B1 General problems of methodology and scientific reasoning

A Defense of *Ceteris Paribus* Laws

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Abstract:

Earman et al raise several objections to the *Ceteris Paribus* laws. In this paper, I argued that CP clauses could be ineliminable even with scientific terminology, and that it is also possible to test the contraposition of a CP law, therefore the law itself. Earman's account of differential equations may violate his MRL view of laws of nature. Again, Earman's view of laws of nature may be inconsistent with his supervenience thesis.

1. *Ceteris Paribus* Lost?

John Earman, John Roberts and Sheldon Smith (thereafter ERS)'s paper "*Ceteris Paribus* Lost?" raises the severest criticism of *Ceteris Paribus* (thereafter CP) laws. They criticize the concept of CP laws in the following 6 ways:

(i) Appeal to examples from physics. ERS argue that CP clauses can be easily eliminated by known conditions if we properly use scientific language. (ii) Confusing Hempel's provisos with *ceteris paribus* clauses. ERS think the conditions of the provisos are conditions for *the validity of the application*, not conditions for *the truth of the law statements of the theory*. So they would accept Hempel's proviso but reject the CP clauses. (iii) Confusing laws with differential equations of the evolution type. ERS argue that those examples provided by CP law proponents are just differential equations of evolution type. But differential equations of evolution type depend on non-nomic assumptions, therefore are not laws. (iv) Early Cartwright on component forces. ERS raise two objections: in many cases component forces are measurable; it is not clear that it follows that something is not occurrent just because it is not measurable. (v) Cartwright's argument from Aristotelian natures and experimental method. ERS repeat the supervenience: "One can grant that there is a lot more to being a law of nature than just being a true behavioral regularity, and even grant that what laws state is helpfully understood in terms of capacities, while maintaining that laws (and capacities) must supervene on the behaviors of physical systems." (vi) The world as a messy place. The CP laws proponents would argue: "The. Therefore, we just have not good reason to." ERS acknowledge the world is an extremely complicated place, but believe that there are any non-trivial contingent regularities

that are strictly true throughout space and time.[1]

ERS also mention two objections to CP laws: (1) there seems to be no acceptable account of their semantics; (2) there seems to be no acceptable account how they can be tested. They think the first objection is "not fatal to CP laws", while the latter, untestability of CP laws, is decisive.[2]

So I summarize ERS' main arguments against CP laws as following three theses: (1) CP clauses can be easily eliminated if we properly use the scientific language, i.e. ERS' (i). (2) The CP laws can not be tested, if we can not substitute testable auxiliaries for the CP clauses. (3) So called "CP laws" are just differential equations of evolution type (which hedged on non-nomic assumption), but laws are strict, i.e. ERS' (ii), (iii), (iv) and, perhaps, (vi). I will argue against the first two theses in section 2 and the third in section 3.

2. Eliminability and Untestability

Is a CP clause eliminable? Here is Lange's example. To state the law of thermal expansion [the change in length of an expanding metal bar is directly proportional to the change in temperature], "one would need to specify not only that no one is hammering the bar on one end, but also that the bar is not encased on four of its six sides in a rigid material that will not yield as the bar is heated, and so on".[3]

ERS think this example is expressed in a language that "purposely avoids terminology from physics". If we use technical terms from physics, the condition can be easily stated: "The 'law' of thermal expansion is rigorously true if there are no external boundary stresses on the bar throughout the process."[4]

But how can we be sure any forces on the metal bar, say gravity by the earth or electric force by electric charges nearby, would not be a stress, which could influence the expansion of the metal bar? Even we agree with ERS' strict terminology, consider the temperature is raised higher than the melting point of the metal, would the length of the metal bar be still be proportional to its temperature? In fact, ERS do not mention the melting temperature at all in their strict or rigorous reconstruction of the thermal expansion law.

ERS give another example "…Kepler's 'law' that planets travel in ellipses is only rigorously true if there is no force on the orbiting body other than the force of gravity from the dominant body and vice versa." [5](Earman et al, 2002, p. 284)

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[1] Earman, J.,Roberts, J., and Smith, S.: 2002, '*Ceteris Paribus* Lost', *Erkenntnis* **57**, pp.283-288.
[2] *Ibid*, p293.
[3] Lange, M.: 1993, 'Natural Laws and the problem of Provisos', *Erkenntnis* **38**, p.234.
[4] Earman, J.,Roberts, J., and Smith, S.: 2002, '*Ceteris Paribus* Lost', *Erkenntnis* **57**, p.284.
[5] *Ibid*, p 284.

But again, is "other than" terminology from physics? Even it is, would the ellipse law still hold if, say, the mass of the sun is increasing or decreasing because of certain chemical reaction, which is not "force" at all? If we consider all such interference, I am afraid that ERS' rigorous reformulation would finally have to expand infinitely.

Is a CP law testable? ERS mention two common views for testability of CP laws: (1) We can confirm the putative law that CP, all Fs are Gs by finding evidence that in a large and interesting population, F and G are highly positively statistically correlated; (2) We can confirm the hypothesis that "CP, all Fs are Gs" if we find an independent, non-ad-hoc way to explain away every apparent counter-instance, that is, every F that is not a G.

ERS think the former just lend confirmation to the stronger claim that in some broader class of populations, F and G are positively statistically correlated, that would not be a CP law. And the latter is not sufficient. Here is their counter-example: "CP, white substances (or compounds containing hydrogen) are safe for human consumption." Although we can explain away any white substance would be not safe for human by modern biology or medicine, it is not a law at all.

I can agree ERS' two objections are nice, especially the first, but I would like to raise another testability possibility for CP laws – their contrapositions are testable. [6] If we write a CP law "If CP, then L" as "CP→L", it is logically equivalent to "∼L→∼CP". We can easily get, say, "If not all Fs are Gs, then not CP".

Here I consider two interpretation of CP, "there are no interferences" and "other things being equal". I give the former the logical form ∼(I1∨I2∨I3…), I*i* refers to different Interferences, which could be a infinite set. The latter can be written as (E1∧E2∧E3…) , here E*i* means various Equal conditions, which again could be infinite. So whenever F is not G, there must be at least one interference or one conditional unequal. So experimenters try to find the interference or unequal condition, finally they do – there is a disturbing factor or something unequal. I think that is a confirmation of the CP law!

So my testability argument can be summarized as the following logical steps.
For "there are no interferences" interpretation
(1) CP→L≡∼L→∼CP
A conditional equals to its contraposition.
(2) [∼(I1∨I2∨I3…)→∀x (Fx→Gx)]≡ [∼∀x (Fx→Gx)→(I1∨I2∨I3…)]
We substitute the logical form for CP and L
(3) Fa∧∼Ga
A counter-instance is found.

[6] I learned the idea from Elgin, M. and Sober, M.: 'Cartwright on Explanation and Idealization', *Erkenntnis* **57**, pp. 441-450. They raise a contraposition argument against Nancy Caright's claim that the fundamental laws do not apply in the real world.

(4) $\sim\forall x\,(Fx\rightarrow Gx)$
L seems not hold.
(5) $I1\vee I2\vee I3\ldots$
CP does not hold, i.e., there is inference.
(6) I*n*
Scientists find the interference (or interferences), which confirms the CP law.

For "other things being equal" interpretation
(1) $CP\rightarrow L\equiv\sim L\rightarrow\sim CP$
A conditional equals to its contraposition.
(2) $[(E1\wedge E2\wedge E3\ldots)\rightarrow\forall x\,(Fx\rightarrow Gx)]\equiv[\sim\forall x\,(Fx\rightarrow Gx)\rightarrow\sim(E1\wedge E2\wedge E3\ldots)]$
We substitute the logical form for CP and L
(3) $Fa\wedge\sim Ga$
A counter-instance is found.
(4) $\sim\forall x\,(Fx\rightarrow Gx)$
L seems not hold.
(5) $\sim E1\vee\sim E2\vee\sim E3\ldots$
CP does not hold, i.e., there is a condition unequal.
(6) $\sim En$
Scientists find the unequal condition (or conditions), which confirms the CP law.

With regard to ERS's "white substances" counter-example, I think it involve the distinction of genuine laws and accidental generalizations. According to the best knowledge of modern science, we regard "CP, white substances (or compounds containing hydrogen) are safe for human consumption" as an accidental generalization rather than a genuine law, even if it is true. But generalizations of the strict form would face the same problem. "All gold are less than 10^6 Kg" would be true while not regarded as a law of nature. So I do not think ERS' counter-example justify the untestability of CP laws.

3. Differential Equations and Supervenience

ERS argue that those so called "CP laws", say, thermal expansion law or Kepler's law, are just differential equations of evolution type. They are not laws at all. But I think, that claim would be inconsistent with Earman's so called "system approach"[7] to the understanding of laws of nature.

In the discussion on laws of nature, there are mainly two camps in the philosophy of science. David Armstrong, Michael Tooley and Fred Drestke give a necessitarian view**.** They think a kind of physical or nomic necessity distinguishes the genuine laws from the accidental generalizations. But it is still difficult for them to work out an explicit definition of that necessity. So nowadays J.S. Mill, Frank Ramsey and David Lewis'

[7] Carroll J. ed.: 2004, *Readings on Laws of Nature*, Pittsburgh: University of Pittsburgh Press, p4.

view (therefore MRL) is more popular. John Earman is in this camp.[8]

MRL think laws are "consequences of those propositions which we should take as axioms if we knew everything and organized it as simply as possible in a deductive system".[9] So "a contingent generalization is a law of nature if and only if it appears as a theorem (or axiom) in each of the true deductive systems that achieves a best combination of simplicity and strength".[10]

Therefore, according to MRL, and Earman, "No sphere of uranium-235 has diameter greater than 100 meters" is a law of nature, while "No sphere of gold has diameter greater than 100 meters" is just an accidental generalization. Because the former belongs to our knowledge system of quantum physics, but the latter does not.

A system approach (MRL and Earman) would acknowledge even theorems (not only axioms) of our deductive system of the modern sciences are laws of nature. The thermal expansion law or Kepler's law are the consequences of modern physics, say, solid mechanics or Universal Gravitation Law. Why Earman insists they are just differential equations of evolution type, not laws of nature? I think his claim in the discussion of the CP law is inconsistent with his point concerning the law of nature.

ERS think there is a distinction between conditions for the truth of a law (CP) and conditions for the validity of its application (Provisos). They accept Hempel's provisos but reject CP clauses. Conceptually, conditions for the truth of a statement may not equal to the conditions for the validity of its application. "The Indpendency Day of USA is July 4" is true; but is not necessary for me to apply it in my pursuing a lady. But the situation in fundamental physics is a little bit different.

The fundamental laws of physics are always abstract. It seems there is no direct way for us to justify their truth. Of course, it does not mean those fundamental laws are untestable. We can deduce something, usually with the help of bridge principles (or correspondence sentences), from the abstract laws, combined with non-nomic assumptions or initial conditions. From my point of view, that is a kind of application of the abstract laws to the real situations. Since these derivations are testable, we can confirm (or disconfirm) the truth of the fundamental laws. So the conditions for the truth of a law are closely related, if not logically equivalent, to their applications.

Consider ERS' supervenience thesis. They insist laws must supervene on the behaviors of physical systems. According to *Oxford English Dictionary*, "supervene" means "to come on or occur as something additional or extraneous; to come directly or shortly after something else, either as a consequence of it or in contrast with it; to

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[8] Earman J.: 2002, 'Laws of Nature', In: Y. Balashov and A. Rosenberg ed.: *Philosophy of Science----Contemporary Readings*, London & New York: Routledge.

[9] Ramsey, F.: 1978, *Foundations of Mathematics*, Altantic Highland, NJ: Humanities Press, p38.

[10] Lewis, D.: 1973, *Counterfactuals*, Cambridge, MA: Harvard University Press, p73.

follow closely upon some other occurrence or condition". So the supervenience thesis should remind us that laws always "come after" the real behaviors.

Here is Cartwright's nice analogy. She regards the relation between laws of nature and real situations as a kind of abstract-concrete relation, like morals and fables. She quotes Leesing's claim, "The general exists only in the particular and can only become graphic (anschauend) in the particular". Consider the moral: The weaker are always prey to the stronger.[11] We can find the real and concrete situation as described in Lessing's fable "A marten eats the grouse. A fox throttles the marten; the tooth of the wolf, the fox." I think her analogy gives a wonderful example of supervenience: the moral supervene on the fable. In what sense the moral is true? It provides a nice idealization of the real situation, say, the relation between martens, grouses, foxes and wolves. It can be applied to the relation between other animals, perhaps humans and nations too. Suppose in a possible world, there are no animal, human, nation or something like that, the moral need not be true any longer, since there is nothing it can supervene on. Now suppose in another possible world, the electric charge of everything is removed, because of a certain evolution of the universe, while other things (so laws) remain equal. Would the law of electromagnetism force, one of the four fundamental forces in modern physics, still hold? According to Earman's distinction of the conditions for truth and for application, one can argue the law of electromagnetism force still holds however it can not apply any longer. But according to the supervenience thesis, the law can not supervene on any physical behavior since there is no electric charge at all. Again, I am afraid Earman's point on the CP laws is inconsistent with his understanding of the law of nature.

4. Conclusion

Earman et al raise several objections to the *Ceteris Paribus* laws. In this paper, I argued that CP clauses could be ineliminable even with scientific terminology, and that it is also possible to test the contraposition of a CP law, therefore the law itself. Earman's account of differential equations may violate his MRL view of laws of nature. Again, Earman's view of laws of nature may be inconsistent with his supervenience thesis.

[11] Cartwright, N.: 1999, *The Dappled World*, Cambridge: Cambridge University Press, pp. 37-43.