Woodward 9
Invariance and Laws

(pp. 239–288)

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Invariance

What it is (p. 239)

A generalization is invariant under a change if it continues to hold, at least to an appropriate level of approximation, when that change occurs.

Example (p. 248)

The generalization, that storms (S) occur when the barometer reading (B) falls, is invariant under:

- Changes in the position of Mars.
- Changes in the price of tea in China.
- Changes in atmospheric pressure.

It is not stable under:

- Interventions on B with respect to S.
- Interventions on S with respect to B.

Explanation and invariance

A generalization is *explanatory* iff it can be used to explain something in accordance with (EXP). (My interpretation)

Theorem

A generalization G is explanatory iff, for some variables X and Y, there is an intervention I on X with respect to Y such that:

- According to G, I will change the value of Y.
- G is invariant under I.

Proof: Follows from (EXP) and the definition of an explanatory generalization.

Examples

- The generalization that storms occur when the barometer falls is not an explanatory generalization.
- Boyle's law, that $PV =$ constant for a gas at constant temperature, is an explanatory generalization.

Exceptions

Woodward's theory implies that explanatory generalizations can have exceptions.

Examples

- Boyle's law: $PV =$ constant.
  - Does not hold, even approximately, if the pressure is too high.
  - Is invariant under some interventions on V for some systems.
- Hooke's law: $F = -kX$, where X is the extension of a spring and F is the restoring force.
  - Does not hold, even approximately, if the material is of the wrong kind, the spring is stretched too far, etc.
  - Is invariant under some interventions on X for some systems.

The exception incorporation strategy

If G only holds in some domain D but seems to be explanatory, then what is explanatory is the exceptionless generalization G^*, which says that G holds in domain D.

Woodward rejects this because:

- Scientists don't formulate generalizations in this way.
- Scientists often use generalizations for explanation when they don't know the boundary of D.
- If vague boundaries are built into a generalization, the generalization has no definite content.

Woodward's view: To use a generalization for explanation, one only needs to know that the system under discussion is in D; this does not require knowing the boundaries of D.

Laws

Paradigmatic laws are simply generalizations with wide scope that are invariant under a large and important set of changes that can be given a theoretically perspicuous characterization. (p. 286)

Example of a paradigmatic law

Newton's law of gravitation: $F = Gm_1m_2/r^2$.

- Applies to all masses throughout the universe.
- Invariant under every change that doesn't involve a strong gravitational field or velocities comparable with light. (p. 286)

Example that isn't a paradigmatic law

$F = -K_SX$, where K_S is the constant for a particular kind of spring S.

- Only applies to one kind of spring.
- Breaks down under extreme extensions; also under high temperature, if the spring is cut or deformed, or . . . (p. 285)

Laws in general (p. 286)

Paradigmatic laws are simply generalizations with wide scope that are invariant under a large and important set of changes that can be given a theoretically perspicuous characterization. We are willing to regard other invariant generalizations as laws to the extent that they resemble these paradigms in these respects. It is thus not surprising that the boundary between those invariant generalizations we regard as laws and those we do not is fuzzy and contentious.

On Woodward's view, it does not matter that the law/nonlaw boundary is vague, because we don't need to know if a generalization is a law to know whether it is explanatory.

Contrast with Lange

	Lange	Woodward
Law/nonlaw distinction	sharp	vague
Content of laws	vague	sharp

Questions

1. Suppose a flagpole is on flat ground and let H be its height, L the length of its shadow, and θ the angle of the sun above the horizon. These variables are related by a generalization G, namely $L = H/\tan\theta$. (a) Give an example of a change under which G is invariant, and a change under which it is not invariant. (b) Is G explanatory? Justify your answer.
2. If you want to use Boyle's law to explain the increase in pressure of a gas, do you need to know the conditions under which Boyle's law is and isn't accurate? Justify your answer.
3. What is a scientific law, according to Woodward? State two respects in which Woodward's view differs from Lange's.
4. Does Woodward's view imply that all laws are explanatory generalizations? Justify your answer.