

Models: Parables v Fables

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How fables and parables help us understand the use of models: a short survey of this paper

Models of different kinds appear throughout the natural and social sciences serving a variety of different ends. This paper will discuss one particular kind of model whose purpose is opaque: the ‘highly idealized’ model, prevalent in physics and economics but widely used elsewhere as well. Models of this kind study the behaviour of stripped-down systems in unrealistic circumstances. The models may study balls rolling down totally frictionless totally stable planes (Galileo 1914, 61-69), or labourers of only two kinds – old and young – concerned only with leisure and income (Pissarides 1992), or, as in Thomas Schelling’s famous model, black and white chequers moving according to artificial rules on a chequerboard, ending up in clumps of similar colour (Cartwright 2009a, Schelling 2000). The objects and situations pictured in these models are very unlike real objects in the real world of interest to the sciences. Yet they are supposed to teach something, indeed something important, about that real world. How?

I am going to defend the use of descriptions of highly unrealistic situations to learn about real-life situations. That, I maintain, is just what Galileo did in his famous rolling-ball experiments. He honed his planes to make them as smooth as possible, and bolted them down, to learn about the effects of gravity acting on its own. Models I urge are often experiments *in thought* about what would happen in a real experiment like Galileo’s if only it could be conducted: What would happen were we able to

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create just the right artificial situation to see the feature under study acting all on its own, without any other causes interfering to mask its effect?

That however is not enough. Doing what Galileo did sounds a good thing. But Galileo's results are still results about the behaviour of balls rolling down totally frictionless planes. We don't have any such planes and anyway what we really want to know is about cannon balls and rocket ships. How do we get from a Galilean conclusion: 'The pull of the earth induces an acceleration of 32 ft/sec/sec in balls rolling down totally frictionless totally stable planes' – to a result about cannonballs, teetering coffee cups or rocket ships? I shall here repeat an earlier answer of mine, that these models are like fables, for instance like this fable that I shall discuss below:

A marten eats the grouse;

A fox throttles the marten; the tooth of the wolf, the fox.

Moral: the weaker are always prey to the stronger.

Like the characters in the fable, the objects in the model are highly special and do not in general resemble the ones we want to learn about. Just as I have never seen a frictionless plane or a worker interested only in leisure and income, I don't think I have ever seen a marten, and seldom a wolf. But the conclusion of the model, like the moral of the fable, can be drawn in a vocabulary abstract enough to describe the things we do want to learn about. For instance, we conclude from Galileo's experiment, 'The pull of the earth induces a downwards acceleration in massive objects of 32 ft/sec/sec'. This is a correct way of describing what we see in the rolling-ball experiments, just as my earlier description is. But this more abstract description also applies to cannonballs, coffee cups and rocket ships since they too are massive objects. Similarly, the moral of Schelling's model might be, 'A group of individuals moving not under the rule, "Create segregated neighbourhoods" but only under the rule "Move from a neighbourhood where almost everyone is different from you to one where that is not so" will almost always end up in clumps in each of which everyone is alike'. In both cases a description of what happens in the model that does not fit the target gets recast as one that can, just as the moral of the fable can apply to a broader range than the kinds of individuals pictured in the fable. To underline this, I

shall employ an idea and a slogan from Menno Rol: Climbing up the ladder of abstraction can take one from falsehood to truth.

There is a problem, however. Fables, like those of Aesop or Lafontaine, typically have the moral built right in. Many of our most familiar parables do not. What is the moral of the parable of the prodigal son² or of the labourers in the vineyard³? It is not written into these parables as morals are written into Aesop and Lafontaine's fables. Consider for instance the labourers in the vineyard. I always thought that the parable teaches about God's intentions to accept late repentants into the Kingdom of Heaven and that those who live virtuously their entire lives just have to put up with that, with perhaps some knock-on moral that we too should indulge in generosity at the cost of seeming fairness. But can its moral cover this case, described to me by a lawyer friend?

Lloyd's of London is an insurance market where individuals ('Names') underwrite insurance risks through syndicates. A syndicate normally consists of several hundred Names. In the late 80s and early 90s Names lost a great deal of money - so much so that the stability of the market was threatened. The

² Luke 15:11-32

³ Matthew 20: 1-16 (The Holy Bible, King James Version): 20:1 For the kingdom of heaven is like unto a man that is an householder, which went out early in the morning to hire labourers into his vineyard. 20:2 And when he had agreed with the labourers for a penny a day, he sent them into his vineyard. 20:3 And he went out about the third hour, and saw others standing idle in the marketplace, 20:4 And said unto them; Go ye also into the vineyard, and whatsoever is right I will give you. And they went their way. 20:5 Again he went out about the sixth and ninth hour, and did likewise. 20:6 And about the eleventh hour he went out, and found others standing idle, and saith unto them, Why stand ye here all the day idle? 20:7 They say unto him, Because no man hath hired us. He saith unto them, Go ye also into the vineyard; and whatsoever is right, [that] shall ye receive. 20:8 So when even was come, the lord of the vineyard saith unto his steward, Call the labourers, and give them their hire, beginning from the last unto the first. 20:9 And when they came that were hired about the eleventh hour, they received every man a penny. 20:10 But when the first came, they supposed that they should have received more; and they likewise received every man a penny. 20:11 And when they had received it, they murmured against the goodman of the house, 20:12 Saying, These last have wrought but one hour, and thou hast made them equal unto us, which have borne the burden and heat of the day. 20:13 But he answered one of them, and said, Friend, I do thee no wrong: didst not thou agree with me for a penny? 20:14 Take that thine is, and go thy way: I will give unto this last, even as unto thee. 20:15 Is it not lawful for me to do what I will with mine own? Is thine eye evil, because I am good? 20:16 So the last shall be first, and the first last: for many be called, but few chosen.

Society of Lloyd's, the body which runs the market, became involved in trying to settle the Names' claims which arose, said the Names, not from bad luck but from the negligence of their agents - the market practitioners who actually underwrote the insurance risks. Some Names sued their agents for damages - something which had rarely, if ever, been done before.

When it came to offering a settlement the question arose whether the offer should be to those who had sued or to all the Names on a syndicate. Those who had sued argued that they had borne the heat and burden of the day and the offer would not be made if they had not banded together and taken legal action. Those who had not sued said they had the same claims and had refrained from suing for reasons of their own - perhaps because they did not believe it to be the right thing to do to de-stabilise Lloyd's. There were only limited funds available to make the offer so if it was made to all Names then each would get less.

My lawyer friend says 'yes', the parable does apply to the Lloyd's case. The relevant issues are not so much the actions or intentions of the parties or whether they are deserving or not but their legal rights and the probability of their enforcement. Here is his read on what the parable teaches:

The labourers in the vineyard is a lawyers' parable. Never mind the slightly confusing stuff about the kingdom of God.... The point of the parable for me is that you get what you contract for, and shouldn't complain if others get more. It is a market-based capitalist parable, opposed to socialist ideas of 'fairness'. The labourers union would not have liked it but the Chamber of Viticulturalists would get the point immediately...

I shall argue here that my earlier defence of 'idealized' models was overly optimistic. Many of the highly artificial, 'idealized' models of economics are like this parable and are unlike the fable of the grouse and the marten where the lesson is written right in. A variety of morals can be attributed to the models, expressed in a variety of different vocabularies involving abstractions of different kinds and at different levels. Importantly, these morals can point in different directions, implying opposite

predictions for the real-life situations to which we want to apply them. Climbing up the ladder of abstraction, whether in a fable, a parable or a model, can take us from falsehood to truth, but only if we know which ladder to climb up. That knowledge, I will propose in closing, comes, if it does at all, not from the model itself but from the rich context of the science in which it is imbedded.

The problem of unrealistic assumptions, Round 1: valid arguments but false premises

The models I discuss here, found typically in physics and economics, offer descriptions of imaginary situations or systems using a combination of mathematics and natural language. The descriptions are thin: Not much about the situation is filled in. They are often unrealistic as well in that what is filled in is not true of many real situations. Yet in many cases we want to use the results of these models to inform our conclusions about a range of actually occurring (so-called *target*) situations.

I am also going to restrict my attention to models in which results are derived by deduction. The whole point of these formal models is rigour, which is why they are preferred by physicists and economists alike over more informal reasonings that merely make results plausible. Deduction is a key ingredient in this rigour. We are assured that the consequences drawn from the models are genuine because they follow deductively from the starting descriptions; these consequences must occur whenever these descriptions are satisfied.

The ‘unrealistic’ assumptions that are offered in a model’s descriptions are no problem so long as they play no role in deducing the intended results of the model. But this is seldom the case. In fact quite the contrary. They are often necessary to the deductions offered in the model.⁴ This gives rise to the canonical **problem of unrealistic assumptions**: How can a result that must occur given characteristics different from those in the target inform conclusions about what will happen in the target? The conclusion is supposed to be guaranteed because it follows deductively

⁴ The requisite deduction will sometimes not be literally on offer in the model but rather presumed.

from the premises. How does that provide information about what conclusions to expect when the premises are different?

The plan

In tackling the problem of unrealistic assumptions this paper will rely on three different strands of enquiry:

- previous work of mine on Galilean thought experiments
- previous work of mine on models as fables
- Menno Rol's insight that abstraction can turn falsehoods into truths.

It will wind through an increasingly narrow spiral

- from **problem, Round 1**: the first broad *problem of unrealistic assumptions* just described
- to **solution, Round 1**, a solution that should work for certain specific kinds of models – those that can count as *Galilean thought experiments*
- to a twist at which the problem of unrealistic assumptions re-emerges in narrower form, as **problem, Round 2**: the problem of *overconstraint*
- to another twist provided by Menno Rol that offers **solution, Round 2** to this new version of the problem, a solution for an even more restricted set of models – by *abstraction* of the kind seen in the moral of a fable
- finally ending in yet another **problem, Round 3**, which arises because models are far more like *parables* than fables.

In the end, this final problem for models with unrealistic assumptions, I hazard, cannot be solved within the model itself nor by philosophy. The problem in the end demands that the model be located in a strong, rich scientific network that can pick out the right abstract concepts with which to formulate the model's results.

Solution, Round 1: Galilean thought experiments

Unrealistic assumptions do not always stand in the way of drawing lessons about real situations from models. Some models function as Galilean thought experiments and for these unrealistic assumptions are not a hindrance but a necessity. A real Galilean experiment (a Galilean experiment really conducted), as I use the term, isolates a single factor as best possible to observe its natural effect when it operates ‘on its own’ with no other causes at work. In a thought experiment we just imagine the situation and what would happen in it if it were conducted. In a real Galilean experiment the effect is produced in accord with the laws of nature. In a model that pictures a Galilean thought experiment it is the principles built into the model that determine what the effect must be. So real experiments and thought experiments have complementary virtues. In the real experiment we can never be sure that we have eliminated all confounding factors but we can be sure the effect is produced in accord with nature’s laws. By contrast the situation described in the thought experiment has only the factors in it that we put there. So we can be sure that confounders are absent but we cannot be sure the effect is right because that depends on the principles we provide in the model.

Typical economics models, and many in physics as well – especially those set as problems to work out in physics texts – can certainly be taken to be Galilean thought experiments, isolating a single factor to study its effect when no other causes of that effect are there to interfere. This is clear not only from the practice in both cases; it is explicit in much economics discussion and in some from physics as well. With respect to those models that serve as Galilean thought experiments, unrealistic assumptions that suppose the factor is at work all on its own, with no alternative causes at work, are no more of a problem than they are for real Galilean experiments. If we can learn about target situations with more ‘realistic’ arrangements from actual Galilean experiments despite the ‘unrealistic’ assumptions necessary to the experiment, the same is true for Galilean thought experiments (so long as the basic principles used in the model to drive the consequences are accurate enough).⁵ So at least for some

⁵ In either case exporting from the Galilean experiment requires both more and stronger assumptions than those supplied in the experiment. My own view is that exporting often employs the logic of capacities, where the assumption that a factor has a capacity to study in the first place takes a great deal of highly varied independent evidence. Cf. *Nature’s Capacities and their Measurement* (Cartwright 1989) and ‘What is this Thing Called “Efficacy”?’ (Cartwright 2009b).

models and some kinds of unrealistic assumptions, unrealistic assumptions pose no problem.

The problem of unrealistic assumptions, Round 2: overconstraint

This is a rather too happy conclusion however. That's because a good many of the models that can be cast as Galilean thought experiments have a number of 'unrealistic' assumptions beyond those necessary for them to count as Galilean experiments – that is beyond those that eliminate all the other causes of the same effect. This is generally for two interacting reasons.

First: Many kinds of causes, unlike gravity, cannot just act without involvement of the specific setting in which they are placed. They need a concrete situation in which to play out. Consider for example a model to study the effect of skill loss during unemployment on future employment levels. If it is to be a Galilean model there must be no further causes of employment or unemployment at work in it: no downturns in consumer spending, no shift to a war economy, and so forth; no motives that differ between when employers invest to open future jobs from when they don't other than the difference in profit they expect due to a difference in the efficiency of the workers. Still, the model needs employers in it in order to study what happens given their different expectations; and it needs to have workers who have lost skills and workers who have not to create these different expectations. How many workers, how many employers? What ratio of employed to unemployed? Etc. These factors are not properly thought of as alternative causes of employment or unemployment, as alternative mechanisms to those of skill loss that can affect future employment levels independently. Hence the answer to what form they should take is not dictated by the rules for a Galilean experiment, i.e. the demand to eliminate all alternative causes of the effect studied. Still they must take some form or other, otherwise the skill-loss mechanism cannot be set operating.

Second is the well-rehearsed reason that matters must often be set in very particular ways if calculations and deductions are to be at all possible. So often mathematically more tractable descriptions are substituted for descriptions that are more true to the

target situations that we want the model results to bear on. Indeed it is often the need for mathematical tractability that solves the first problem by settling how to fix the concrete setting in which the isolated cause will play out.

So most Galilean thought experiments have many more ‘unrealistic’ assumptions than those they should. Again, this would not be a problem if these assumptions did not play a role in deducing the final results. But of course generally they do – that is the point of including them in the first place. Just by inspection we can see that they are a necessary part of the deduction offered by the model.⁶

In these cases I say that the results of the model are *overconstrained*. All the conditions sufficient to ensure that the model describes a Galilean experiment are met. The results are constrained to be ones brought about by the cause operating without any other independent causes of the same effect present. So (pace mistakes in the driving principles) the results must be ones we would see in a real Galilean experiment. The problem is that the Galilean experiment takes place in a very special and unusual setting. What we see is indeed the result of the cause acting on its own without other causes interfering but it is a very special result that we cannot expect in all other Galilean experiments. The setting *overconstrains* the results – it constrains them to a narrower set than those permitted by just the assumptions necessary to ensure that there independent causes are at work. We know we cannot expect the overconstrained result to occur in other different settings for the Galilean experiment because we can see by inspection that the description of the special setting plays a necessary role in the derivation offered. So unrealistic assumptions that overconstrain

⁶ Explicit attempts to deal with this problem often involve so-called ‘robustness’ investigations: Vary these extra assumptions in different ways to see if the results are still more or less the same. Then, I suppose, we are supposed to do a quick induction to the conclusion that the results will be the same under the conditions that hold in the target situations. Not only is this inductive inference dicey but usually the variation is not very great. Also often the interest is not so much in varying the ‘extra-Galilean’ assumptions but rather in adding in some further causes to see how the results are affected when a more realistic arrangement of causes occurs. This latter offers some help with the problem of whether the results are exportable from the experiment to other situations – the question ‘Can an induction be done at all?’ – but not with the problem of *which* results to export.

the results are a problem for learning lessons that apply elsewhere even if the model does function as a Galilean thought experiment.⁷

In order to explain the proposed solution to this new problem of overconstraint, I first turn to another topic altogether, that of fables and their morals. I shall spend quite a bit of time on this topic because doing so will make it easy to see Rol's proposal, which I summarize in the slogan: 'Abstraction can turn falsehoods into truths'.

Fables and models, their morals and lessons

Many models, I argue, are like *fables*, and the lesson derived from the model is its *moral*. I say this in order to stress that the relationship between the description of the result that can be exported to new situations and the description of the result using the language of the model is often that of the *abstract* to the *concrete*. It is a truism that scientific terms are often abstract. My claims here involve one very specific way in which one description used in science – like '...is a source of utility' or '...is a labourer' – is more abstract than another – like 'income' and 'leisure' or '...is an "older" labourer in a setting containing only two generations of labourers'. This is a sense of 'abstract' that I take from the theory of the fable defended by Gotthold Ephraim Lessing, the great critic and dramatist of the German Enlightenment.⁸

Lessing argues, 'In order to give a general symbolic conclusion all the clarity of which it is capable, that is in order to elucidate it as much as possible, we must reduce it to the particular in order to know it intuitively.'⁹ For him this is in part a matter of *Anschaulichkeit* – intuitive understanding. 'Income' for instance is probably more intuitively understandable than 'utility'. It is also a matter of ontology: 'The general

⁷ For a more detailed description of Galilean thought experiments and the problem of over constraint see 'The Vanity of Rigour in Economics', chapter 15 in *Hunting Causes and Using Them* (Cartwright 2007).

⁸ My discussion of Lessing here is taken from *The Dappled World*, (Cartwright 1999) pp. 35-48.

⁹ Lessing 1759 [1967], sec I, p.100.

exists only in the particular....'¹⁰ This is the aspect I want to stress about the conclusions derived in models that function like Galilean thought experiments.

I illustrate the relation of the abstract to the concrete, following Lessing, with a fable of his own, which I introduced at the start of this paper:

A marten eats the grouse;

A fox throttles the marten; the tooth of the wolf, the fox.

Moral: the weaker are always prey to the stronger.

As I described in *The Dappled World*, Lessing makes up this story as part of his argument to show that a fable is no allegory. Allegories say not what their words seem to say, but rather something similar. But where is the allegory in the fable of the grouse, the marten, the fox and the wolf: 'What similarity here does the grouse have with the weakest, the marten with the weak and so forth? Similarity! Does the fox merely *resemble* the strong and the wolf the strongest or *is* the former the strong, the latter the strongest. He *is* it.'¹¹ For Lessing similarity is the wrong idea to focus on. The relationship between the moral and the fable is that of the general to the more specific and it is 'a kind of misuse of the word to say that the special has a similarity with the general, the individual with its type, the type with its kind.'¹² Each particular *is* a case of the general under which it falls.

The point comes up again when Lessing protests against those who maintain that the moral is hiding in the fable or disguised there. Lessing argues: 'How can one disguise (*verkleiden*) the general in the particular... If one insists on a similar word here it must at least be *einkleiden* rather than *verkleiden*.' *Einkleiden* is to fit out, as when you take the children to the shops in the autumn to buy them new school clothes. The children are not disguised by their clothes, hidden in them. Dressed up one way or another, they are still the same children, visible as such. But when dressed up, they are filled out and have more to them. And the very same children could be, and out of school generally are, dressed up, filled out, in a different ways. So the moral is to be

¹⁰ *Ibid.*, sec I, p. 73.

¹¹ *Ibid.*

¹² *Ibid.*

‘fitted out’ by the fable. The moral describes just what happens in the fable; but the fable fits it out in a special way – a way true to the moral but not necessarily shared by all cases of which the moral is true.

The account of abstraction that I borrow from Lessing provides two necessary conditions.

- A concept or claim that is abstract relative to a set of more concrete descriptions or more concrete claims never applies unless one of the more concrete descriptions or claims also applies. These are the descriptions/claims that can be used to fit out the abstract description or claim on any given occasion.
- Satisfying the associated concrete description/claim that applies on a particular occasion is what satisfying the abstract description/claim consists in on that occasion.

What I want to take away from Lessing’s account of the fable and its moral is the idea of how the model relates to the abstract lesson that might be drawn from it. Like fables and their morals, the lesson we might hope to export from the model may be *abstract* relative to the more concrete conclusion derived in the model using the more concrete descriptions provided by the model. Like the fable, the model ‘fits out’ the more abstract lesson; and when a situation satisfies the more concrete result expressed in the language of the model, that is what it is for that situation to satisfy the more abstractly expressed result.

Solution, Round 3: From falsehood to truth via abstraction

The problem of models with unrealistic assumptions is one of the standard worries both in the philosophy of economics and in economics itself. Philosopher of economics Menno Rol (2008) has a nice account of why it need not always be a problem. One can, he argues, go from falsehood to truth by climbing up the ladder of

abstraction. Rather than delving into economics, let me illustrate his point with a physics example that I think will be familiar to everyone.

Suppose we perform a careful real Galilean experiment to see how bodies move *inertially*, that is, subject to no forces. We do it perfectly; we succeed in stripping (or calculating) away all forces. So we have eliminated all the other independent causes of motion besides inertia, as we are supposed to do in a Galilean experiment. But we do our experiments on a Euclidean plane. From this we conclude that bodies moving inertially follow a Euclidean straight line. This conclusion is entirely correct in the setting of the experiment. But it need not be true elsewhere. In particular this will not describe correctly inertial motion in a spherical geometry, where a body subject to no forces will move on a great circle. To use my earlier language, we succeed in carrying out a Galilean experiment but the results are overconstrained. The solution, following Rol, is to move away from the overconstrained result and describe the results of the experiment *equally correctly* in more abstract vocabulary: The bodies in the experiment travel on *geodesics* – that is, they take the shortest distance between any two points in the relevant geometry. This conclusion is true both in the experiment we conduct and (putatively) everywhere else as well.

So, suppose then that we want to learn from our experiment how a body subject to no forces will travel in our target case, which is a body in a spherical geometry. If the result seen in the experiment is expressed too concretely – ‘Bodies subject to no forces follow Euclidean straight lines’ – then the conclusion of the experiment is false of the target we had hoped to learn about from the experiment. But if the conclusion is expressed more abstractly, we get a prediction from the experiment that is true of the target. That is the sense in which climbing up the ladder of abstraction in describing the results of the experiment can take us from falsehood to truth: Stating the lesson of a model using more abstract concepts than those directly involved in presenting the model can generate true predictions about behaviours in a target.

This account dovetails with the image of models as fables. The lesson of the model is, properly, more abstract than what is seen to happen in the model and that can be described in the concepts introduced there. In the model the marten eats the grouse; the body moves along a Euclidean line. The lesson is that the weaker are prey to the

stronger; that inertial bodies move on geodesics. The abstract lesson can be true of a variety of new, different situations where the more concrete behaviour will fail.

The advantage of thinking of what happens here in terms of Lessing's account of morals and fables is that it makes clear that there is *nothing wrong with the initial experiment*. What is wrong vis-à-vis applicability elsewhere is the level at which the conclusion is described. Moreover, no experiment could have done better.

Experiments must be performed in some geometry or other. That is the point of invoking Lessing's theory of the relation of the abstract to the concrete. The abstract can exist *only* in the concrete. You can't get it unless it is fitted out in one way or another. What the abstract consists in given one filling out will be very different from what it consists in given another. For the marten and the grouse, the grouse's being weaker consists in being slow and not having sharp teeth, claws or a hard shell; being prey is being eaten. For a worker vis-à-vis employer, being weaker can consist in having no union, no transferrable in-demand skills and no wealth; and being prey to equals working long hours in bad conditions for little pay. Still, both are cases where the weaker are prey to the stronger. And in any case, it cannot just be true that someone is weaker and prey to another. In every case there must be something more concrete – and thus less generalizable – that this consists in.

My topic here is thought experiments not real experiments. But the same lessons apply. A thought experiment can succeed perfectly in isolating the factor under study and observing – correctly – what it does on its own, without impediment. But if the results are overconstrained they will not readily generalize. Yet, just as with the 'real' Galilean experiment I described for inertia, there may be no alternative. The experiment must be performed in some geometry or other. Similarly, the model to study the effects of skill loss during unemployment on future unemployment rates may have only two generations of workers and one employer, where these affect the outcome though they could not properly be counted as alternative causes of unemployment, as confounding factors that must be eliminated in a Galilean experiment. Yet all situations have some generational structure among the workers and some number of employers. 'Real' economic experiments cannot eliminate them either and so will also be overconstrained.

Thinking of thought experiments as fables, then, points out two important methodological lessons

- Though the results of an experiment or of a thought experiment may be overconstrained, this may be inevitable since the abstract exists only in the concrete.
- To get a conclusion that is true both in the model and in a variety of other cases, it may well be necessary to follow Rol's advice and climb up the ladder of abstraction.

The problem of unrealistic assumptions, Round 3: Not fables but parables

Consider the parable of the prodigal son, of the good Samaritan or of the workers in the vineyard that I discussed in the introduction. As I pointed out there these parables differ from Aesop's and Lafontaine's fables and from Lessing's fable of the marten and the grouse in that no moral appears as part of the parable itself. The moral is not written in but must be supplied from elsewhere. Defending a moral as the correct one requires a great deal of outside work, including much interpretation of other parts of the available text and of the world itself and how it operates.

So too with 'unrealistic' models. Many of these may be Galilean thought experiments and so rightly have 'unrealistic' assumptions. And in many cases the correct lessons to be drawn may be more abstract than those described immediately in the concrete situation of the model. But seldom can we really cast the models as fables because the moral is not written in. They are rather like parables, where the prescription for drawing the right lesson must come from elsewhere. Theory can help here, as can a wealth of other cases to look to, and having a good set of well-understood more abstract concepts to hand will play a big role. So the good news that one can move from falsehood in a model to truth by climbing up the ladder of abstraction is considerably dampened by the fact that the model generally does not tell us which ladder of abstraction to use and how far to climb.

I should stress that this problem is not peculiar to thought experiments. As I have mentioned, real experiments can be overconstrained too. As with thought experiments this need not be a problem since, as with fables and their morals, what results in the (correctly conducted) overconstrained experiment will be what the generalizable result consists in for that situation; it will be an instance of the generalizable conclusion. But the experiment does not show what the generalizable conclusion is, how far up which ladder of abstraction one must climb to reach a result that will be true of new target situations as well or whether we can do so at all. This is, I think, clearly recognized in physics and in much of economics as well, even though not articulated in this way. I stress it because I think that it has not been taken on board in the new drive for experiments in evidence-based policy, where practitioners are trying to draw general conclusions without the aid of theory or appeal to a set of well-understood abstract concepts whose reliability has been established elsewhere. So it is important to stress that real experiments, just like thought experiments, are far more often parables than fables.

Still, it may be harder to notice this problem in the case of models and thought experiments because these come – indeed must come – in some specific vocabulary or other, using some particular concepts or other. If we are to use Rol's ladder to derive from the model conclusions true of the various targets we are concerned with, the trick is not to get stuck in that vocabulary but to climb (if possible!) to one sufficiently abstract to be true both of the model situation and of our target situations. The bigger trick of course is to figure out which ladder, if any, to climb.

Conclusion

If we are to use Galilean thought experiments to inform ourselves about target situations we had better recognize that these models are more like parables than they are like fables. So constructing the model and deriving its consequences are just a small step towards drawing a lesson from it. In order to know what the parable means we need to study a great deal of text, reading both the theory that imbeds the model and reading the world itself.

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