What Engineers Can Do but Physicists Can't: Polanyi and Margitay on Machines

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ABSTRACT Key Words: Michael Polanyi, ontological emergence, technological reduction, industrial standards, philosophy of technology, philosophy of engineering.
This is a comment on Tihamér Margitay's "From Epistemology to Ontology," where he criticizes Polanyi's claim that there is a systematic correspondence between the levels of ontology and the levels of tacit knowing. Margitay contends that Polanyi supports this correspondence by appealing to a "purely ontological argument," one which concludes that it is impossible to reduce machines to a singular, chemical-physical type, and criticizes this claim by pointing to industrial standards (machines that do reduce to singular physical-chemical type). I respond to Margitay's claim by distinguishing two different "purely ontological arguments" in Polanyi's thought (one relying on the multi-realizability of a machine in different physical-chemical types, the other pointing to the inability of a purely physical-chemical ontology to account for the artificial shaping and functioning of machines). With these two arguments clarified, Margitay's criticism by appealing to industrial standards loses much of its initial force.

Michael Polanyi contends that the properties of machines supervene on physical-chemical properties (i.e., there is no difference in the mechanical properties of a machine without a difference in its underlying physical-chemical properties), but he rejects the ontological component of physicalism that physics and chemistry have complete authority over specifying what there is. Clocks, typewriters, boats, telephones, locomotives, and cameras are ontologically complex and emergent entities composed of (i) a lower layer consisting of physical-chemical particulars that are governed by physical-chemical laws and (ii) a higher layer consisting of novel properties belonging to machines and laws governing these properties (cf. Polanyi 1962 [1958]:328). Machines represent time, allow philosophers to punch out books, and ease our travels by land and sea but these functional properties are *ontologically emergent*. As such, they don't reduce to lower-level physical-chemical properties and the higher-level laws that govern these machines cannot be reduced to lower-level physical-chemical laws.

In no sense is it the case that higher ontological layers "break" physical chemical laws for Polanyi contends that machines are subject to "dual control," namely they are controlled both by lower level laws that apply to the particulars of the object in themselves and by higher level laws that apply to the comprehensive entity formed by these particulars (1966:36). Rather, while physics and chemistry may have full coverage over the particulars of reality, it does not have full coverage over the entities that emerge out of these particulars. So while machines are comprised of particulars that are themselves governed by physical-chemical laws, these laws do not cover certain novel properties that belong to machines.

Polanyi's Correspondence Thesis Argument for Ontological Emergentism

How does Polanyi establish this claim concerning the ontological emergence of machines? Polanyi's argument is this:

Polanyi's Correspondence Thesis Argument for Ontological Emergentism	
P1	*Correspondence Thesis*: There is a systematic correspondence between the levels of ontology and the levels of tacit knowing (cf. Polanyi 1966:33-34)
P2	*Structure of Tacit Knowing*: When we engage in tacit knowing, we integrate subsidiary clues into a focal whole (e.g., a recognized object, a skillful act, a justified belief). In this structure, it is impossible to reduce the focal whole to a single set of clues and to a single way in which they were integrated for (i) the same focal whole is realizable by heterogeneous types of subsidiary clues and (ii) the same subsidiary clues, in their functional relationship, can be realized by different focal wholes.
C	Thus, it is impossible to reduce complex ontological entities like machines to a single set of physical-chemical particulars and a single way in which they were constituted for (i) a machine as a type is realizable by heterogeneous types of physical-chemical particulars and (ii) one set of physical-chemical particulars, in their functional relationship, can be realized in different machine types.

Against this argument, Tihamér Margitay (2010) has argued that Polanyi's *general* thesis that there is a systematic correspondence between the ontological levels and the hierarchal levels of knowing (P1) is false. According to Margitay, we ought to moderate Polanyi's position by confining it only to skillful performances and not to ontology writ large. On his account, we cannot determine the ontological structure of a complex entity simply by appealing to the way in which we know these entities. There is nothing about the latter that determines the former. Thus, when Polanyi (1966:55) writes that "the structure of tacit knowing determines the structure of comprehensive entities," Margitay (2010:131) contends (and I agree) that this is an overstatement. In order for Polanyi to defend the correspondence thesis (P1), what he must do is pursue some purely ontological argument. However, Margitay also argues that Polanyi's purely ontological arguments don't work either. In what follows, I present two such ontological arguments, articulate Margitay's objection to one of these, and offer a Polanyian response to this objection.

The Multiple Realization (the Many-One) Argument

Just as it is impossible to reduce the focal whole to a single set of clues and single integration, Polanyi argued that it is impossible to reduce a complex entity like a machine to its physical-chemical parts. According to Polanyi, "[m]achines are solid structures made up of several parts, which have their several functions in the operation of the machine" (1969 [1962]:175). While a token of a machine can be defined through a physical-chemical description of the particular configuration of these solids, Polanyi argues that a *type* of machine cannot be defined in this way. Why? Polanyi's answer was that such a description would fail to take into account that there are an infinite number of diverse realizations of the same machine as the same machine could be made in different sizes and different materials (1969 [1962]:175, 1962 [1958]:328-29). Given that a higher level type (the machine) corresponds to several heterogeneous lower level types (the latter of these being given a physical-chemical description), there can be no *unified* physical-chemical account of what a machine is or how it operates. And so, given the infinity of diverse realizations, Polanyi concluded that a class

of machines "*cannot be even approximately specified in terms of physics and chemistry*" (1962 [1958]:329, 1969 [1962]:175).

Margitay argues that in putting forward the above argument, Polanyi overlooked the significance of industrial standards. "Industrial standards," Margitay writes, "show that comprehensive entities can be identified by physical-chemical parameters" as these standards "reduce the possible variations of simple tools and fittings which for Polanyi are emergent structures in the same way as machines are […]. Standards specify the physical-chemical topography of nuts, bolts, etc. by specifying their dimensions and chemical compositions" (2010:138). In other words, Margitay points to one higher level *type* (of machine) that corresponds to a single lower level type, the latter of which can be given a unified physical-chemical description.

Polanyi, I think, has three options. First, he could respond by saying that nuts, bolts, etc. are *not machines* and so while those types of things admit of reduction, *real machines* don't reduce. This seems a little ad hoc but whenever Polanyi refers to machines, the ones that he has in mind are clocks, typewriters, boats, locomotives, and cameras and his typical description of machines are those with multiple, separated, and interacting parts (see 1962 [1958]:328). Second, Polanyi could moderate his correspondence thesis and say that *some types* of machines are not emergent and these wholly reduce to physical-chemical types, but *other types* of machines (e.g., types that allow for heterogeneity of parts and size) are emergent and so cannot be reduced as Margitay suggests. Note that Polanyi would have to weaken the correspondence thesis (P1) so as to say that the structure of tacit knowing corresponds to the structure of ontology not in every case but just in those cases where the subsidiary parts are notably heterogeneous. Finally, Polanyi could contend that this argument is meant to be a knock-down argument. Instead, it is a part of a multi-pronged approach to showing that machines don't reduce to a single physical-chemical type. Thus, while the objection from industrial standards is effective, Polanyi might appeal another argument to shore up his correspondence thesis. But, for this to be an effective reply, Polanyi would need another purely ontological argument. It is to this that I now turn.

The Context-Dependence (the One-Many) Argument: What Engineers Can Do but Physicists Can't

Polanyi pointed to another way in which the levels of tacit knowing correspond to ontological layering, and thus another way in which machines are emergent entities that supervene upon (but don't reduce to) physical-chemical objects. Just as it is impossible to reduce a focal whole to a single set of clues and integration (as the same subsidiary clues can be realized by different focal wholes), it is impossible to reduce a single machine type to a single set of physical-chemical particulars as their constitutive relation allows for realization in different machines and even non-machine types. In other words, a one-many relation exists between physical-chemical particulars and higher-level types wherein the same physical-chemical particulars can be realized in several different machine types. This multiple realization of the same physical-chemical particulars on a higher level is thus due to the fact that lower level physical-chemical laws and particulars do not determine the upper level laws that govern machines.

Polanyi's argument for this position is similar to those who argue against biological reductionism. For example, a single allele can result in different phenotypes for the higher level property partially depends upon the *context* in which the allele occurs. For Polanyi, however, the contextual features that allow for a single set of physical-chemical particulars to be realized in different machine types are those relating to the human shaping, organizing, and developing of physical-chemical particulars for material human advantage.

Polanyi's argument begins with a definition of a machine as something that is both *artificially shaped* by intelligent beings and employed for a *specific purpose*, usually for some material advantage (1966:40, 1969 [1964]:153-54, 1969 [1968]:225).[1] Next, Polanyi contends that while physical and chemical properties and laws are independent of whether intelligent beings exist, the properties of machines and their laws depend upon intelligent beings existing (cf. Polanyi 1969 [1968]:225). On this account, to be a machine is to exist in a relation to an intelligent being's capacity to mold physical-chemical particulars in a certain way and to their goals. Thus, the same physical-chemical particulars could constitute several different types of machines for they might be integrated for different purposes or conceived as having different functions. But, perhaps more importantly, we might draw out the following consequence:

> from the point of view of the physicist qua physicist, if there were two objects *x* and *y*, both consisting of the same physical-chemical particulars but where *x* is both the result of human invention and plays an instrumental role in human life while *y* naturally emerged as a result of cosmic chance in a world devoid of intelligent life, then *x* and *y* would be metaphysically identical.

For Polanyi then, the above consequence shows that a reduction of entities to wholly physical-chemical entities would not allow for any difference between those complex objects that we intuitively recognize as machines (i.e., those that are the result of human shaping and that play a role in human goals) and those that naturally emerged. There is thus no one-to-one reduction between a unitary description of physical-chemical particulars and a machine type as machines only exist relative to the role they play in intelligent activity.

This lack of an ontological difference translates into an important explanatory difference with respect to physics and engineering. On Polanyi's account, there is something that engineers can, but physicists cannot, tell us, namely:

> (i) whether an object is a machine (1966:39, 1962 [1958]:330),
> (ii) how a machine works (1966:39, 1969 [1964]:153, 1962 [1958]:330), and
> (iii) the purpose of a machine (1966:39, 1969 [1964]:153, 1962 [1958]:330).[2]

If we take a strictly physical and chemical perspective—abstracting the human element out of ontology—, then Polanyi contends we cannot explain (i)–(iii) precisely because the particulars and laws of physics and chemistry are specified independently of their artificially shaping by and functional purpose for humans. Thus, the correspondence thesis holds: for just as acts of tacit knowing require an integration of subsidiary clues into a focal whole, Polanyi contends that machines require a special kind of integration of physical-chemical particulars.[3]

Endnotes

[1]Concerning the point that something is a machine only if it can be employed to serve a purpose, Polanyi (1962 [1958]:330) writes: "We identify a machine by understanding it technically; that is, by a participation in its purpose and an endorsement of its operational principles."

[2]What is, however, a pretty constant point is that there are certain explanations that only physics and chemistry can provide, namely engineering cannot ultimately tell us why a machine failed (1969 [1962]:176,

1969 [1965]:217-18, 1966:39, 1969 [1968]:225). In relation to tacit knowing, Polanyi contends that we can use a machine skillfully without knowing how it works (1966:19-20; Polanyi and Prosch 1975:141) and that we can know how a machine works without knowing how to use it skillfully (1966:19-20).

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