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Scientific Realism: Between Platonism and Nominalism

Stathis Psillos[†‡]

In this paper, I discuss the prospects of nominalistic scientific realism (NSR) and show that it fails on many counts. In section 2, I discuss what is required for NSR to get off the ground. In section 3, I question the idea that theories have well-defined nominalistic content and the idea that causal activity is a necessary condition for commitment to the reality of an entity. In section 4, I challenge the notion of nominalistic adequacy of theories.

1. Introduction. Philosophy of science proper has been a battleground for a key battle in the philosophy of mathematics. On the one hand, indispensability arguments capitalize on the strengths of scientific realism, and in particular of the no-miracles argument (NMA), in order to suggest that (*a*) the reality of mathematical entities (in their full abstractness) follows from the truth of (literally understood) scientific theories and (*b*) there are good reasons to take certain theories to be true.[1] On the other hand, arguments from the causal inertness of abstract entities capitalize on the strengths of scientific realism, and in particular of NMA, in order to suggest that (*a*) if mathematical entities are admitted, the force of NMA as an argument for the truth of scientific theories is undercut; and (*b*) the

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1. The best defense of this argument is by Colyvan (2001).

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best bet for scientific realism is to become nominalistic scientific realism (NSR) and to retreat to the nominalistic adequacy of theories.

In this paper, I focus on NSR and argue that it fails as an adequate version of scientific realism. In section 2, I discuss what is required for NSR to get off the ground. In section 3, I question the idea that theories have well-defined nominalistic content and the idea that causal activity is a necessary condition for commitment to the reality of an entity. In section 4, I challenge the notion of nominalistic adequacy of theories.

2. Nominalistic Scientific Realism. A standard argument against Field's (1980) anti-Platonist move is that scientific theories (especially high-level ones) resist nominalization: they resist a nominalism-friendly reformulation that implies commitment only to concrete entities. Be that as it may, there is a general strategy for bringing together scientific realism and nominalism, akin to Bas van Fraassen's (1980). This is to introduce the concept of nominalistic adequacy and to argue that even if scientific theories cannot be nominalized, even if mathematics is theoretically indispensable, commitment to abstracta is avoided. What matters, it is argued, for the applicability of scientific theories and what is enough to explain their empirical successes is that they are nominalistically adequate, where a theory *T* is nominalistically adequate if (and only if) "it is correct in its nominalistically-stated consequences (i.e., if it is correct in those of its consequences that do not quantify over mathematical entities)" (Leng 2005, 77).

I shall discuss the concept of n-adequacy in section 4, but for now let me focus on the general idea behind it, namely, that a theory can be false (if literally understood) and yet get everything right vis-à-vis whatever is concrete. We tend to forget that the consensus over the claim that theories should be taken at face value is a hard-won one. Literally understood, theories purport to refer not just to theoretical entities but to mathematical entities too. In fact, theories typically comprise a host of mixed statements, not just connecting the theoretical and the observational vocabulary but also connecting both vocabularies with a mathematical vocabulary. Mixed statements, under the assumption of a literal understanding of them, require mixed truth makers. If, as it happens, some part of the required truth maker is missing (as will be the case if there are no mathematical objects), two options are available to a would-be scientific realist. One is to go for a nonliteral understanding of the mixed statements, thereby claiming that the appropriate truth maker is not really mixed and hence that no part of it is really missing. The other option is to insist on a literal understanding of theories and to concede that they are false. Leaving the first option to one side, the second option would be prima facie disastrous for realism, at least as an epistemic thesis. How, for instance, can this systematic and symptomatic falsity of theories explain their empirical successes?

There is a nominalism-friendly way out of this problem, but it requires that there are ways to (*a*) carve up entities into two disjoint sets—the concrete and the abstract; (*b*) disentangle whatever the theory asserts about concrete causal entities (its nominalistic content) from whatever it asserts about abstract ones; and (*c*) show that whatever credit accrues to the theory from its applications to the world comes exclusively from its nominalistic content.

Assuming that *a* can be dealt with (more on this in the next section), what Mark Balaguer (1998, 130) has called 'nominalistic scientific realism' aims to deal mostly with *b*. He enunciates the following two theses:

> **(NC)** Empirical science has a purely nominalistic content that captures its 'complete picture' of the physical world.

> **(COH)** It is coherent and sensible to maintain that the nominalistic content of empirical science is true and the Platonistic content of empirical science is fictional.

NC asserts what needs to be shown. The argument for this is that mathematical entities, if they exist at all, are causally inert (see Balaguer 1998, 132). Hence, there would be no causal difference in the world if they did not exist. Hence, there is a way the world is—causally—that is independent of any mathematical objects. The nominalistic content (n-content) of the theory, then, is what the theory says about whatever is part of the causal blueprint of the world. COH follows right away and makes possible the claim that though, literally understood, scientific theories are false, it is enough for realism that the n-content of theories is true, since we do not thereby lose "any important part of our picture of the physical world" (134). As Balaguer put it, "The nominalistic content of a theory T is just that the physical world holds up its end of the 'T bargain', that is, does its part in making T true" (135). In the end, nominalists do not have to replace Platonistic scientific theories with nominalized ones. They can argue that when these Platonistic theories are accepted, we should be committed only to the truth of their nominalistic content.

Note that the move from 'no causal difference' to 'no difference', which is required for the assumption that the causal image of the world is the complete image of the world, is fallacious. It would imply that laws of nature make no difference since they make no causal difference. But laws do make a difference, even if it is not causal. They are unifiers; or they govern/explain their instances; or (more importantly), being patterns under which sequences of events are subsumed, they constitute what we call the causal structure of the world, namely, they make causal happenings possible—where this relation of constitution is not, of course, causal.

Even if Balaguer's strategy were impeccable, there would still be need for an argument for part *c* of the tripartite strategy for NSR. A form of this has come from Leng (2005). Her view is that the best bet for a scientific realism is to go for NSR: the (alleged) Platonistic content of theories is an extra burden that scientific realists cannot discharge. Her argument is this. If true, theories (literally understood) imply the existence of both theoretical and mathematical entities. But the mathematical entities are causally inert; hence, they are not involved in any causal explanation of certain empirical successes of theories (e.g., a novel prediction). Hence, the no-miracle argument that scientific realists employ to ground their epistemic optimism no longer offers reasons to believe in the full truth (nominalistic + Platonistic) of scientific theories. And yet, it could give us reason to believe that successful theories are nominalistically adequate. Ergo, scientific realism is in much better shape if truth is replaced by nominalistic adequacy.

3. On the (Alleged) Nominalistic Content of Theories. Drawing a sharp distinction between the concrete and the abstract is notoriously difficult, even if there are paradigmatic cases of entities that are concrete and entities that are abstract (see Dummett 1991, 239). Most typical criteria for this distinction (lack of spatiotemporal location and causal inertness) admit of interesting (though occasionally contentious) counterexamples. Be that as it may, there is little doubt that mathematical objects are abstract, if only because they are the paradigmatic cases of causally inert entities.

It is noteworthy that there is a whole category of abstract objects whose existence is contingent (i.e., they do not exist necessarily) and also contingent on the existence and behavior of concrete objects. Examples of such objects are the equator, the center of mass of the solar system, directions, shapes, and semantic types. More importantly, abstract objects are (parts of) the truth makers of the descriptions of (most) theoretical models employed by theories. The linear harmonic oscillator (LHO), for example, or the two-body Newtonian system, or a frictionless inclined plane are pertinent examples. It is tempting to conflate models with their descriptions. But if care is taken, models are abstract objects that satisfy certain descriptions. They are not pure abstract objects since physical properties are ascribed to them, but they are abstract nonetheless—and certainly not causally efficacious. We can borrow Dummett's (1991, 300) expression and call models 'physical abstract entities'.[2] We may draw a

2. For more on this, see Psillos (forthcoming).

distinction between nonmathematical abstract objects (NMAOs) and mathematical abstract objects (MAOs).

Literally understood, theories imply commitment to a host of NMAOs, that is, to a host of causally inert entities. It is absurd to say that all these NMAOs are not explanatorily relevant to the successes of theories, or that they contribute nothing to the explanation of the behavior of concrete physical objects. An LHO, for instance, does explain why the period of a concrete pendulum is (roughly) proportional to the square root of its length; it supports certain counterfactuals (e.g., about changes of the length of the pendulum); it unifies under a type a variety of resembling concrete objects. It follows that causal inefficacy is no reason to deny that some entity is part of reality. Causal inertia does not imply explanatory inertia.

The obvious riposte available to NSR is that all these entities are dispensable. But this reply would be too quick. We should distinguish between two types of NSR: lenient and austere. The lenient version is tough on mathematical objects but does allow nonmathematical abstract entities. The austere version puts a ban on anything abstract. The austere version should aim to dispense with all putative abstract objects by reformulating theories so that they do away with them. I do not know whether this is feasible but suppose it is. The result of this herculean operation would be, in all probability, a massively complicated theory that would be unable to make any general claims about concrete objects. Generality requires abstractness: otherwise the general cannot cover the particular. There is not a theory of concrete springs, and another of concrete pendula, and another of . . .: there is a theory of the LHO, which covers many concrete structures that are inexact tokens of the LHO.

The lenient version of NSR at least has the resources for the development of simple, explanatory, and unified theories via the employment of NMAOs. The latter provide, among other things, the resources for the formulation of comprehensive laws. But if NMAOs are (allowed to be) part of the content of theories, the very idea of an n-content of a theory that bans abstract entities altogether becomes otiose. For NMAOs play a key role in specifying what the theory asserts about concrete objects and their behavior. They also play a key role in explaining the behavior of concrete objects. What is more, parts of the identity of some NMAOs (more particularly, of models) are mathematical entities, like phase spaces, vector spaces, and groups (cf. French 1999). Since NMAOs are, after all, abstract entities, there is no principled problem in having mathematical abstract objects as part of their constitution. So if NMAOs are explanatory, so are those mathematical objects that are part of their constitution.

Friends of lenient NSR might retort that the employment of descriptions that, taken at face value, refer to alleged abstract objects are purely descriptive and representational devices that, though expressively and theoretically indispensable, are not metaphysically indispensable. Here again, however, the only general (and initially plausible) argument for the alleged metaphysical dispensability of abstract objects comes from their causal inertness, and this is not enough to deny existence. Abstract entities can still be explanatorily indispensable and explanatorily efficacious as well.

If this is broadly correct, the very idea of an abstract entities–free n-content of theories is hollow. Abstract entities get entry visas because very little interesting (general and explanatory) can be said about the physical world without being committed to them.

4. On Nominalistic Adequacy. Let us presume we can make good sense of the idea of the n-content of a theory and pay some attention to the concomitant idea of nominalistic adequacy. The significance of this idea is that a theory can be nominalistically adequate and yet false (in that there are no mathematical entities). It is further argued that a nominalistically adequate theory (which is not just an empirically adequate theory) is exactly as explanatory of the observable phenomena as a theory that assumes the existence of abstract entities, since the latter make no contribution to the causal explanation of the observable.

There is first an issue with the very idea of characterizing n-adequacy. Leng's preferred characterization (introduced in sec. 2), stated as it is in terms of the truth of nominalistically stated consequences of a theory, is problematic.[3] As Jeff Ketland has noted (private communication), the required notion should be model theoretic.[4] Accordingly (and roughly put), a theory T is n-adequate if a substructure of a model of the theory

3. Even if a syntactic characterization of n-adequacy were adequate, the following would be a problem. Theories yield consequences only with the aid of auxiliary assumptions. The claim of n-adequacy would then have to be that a theory T is n-adequate if for *all* auxiliaries M cast in mathematical language, M & T yields no extra nominalist consequences that do not follow from T alone. If this were not the case, some of the n-content of T would depend on the truth of mathematical claims. The only way to secure this does not happen is to retreat to the conservativeness of mathematics.

4. According to Ketland (private communication), to get to a characterization of n-adequacy, we start with a formalization of the mathematized language L of a theory and its intended semantics and then we define the notions of 'weak nominalistic adequacy' and 'nominalistic adequacy'. In essence, a theory T is nominalistically adequate iff T has a model M whose L_N reduct (i.e., its reduct in the sublanguage L_N, which has no variables ranging over abstracta) is isomorphic to I_N (i.e., to a partial nominalistic interpretation (D_N, $\{N_i\}$) of L, where D_N is the domain of concreta and N_i are the nominalistic relations). It can then be shown that if T is n-adequate, then T is weakly n-adequate, but not conversely. For some discussion of relevant notions, see Ketland (2004).

(the substructure that is fit for the representation of nominalistic facts) is isomorphic to the causal structure of the world.[5] But now we have quantified over models—that is, mathematical objects. Even if this objection is not fatal for the use of the concept of n-adequacy by the advocates of NSR, it would surely remove a lot of the attraction of NSR. Their advocates would have to have a fictionalist stance toward a central building block of their own account of how theories latch onto the world.

Recall that NSR forfeits the idea of a mathematics-free reformulation of scientific theories. This kind of situation leads to an interesting case of underdetermination, whereby the nominalistic content of a theory underdetermines its full content. We can easily envisage a situation in which two (or more) theories $T1$ and $T2$ have exactly the same n-content but differ in their mathematical formulations. These theories are, by definition, nominalistically equivalent. To simplify matters let us assume that theories have two distinct and separate (or separable) parts, one nominalistic (call it N) and another mathematical (call it M). So a theory T is, in effect, $N + M$.

Suppose we take NSR to accept, as it surely must, that it is not a necessary truth that mathematical objects do not exist. Take, then, a theory $T1$ $(= N + M)$ and another theory $T2$ $(= N + [-M])$. Theory $T2$, in effect, asserts there are no mathematical objects at all and equates the content of the theory with its n-content: $T1$ and $T2$ are n-equivalent. Yet, given that there could be mathematical objects, there is a possible world $W1$ in which there are mathematical entities, and in $W1$, $T1$ is true and not just n-adequate, while $T2$ is n-adequate but false. Similarly, there is a possible world $W2$, in which there are no mathematical objects, in which $T2$ is n-adequate and true. How can we tell whether the actual world @ is like $W2$ and not like $W1$? That is, how can we tell whether $T2$ is n-adequate and false as opposed to n-adequate and true? Given that we read the mathematical parts of our theories literally, as NSR agrees, @ could be like either $W1$ or $W2$, and, if anything, it is a contingent matter what it is like. The advocate of NSR simply lacks the resources to make all these distinctions and, in particular, to discriminate between all these worlds. It follows that NSR cannot reasonably assert that @ is like $W2$; nor can it reasonably assert that theories are n-adequate and false as opposed to n-adequate and true (in the sense that there are no

5. Though he does not endorse nominalism, Gideon Rosen (2001, 75) has characterized n-adequacy thus: A (mathematized) theory “S is nominalistically adequate iff the concrete core of the actual world is an exact intrinsic duplicate of the concrete core of some world at which S is true—that is, just in case things are in all concrete respects *as if* S were true.” A concrete core of a possible world W is “the largest wholly concrete part of W: the aggregate of all of the concrete objects that exist in W.”

mathematical entities). Unless there is an argument to the effect that, necessarily, mathematical entities do not exist, the advocate of NSR can at best be an agnostic about their existence. Note that an appeal to Ockham's razor in this context would be question begging. Given that n-adequacy underdetermines truth and that n-adequacy is all we have, the issue at stake is precisely to offer reasons to apply Ockham's razor to mathematical entities as opposed to remaining agnostic about the reality.

Here is another problem. Take $T1$ ($= N + M$) and $T2$ ($= N + M'$) such that they are n-equivalent. Since, according to NSR, there are not mathematical entities, $T1$ and $T2$ are both false. But there are two ways in which a theory can be false: one is when there are no mathematical entities and the other is when it asserts something false about a putative mathematical entity. So, for a nominalist, to say that '3 is composite' is false on both counts, but to say that '3 is prime' is false only on the first count. Envisage a situation in which $T1$ and $T2$ are such that a claim of the sort '3 is composite' is part of $T2$ and a claim of the sort '3 is prime' is part of $T1$.[6] There is something deeply wrong with $T2$, but an advocate of NSR should tolerate it because it has no bearing on the nominalistic adequacy of $T2$ and its presumed n-equivalence with $T1$. A standard riposte by nominalists (when a similar story is told about pure mathematics) is that '3 is prime' is true-in-the-story-of-mathematics, while '3 is composite' is false-in-the-story-of-mathematics. This kind of answer, whatever its merits in the case of pure mathematics, has no relevance to the present situation. If what really matters is nominalistic adequacy and both theories are n-adequate, it is irrelevant that one of them has some part that is true-in-the-story-of-mathematics while the other does not, since, on the NSR view, truth-in-the-story-of-mathematics has no bearing on truth-in-the-story-of-physics, that is, on n-adequacy. What follows from this is that there is a sense in which NSR cannot respect even the role of mathematics in science that NSR finds unobjectionable. Mathematics, of the standard variety, is not even theoretically and descriptively indispensable, since NSR cannot discriminate between false mathematical theories and those that are standardly used by mathematicians and physicists.

Here is yet another problem. Take $T1$ ($= N + M$) and $T2$ ($= N + M'$) such that they are n-equivalent. For NSR, that is all that can be said of them. Any choice between them has no further epistemic relevance. But suppose that $T1$ ($= N + M$) is simpler or more unified than $T2$ ($= N + M'$). Suppose, that is, that the mathematical formulation M of $T1$

6. This example is, of course, merely illustrative of the general point. Other more serious examples can be easily found.

endows $T1$ with a number of theoretical virtues over the mathematical formulation M' of $T2$. For a scientific realist, theoretical virtues are truth conducive. Hence, a scientific realist would have reasons to prefer $T1$ over $T2$ and to claim that $T1$ is more likely to be true than $T2$. But since $T1$ ($= N + M$) and $T2$ ($= N + M'$) are n-equivalent, the respects, for a realist, in which $T1$ is more likely to be true than $T2$ should have to do with the *m*-content of $T1$, for example, its abstract structural claims. Note that the kind of situation just envisaged cannot be circumvented by taking M and M' to be merely descriptive and representational devices. Any serious advocate of NSR would have to reformulate $T1$ ($= N + M$) and $T2$ ($= N + M'$) in such a way that they are mathematics-free and then to show that the reformulated $T1$ is simpler and more unified than the reformulated $T2$. There is no general reason to expect this to be the case. It will depend on the further axioms that are chosen and employed.

A fully fledged scientific theory is a theory proper. The claim that a theory T is n-adequate does not amount to presenting another theory. But let us accept, for the sake of the argument, that T_{na} is a theory: the nominalist reduct of T. Take two theories $T1$ and $T2$ and conjoin them. Then $T1$ & $T2$ will have extra nonnominalistic consequences and, in all probability, extra nominalistic ones. Put together, instead, T_{na1} and T_{na2}. Is there a guarantee that T_{na1} & T_{na2} has all and only nominalistic consequences of $T1$ & $T2$? The only way to secure this is via the conservativeness of mathematics. If mathematics is indeed conservative, then all and only the n-consequences that follow from ($T1$ & $T2$) + M will follow from T_{na1} & T_{na2}. There is nothing wrong with conservativeness per se. But the pertinent point is that any possible benefits from going for n-adequacy of scientific theories instead of their truth require the conservativeness of mathematics; the move to n-adequacy does not add much to whatever benefits already follow from conservativeness.[7] Leng (2005, 76–77) has stressed that commitment to n-adequacy provided an easier route to nominalism than Field's reliance on nominalization-plus-the-conservativeness-of-mathematics. If I am right, Leng's claim is wrong.

One further reason to challenge the very notion of n-adequacy is that

7. James Hawthorne (1996) has proved that if scientific theories are properly fleshed out, no excess nonmathematical content will be generated when they are conjoined with other such theories. But his proof holds under very special conditions, which require that there are representation theorems between a mathematical theory $T1$ and a nonmathematical theory $T2$ such that (*a*) every sentence of $T2$ is a nonmathematical consequence of $T1$ and (*b*) adding set theory to $T2$ yields all and only the consequences of the mathematical version of $T1$. As Hawthorne notes, this kind of proof cannot be general and does not follow from the conservativeness of set theory. That these representation theorems hold has to be proved individually for each and every pair of theories. Obviously, this kind of strategy cannot be helpful to NSR.

theories do not confront the phenomena (i.e., physical occurrences) directly. Rather, they confront models of the data, which are mathematical structures (or, more generally, NMAOs). The path of a planet, being an ellipse, is already a model of the data (and, hence, an abstract object). The actual physical path is too messy to be of any use in the physical theory. Newton's theory accounts for the model of the data, that is, the elliptic orbit (at least in the first instance). More generally, what really happens when a theory is applied to the world is that the theory is first applied to a model of the data or to a heavily idealized (and mathematized) abstract physical object, and then it is claimed that this abstract model captures some physical structure. As French (1999) has forcefully argued, intertheoretic relations as well as relations between the theory and the world are ultimately relations among mathematical structures.

Actually, this is not very surprising. Even if not all representation in science is based on isomorphism (or some other kind of morphism), a lot is so based, and the very idea of structural similarity requires comparison of structures. But then, what are really compared when the n-adequacy of a theory is judged are two models, namely, two mathematical structures: the theoretical model and the model of the data. It is a further and separate claim that the model of the data (or the theoretical model for that matter) adequately represents concrete (causal) physical systems (or patterns). For the theory to be n-adequate, it is the latter claim that has to be true. But this simply pushes the problem one step back. For now, the question is whether the model of the data itself (let us fix our attention on this to make things easier) is n-adequate vis-à-vis the phenomena, and answering this question presupposes either a direct confrontation of the model with the (unstructured) phenomena or the comparison of the model with another—one that (presumably) captures the causal structure of the phenomena. The first option does not seem to make much sense. The second option requires that the phenomena (or the world) have a built-in causal structure.

The key point here is not that this last assumption can be questioned.[8] Rather it is that the friends of NSR should come up with a conception of *the* causal *structure* of the world that is nominalist-friendly—by no means an easy feat.

5. Concluding Thoughts. NSR faces a number of problems in its attempt to motivate the weaker-than-full-truth notion of nominalistic adequacy. Even if we were to grant a clear and tolerably explained notion of n-adequacy, it would not follow that it would offer a better explanation of the success of science than the full truth of scientific theories. Discarding

8. For more on this, see Psillos (2006) and van Fraassen (2006).

the abstract content of scientific theories (including the mathematical one) from being part of the best explanation of the success of theories is question begging: it requires identifying explanation with causal explanation. The abstract content of theories plays a key role in ensuring the generality of the explanations offered and the unification of disparate phenomena in theoretical models. All this means that there is need for a more nuanced account of the no-miracles argument (and of inference to the best explanation), where causal considerations are just one set out of many explanatory considerations. In my past writings (e.g., Psillos 1999, chap. 4) I too placed emphasis on causal explanation. This was wrong, especially insofar as it was read as being exclusive of noncausal explanations. But clearly, not all explanation is causal (e.g., the explanation of low-level laws by reference to high-level ones). And explanation can also be of more abstract features of a system.[9] Hence, even if causal explanation is important, there is a more general level where the whole of the theory, with its abstract panoply, is seen as offering the best explanation.

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9. Pincock (2007) has rightly stressed that mathematical objects can feature essentially in abstract or structural patterns of explanations in science, which proceed on the basis of descriptions of a physical system at a higher level of generality than its concrete physical constitution, by ignoring the microphysical properties of the system under study.

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