us. When graphed on regular scales (unlike Figure 1), the relationship of cabinet duration to the number of parties appears as a downward curve, NOT a straight line. So forget about knee-jerk linear regression!

This curve suggests that cabinet duration might be inversely proportional to the number of parties. Further *thinking*, however, leads us to predict that it should be the *square* of this number: $C=k/N^2$, where k is an as yet unspecified constant.[14] The resulting equation is non-linear (as most relationships in the sciences are). But it is non-linear in such a way that we logically expect that the logarithms of cabinet duration and number of parties must be linearly related, and with a slope of -2. *Graphing* again, but now on log-log scales, confirms this hunch, as we could see in Figure 1.

Now, and only now, *statistical* approaches enter, so as to test the proposed logical model. To make sense, linear regression must apply to the logarithms of cabinet duration and number of parties – *not* to the quantities themselves. This linear regression confirms the expected slope –2 and also supplies the best value for the constant, 42 years.

The end point is a *quantitatively predictive logical model: $C=42$ yrs/N^2*. This model is 'quantitatively predictive' because it predicts not only the direction of change but also the quantity of cabinet duration at a given number of parties. The model is 'logical' in that dividing by the square of the number of parties comes from logical considerations.

Note that we took alternating steps with each of the legs on which science walks. We started with observation, the left leg, followed by directional thinking, the right leg. Graphing involved the observation leg. Further thinking led to the inverse square model. This made us ask: How can we turn this curve into a straight line? Conversion to logarithms did the trick. Then we again shifted to the observation leg, linear regression of the transformed data. Finally, we must shift again to the thinking leg and ask: 'Does the result make sense?' It does. In particular, with a huge number of parties, cabinet duration would approach zero, as it should.

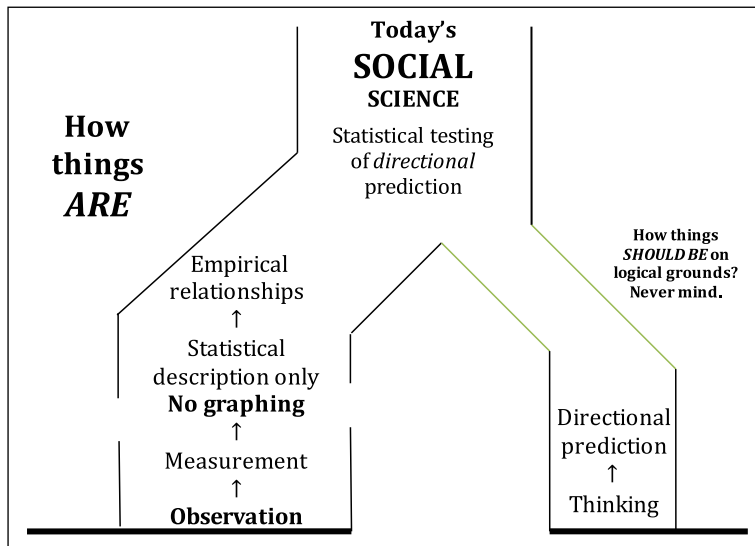## But social sciences try to hop on one

Now consider what a statistics-only operator would do, instead. After deciding on the direction of the relationship, he would abandon any further logical thinking. He would try to hop on the observation leg alone, as shown in Figure 4. Even here he would *omit graphing*. He would feed raw data into linear regression, oblivious of the fact that the data pattern is not linear. Without graphing, how would he know?[15] His computer printout would produce a negative sign for the slope coefficient. This would confirm the directional hunch, and this is all this operator is after.[16]

But hold it! What cabinet duration would his regression line predict for a very large number of parties? His downward line would predict negative cabinet durations when the number of parties becomes very large. This is absurd. He violates the basic criterion: 'Does the result make sense?'

I see such absurd regressions published all the time. Oblivious of logical thinking, social sciences too often take the lazy road of fitting raw data with a straight line, or some other standard format chosen on purely statistical or fashionable grounds.[17] Dear colleagues, if we wish scientists to take political science seriously, we must not publish absurdities. We must not do so, if practitioners of politics are to take us seriously.

A cancer is eating at the social sciences. Canned computer programs enable people with little understanding of mathematics to grind out reams of mindless regression analysis and the like, and this pretends to be science. The very notion of logical models is subverted by calling regression outputs 'empirical models'.

Mind you, this is not 'junk in, junk out'. This is more pitiful than that. This is good, valuable data going in, and junk coming out. Why? Because the data were not properly converted, using

Figure 4. Today's social science tends to hop on one leg, Observation (Taagepera, 2015 modified).

Figure 5. Statistical approaches are useful tools. So are chisels. But woe to a society where everyone is pressured to use chisels also for sawing and digging, or where quantitative research is reduced to statistics.

logical thinking, before being fed into the computer. Instead of using statistics as a tool, this has become akin to a religious liturgy. Too many journal reviewers act like jealous priests of this religion. They impose their liturgy even on those researchers who would rather avoid it. This is part of how political science has moved from non-scientific toward pseudo-scientific.[18]

Make no mistake: Statistical approaches are useful tools. So are chisels (Figure 5). But woe to the person who discovers chisels and becomes so enamored that he uses chisels also for cutting, piercing, sawing, and digging, when other tools are available. Doubly woe to a society where such priests of the chisel religion can impose it on others! In social sciences we are at a stage where priests of the statistics religion forcefully impose their tool as the only one. The ones who least understand statistics beyond canned computer programs are often the most adamant about enforcing the liturgy.

The way out

The situation is sad but not hopeless. Work that balances thinking and statistical approaches does exist. Witness the previous winners of the Karl Deutsch Award[19] and so many others, such as Arend

Lijphart and Ronald Inglehart. Scholars such as Josep Colomer (2007)and Bernard Grofman (2007) have pointed out the limited range of methodology used in social sciences, compared to other sciences. Many social scientists have pinned down specific shortcomings of misapplied and misinterpreted statistical approaches.[20] However, it does not suffice to improve statistical approaches. We must also extend the intelligent use of graphing and develop the thinking leg. James McGregor (1993) and I (Taagepera, 2008: 14–22) have shown, how and why, basic natural science laws couldn't possibly be discovered using even the best statistical approaches alone. Do not expect more in social sciences. [21]

Dear colleagues, practice qualitative political science, with few numbers, and may peace be with you. If you also wish to be quantitative, try to practice genuine quantitative science that tries to walk on two legs. But avoid doing fake quantitative science that hops on one leg. How can this be done, without any training and support? I have written two books on the topic. They may help.

The first was *Making Social Sciences More Scientific*: *The Need for Predictive Models* (Taagepera, 2008). It has chapters like 'Physicists multiply, social scientists add – even when it does not add up,' and 'Why most numbers published in social sciences are dead on arrival'.

But my students also needed a more hands-on textbook on how to construct logical models. Students should get repeat practice to the point where they may retain some skills for life. So I wrote *Logical Models and Basic Numeracy in Social Sciences* (Taagepera, 2015), freely available on the Internet: www.psych.ut.ee/stk/Beginners_Logical_Models.pdf. This book expects little mathematics beyond arithmetic. Constructing logical models requires, above all, the courage to be simple, and the critical mind to ask: But can this be so?

I use this book with undergraduates as well as with doctoral students, in California and in Estonia. Many social science professors might profit from working through it. The forthcoming *Votes from Seats* (Shugart and Taagepera, 2017) makes systematic use of this approach. This will be a rare *scientific* book about politics and should set a methodological standard for all social science.

Make no mistake: In many ways, the social sciences have become a success story. They have made great progress in *qualitative* understanding of society. Statistical methods are very much needed, as long as they do not become cancerous. But it is high time to complement statistical description with logical models, these logical models that Karl Deutsch included in his toolkit.

Ever since 1970 I have devoted time and effort on two unrealistic endeavors. One was doing away with Moscow's yoke on my native Estonia (Misiunas and Taagepera, 1983; Taagepera, 1984). The second was making a science out of political science. The first one has paid off. Estonia is free (Taagepera, 1993a, 1993b). Making a science out of political science has been an equally foolhardy Sisyphean effort. And it hasn't *yet* paid off. But I keep trying. The Karl Deutsch Award will keep up my hopes.

Notes

1. An anonymous reviewer's feelings are all too typical. After raising a slew of detailed issues about Taagepera and Allik (2006), he candidly noted: 'Perhaps I have continued problems with this paper

because I am skeptical that there is much of value operating at such a high level of generality. … huge amounts of real-world variation are consigned to nowhere'. Actually, we consigned these variations to a much better place than nowhere, namely to next-stage analysis. While ferreting out the universal, science does not ignore detail, but it does introduce some hierarchy. This reviewer continued: 'The pattern the paper identifies, though it can be modeled in a convincing way, may simply be a contingent summary of a particular real-world data used'. Here we reach the core of a general unease about my approach, among some colleagues. If my models fit, they supposedly must fit for the wrong reason, even if the hidden artifact cannot be pinned down (Taagepera, 2007: viii).

2. In some other respects presidential elections do differ from parliamentary, because extreme cases are peculiar. One of the goals of Shugart and Taagepera (2017) is to specify the *quantitative* details of where and how presidential elections differ.

3. 'Communication is the cement that makes organizations', as Deutsch pointed out in *The Nerves of Government* (1964: 77), quoting Norbert Wiener.

4. The challenge is to get the data to agree with the preconceived model. For this, one may have to modify the model, or revise the data (Taagepera, 2008: 48, 79, 176).

5. Note that I talk of factors, not variables. 'Variables' is statistics terminology. Using it risks detracting attention from the fact that we deal with substantive factors such as voltage and resistance, seats and votes, not just abstract mathematical x and y. A negative value of variable x raises no eyebrows. A negative number of seats should.

6. However disparate the cube root law of assembly sizes and the inverse square law of cabinet duration may be in form and substance, they have one thing in common: Both result from considerations about the number of communications channels, this 'cement that makes organizations'.

7. The law offers the *expectation value*, as quantum physicists call it: the value at which there is a 50:50 probability of the next actual case being below or above the prediction. This is not a rigidly 'deterministic' prediction, it only expresses the average expectation, within a specified range of likely error, such as 'by a factor of 2' or plus or minus some percentage, such as ±15%.

8. Assembly size itself depends on population, as shown at top left in Figure 2. This leaves district magnitude as the only factor nations are fairly free to choose.

9. As each step in the logical sequence piles up random scatter, one might expect the overall scatter to become huge. Surprisingly, 90% of countries with simple electoral systems have durations within a factor of 2 of 42 years/$(MS)^{1/3}$, even while R^2 for the logarithms of C and MS drops to 0.24 (Taagepera, 2007: 171, Fig. 10.2).

10. Portugal's N deviates from the model prediction to a median degree. So its agreement with the model is neither atypically good nor atypically poor.

11. What is blithely lumped as statistical 'analysis' includes two utterly different functions. One is statistical *description* of data: Best fit to whatever is deemed a suitable mathematical format, including the values of constants in this format, measures of lack-of-scatter around this best fit (such as R-square), etc. The other is statistical *testing* of preconceived models: How well the prediction agrees with data *average*. Measures of goodness of agreement vary, but they are utterly distinct from measures of lack-of-scatter. In particuler, R-square is irrelevant or marginal when it comes to model testing.

12. This presentation and application of the two-legs process parallels the one in Chapter 1 of Shugart and Taagepera (2017) but uses a different example.

13. Actually, we must graph *more* than the data (Taagepera, 2008: 202–204; 2015, ch. 8). We must show the forbidden areas where data points cannot be on conceptual grounds – in the present case, $N<1$ and $C<0$. Also show 'anchor points' the relationship must logically include. For example, any relationship between the largest seat share and the seat product must be such that $MS=1$ (presidential election) yields $s_1=1$ – the largest share must be 100%. So, 1;1 is a logical anchor point. Here graphing takes us to the Thinking leg, in addition to the Observation leg.

14. The functional form $C=k/N^2$ is deduced logically, but the value of constant k is determined empirically. This is quite usual in physics.

15. Actually, he might do even worse. He would include a half dozen control variables that might plausibly affect cabinet duration, like state of the economy, left or right political party, public approval of the prime minister, etc. Each of these may 'cannibalize' a bit on the impact of the number of parties, the full extent

of which is reduced when subtracting N instead of dividing by the square of N. Then several other factors may reach phantom levels of 'significance'.

16. Quantitatively specific predictions can easily turn out false in detail, even while confirming the broad direction of change. In contrast, all too many studies in political science are safe against being proved false because they only predict the broad direction of the change, while leaving its precise amount unspecified.

17. This single sentence acts like a lightning rod, if one omits the word 'often'. As one comment on the draft of this paper put it:

    As such, it applies well to political science until quite recently but not really to other social science disciplines like economics where log-log, log-lin and lin-log models are common, and where probit and logit and other non-linear *estimating* models [my emphasis] have become the norm. It does not even apply well to some of the most recent sophisticated stuff in journals like *Political Analysis* that uses nonlinear models (esp. probit and logit) and also interaction effects.

    This comment is an excellent abstract of the next level of formalism to overcome, past linearity. Indeed, the best social scientists do escape purely linear thinking. But here the second part of my sentence often weighs in: 'or some other format, chosen on purely statistical grounds, oblivious of logical thinking'. Indeed, in some subfields 'probit and logit *have become the norm*' –and that's a problem. When a norm is followed, thinking may stop. How many of those who apply push-button probit and logit can recognize to which of them the equation $y=M/(1+e^{kx})$ pertains? Being aware of a more extensive stable of push-button log-log, log-lin, and lin-log 'estimating models' is not the same thing as mastering the full content of exponential thinking. In particular, social scientists all too often are ignorant of exponential approach to a ceiling, so pervasive in natural and social phenomena: $y=M(1-e^{-kx})$. I have seen scholars try fitting such data with logit (even when the early part of the data cannot fit) or much worse, quadratic equation (even though the rise to the peak is eventually followed by an absurd drop to zero and even negative values). 'Interaction effect' all too often is naively taken as synonym for the product xy, even while thinking might suggest that interaction should be x^2y or x/y, or still something else.

18. There are many other problems of methodology (Taagepera, 2008). For one, standard OLS regressions cannot provide the basis for connections among connections, because OLS is directional: The best fit y-on-x differs from the best fit x-on-y (Taagepera, 2008: 154–174). All too many political scientists who use OLS do not know that.

19. Gabriel Almond, Jean Laponce, Juan Linz, Charles Tilly, Giovanni Sartori, Alfred Stepan, Pippa Norris.

20. Gary King et al. (2000) proposed improvements in interpretation and presentation of statistical analysis. Gerd Gigerenzer (2004) was concerned about 'Mindless statistics', and Gigerenzer et al. (2004) exposed the empty 'null hypothesis ritual', previously criticised by Jeff Gill (1999). Nicholas Longford (2005) deemed much of contemporary statistics-based research a 'junkyard of unsubstantiated confidence'. Christopher Achen (2005) wished to dump garbage-can probits. Bernard Kittel (2006) and Kittel and Winner (2005) showed that different statistical approaches to the same data could make factors look 'highly significant' in opposite directions. Philip Schrodt (2014) listed seven deadly sins of quantitative political analysis. Valentine et al. (2015) showed how to describe data 'without 'p-ing' everywhere'.

21. Much hope has been placed in quantitative political science on the EITM movement that began around 2001, with yearly summer workshops. They laudably aimed at scholarship that 'integrates theoretical model development with empirical evaluation'. Their definition of 'theoretical models' must differ from mine, given that our paths have not crossed. When the EITM people produce their first relationship of the type of $C=42$ yrs/N^2, or even good old empirical $S_A/S_B=(V_A/V_B)^3$, then I'll start figuring out what their intricate methodological terminology means.

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