On dispensability and indispensability

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ABSTRACT

Many philosophers present dispensability or indispensability arguments that presuppose a specific conception of dispensability. The present paper explores and critiques the reigning conception of dispensability. In particular, I argue that it entails that too many things are dispensable to our best scientific theories. This entailment is at odds with the purpose for which we seek a conception of dispensability. In light of my arguments, I present a positive proposal that radically shifts our understanding of how dispensability and indispensability arguments work. This new proposal demands a metaphysics of science that splits the difference between pure empiricism and pure rationalism.

1 INTRODUCTION

Most philosophers of science and metaphysicians agree that electrons are indispensable and that absolute rest is dispensable to our best scientific theories. What's more, they admit that these beliefs have metaphysical consequences: we should ontologically commit to electrons and reject the structure of absolute rest. But these are easy cases. What of difficult ones? Of numbers? Composite objects? Causation?

Indispensability and dispensability arguments infer from the formulation of our best scientific theories to some claim that we ought or ought not commit to some entity or structure. It is not immediately clear, though, what parts of theories are dispensable. For these arguments to do any

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work, we must have a clear conception of what it takes for an entity to be dispensable. The historical and contemporary literature has coalesced around a definition, best articulated by Colyvan (2001, 71):

Colyvan's definition. An entity (or structure) X is *dispensable* to a theory T if and only if there exists a theory T^- in which:

(i) T^- doesn't appeal to Xs,

(ii) T^- is empirically equivalent to T, and

(iii) T^- is suitably attractive.

Condition i says that a dispensing theory must no longer appeal to some relevant entity or structure. (Plausibly, replacing appeal to electrons with schmelectrons, which have all the same properties as electrons, is not a way of avoiding appeal to electrons.[1]) Condition ii says that a dispensing theory must be empirically equivalent to the original. By empirically equivalent, we mean that the theory makes the same predictions and is confirmed by the same observations. Condition iii says that a dispensing theory must be suitably attractive. It is important that we do not, for example, move to a theory that is so unattractive that it's not a legitimate candidate for belief.

There is a desideratum on any definition of dispensability: it ought to get the right result in easy cases. The purpose of this definition is to help provide a reasonable metaphysics of science. If the definition does not fulfil its purpose, it fails. I argue that Colyvan's definition fails this desideratum. My hinge case is causation. Colyvan's definition entails that causation is trivially dispensable to our best scientific theories. And causation is not *trivially* dispensable if it is dispensable at all.

I will then parlay my criticisms of Colyvan's definition into a positive proposal. Colyvan's definition presumes that a dispensing theory must always preserve only empirical content. But sometimes, as I argue, we demand that a dispensing theory preserve more than empirical content. If I am right, this reveals an unconsidered first step in any dispensability or indispensability argument. We must *first* identify what content must be preserved, and only then can we ask whether some entity or structure

[1] Also plausibly, a theory can appeal to some entity or structure just by presupposing, rather than stating, its existence.

is dispensable or not. Indispensability arguments, to borrow a phrase, do not tell us what exists, they tell us what *else* exists.[2] They aim to tell us what we must accept beyond that which we already do.

2 PRELIMINARIES

We began with two inferences. First, that the indispensability of electrons to our best scientific theories entails that we ought to ontologically commit to them.[3] Second, that the dispensability of absolute rest to our best scientific theories entails that we ought to reject the structure of absolute rest.[4] These inferences are respectively justified by appeal to the following principles:

Indispensability. If some entity or structure is indispensable to any of our best scientific theories, then we ought to metaphysically commit to that entity or structure.

Dispensability. If some entity or structure is dispensable to all of our best scientific theories, then we ought not metaphysically commit to that entity or structure.

These principles serve as a thruway between the formulations of our best scientific theories and some consequence for our metaphysical picture of the world.

A straightforward argument for the indispensability principle appeals to inference to the best explanation (IBE).[5] Suppose you see stains in the wallpaper and warped floorboards, and the best explanation for this is that the pipe behind the wall burst. According to a standard form of IBE, in accepting the burst pipe as the best explanation, we commit to the entities and structure that are required in order to put forward that

[2]The phrase is Baker's, which I don't fully endorse: "It is not that science tells us what exists; science tells us what *else* exists" (Baker, 2007, 18).

[3]See, e.g., Melia (2000, 474 - 475), Field (2016, 43), Colyvan (2001, Ch. 4.3), and Dorr (2010, §4).

[4]See Norton (2008) and Friedman (1983, p.112).

[5]This is not the only argument for the principle. Another historically famous argument stems from scientific realism. See Putnam (1971), Colyvan (2001), and Field (2016, 1989).

explanation (viz., the burst pipe and its causal relationship to the empirical phenomena) (Field, 1989, 15). *Mutatis mutandis* for our best scientific theories: if a scientific theory is the best explanation for some phenomena, then upon accepting as much, we are committing to the entities and structure that are required in order to state the theory. A definition of dispensability is meant to pick out exactly those entities and structure that are required in order to state the theory.

The most common justification for the dispensability principle relies on naturalism.[6] If one believes that the only reliable guide to metaphysics is science, then if some entity or structure is dispensable to our best scientific theories, we should abandon commitment to that entity or structure. But some reject this variety of naturalism. If so, they might endorse a principle that weakens the consequent of the dispensability principle, e.g., that an entity or structure's dispensability provides some defeasible reason to not commit to it.

We cannot even interpret the dispensability and indispensability principles unless we understand what it means for an entity to be dispensable. We must have a definition of dispensability in order to make these principles precise. Colyvan's definition is orthodoxy within philosophy of science.[7]

Colyvan's conditions are relatively straightforward, though I wish to note something about condition *ii*, my target in the current essay. When one offers a dispensing theory, one is showing that we can retain all of the relevant content of the original without some entity or structure. We shall

[6]See Colyvan (2001, Ch. 2.2).

[7]Here are three representative samples. In the 1950s and 60s, philosophers were concerned with the ontological status of *all* theoretical entities. These philosophers often cited the fact that we can construct relatively attractive, empirically equivalent, theoretical-entity free theories. See Craig (1953, 1956), Carnap (1956), Goodman (1957), Scheffler (1957), Hempel (1958), Nagel (1961), Nagel (1965), Maxwell (1962), Putnam (1965), and Hooker (1968a,b). Second, the indispensability argument for the existence of numbers claims that numbers (or some other mathematical objects like sets) are necessary parts of our best scientific theories. Field (2016) is the locus classicus of attempting to provide empirically equivalent, attractive, number-free alternatives to scientific theories. Third, some are concerned with the *dis*pensability argument in object metaphysics that claims composite objects are dispensable to our best scientific theories (Dorr, 2002; Brenner, 2018; LeBrun, 2021). There, philosophers presuppose that what it takes to show composites to be dispensable is that we provide alternative theories (or a schema for constructing alternatives) that do not appeal to composites, are suitably attractive, and are empirically equivalent to our ordinary theories.

call this content that must be preserved the *privileged content* of the theory. To dispense with some entity or structure X, we provide a suitably attractive theory that preserves the privileged content of the original theory and doesn't appeal to Xs. According to Colyvan's definition, the privileged content of a theory is the theory's *empirical* content, captured in condition ii. Part of the appeal of Colyvan's definition is that it is maximally empirically conservative: if we accept it and the indispensability principle, then we are only required to commit to the empirical phenomena and exactly as much structure and as many entities as are needed to explain the empirical phenomena. In this way, Colyvan's definition presupposes that a theory's privileged content is exactly its empirical content.

As we saw above, the desideratum on a definition of dispensability is that it gets the right result in easy cases. More precisely, a definition of dispensability ought to be materially adequate when conjoined with the dispensability principles: it should entail the dispensability of entities or structure we obviously ought to reject and it should not entail the dispensability of entities or structure we obviously ought not reject.

3 AGAINST COLYVAN'S DEFINITION

My objection to Colyvan's definition is that empirical equivalence isn't exactly the relation that a successful dispensing theory bears to the original theory, and that this contributes to his definition failing the desideratum.

Here I provide two examples. The first motivates the thought that ii doesn't do enough to guarantee that a dispensing theory preserves the privileged content of the original theory. I don't take this first one to be a counterexample to Colyvan's definition. There are responses that he can give to it, but my alternative diagnosis is more plausible. The second example is a more traditional counterexample. Colyvan's definition entails that some entities which aren't obviously dispensable are trivially dispensable.

3.1 Geometry

We consider the history of axiomatizations of geometry. The traditional way of formulating geometry is analytic geometry, which appeals to points and lines on a coordinate system together with unit of distance. Analytic geometry appeals to a primitive distance function which maps pairs of

points to real numbers: the distance between a and b is n. Because this geometric system uses a coordinate system with a unit of distance, it requires the apparatus of the real numbers.

Synthetic geometry, axiomatized by Hilbert (1930) and Tarski (1959) attempts to do away with a coordinate system and a distance predicate, and thus numbers. (Don't accord philosophical weight to the names 'analytic' and 'synthetic'.) Synthetic geometry will not entail that the distance between any two points is equal to some real number n. In fact, a distance predicate (as a polyadic relation between a pair of points and a real number) is incomprehensible in synthetic geometry. Instead, it gets by with relative notions like congruence—*the distance between two points a and b is the same as the distance between b and c*. Accordingly, synthetic geometry does not require numbers, a coordinate system, or a metric.

All the same, it is well-known that these two formulations of geometry capture all of the same relevant theorems and axioms. Synthetic geometry can accommodate all of the theorems of analytic geometry without the use of numbers. Thus, it seems that synthetic geometry explains everything that analytic geometry does, but without the use of numbers. If so, then numbers *dispensable* to theories of geometry. And this consequence has generally been the lesson from the move to synthetic geometry.[8]

Consider whether synthetic geometry meets conditions i - iii. Regarding i, it seems clear that synthetic geometry does not appeal to numbers. Likewise, regarding iii, synthetic geometry is at least as attractive as analytic geometry. Now consider ii, the demand that a dispensing theory be empirically equivalent to the original theory. It almost seems like a category mistake to ask whether synthetic and analytic geometry are empirically equivalent. Neither theory has empirical consequences. So, *prima facie*, it seems unanswerable whether condition ii is met, even though it seems that synthetic geometry dispenses with numbers.

Certainly, Colyvan's defender has replies. They may say that there is a sense in which the two theories have empirical consequences—in particular, when we assume them to be theories of space. Analytic and synthetic geometry *as theories of space* are empirically equivalent. If so, we can count synthetic geometry as a case of dispensing with numbers. The problem with this reply is that it seems that synthetic geometry *as a theory of geometry* also dispenses with numbers. Or they may say that trivially these

[8]See Burgess (1984), Burgess and Rosen (1997, IIA), and Field (2016).

geometric formulations are empirically equivalent. They have the same empirical consequences: none at all. The problem with this reply is that it would entail that $\forall x(x = x)$ dispenses with numbers as well. It has the same empirical consequences as both analytic and synthetic geometry, but does not appeal to numbers (or points or lines, for that matter). Or they may deny the relevant dispensability principle which says that dispensability is relevant for pure mathematical theories. Instead, they insist that dispensability only matters for physical theories. Strictly speaking, this response neutralizes the counterexample, as the example would no longer entail anything about what we ought to commit to. However, I am not especially moved by this response. The example is meant to bring out something important about *dispensability* as it applies to all theories. Denying a variety of the dispensability principle seems to change the subject.

So, this example puts *some* pressure on Colyvan's definition, but there are ways to defend it. My primary aim here is to motivate the following framing of this example. We agreed that some core claims of analytic geometry must be preserved in any adequate axiomatization of geometry. This is the privileged content of analytic geometry. The privileged content includes Playfair's axiom, that there is at most one line that can be drawn parallel to another given one through an external point. But the privileged content does not include a measurement, which assigns a numerical value to each line segment. Synthetic geometry shows that we can preserve the privileged content of analytic geometry without appealing to numbers. More generally, we might offer the following two-step procedure of dispensing: identify the privileged content of a theory, and then any successful dispensing theory will be one that preserves that content while doing away with the dispensable part. And while the privileged content usually includes empirical consequences, it might have nothing to do with the empirical realm, as with the dispensing of numbers in geometric axiomatizations.

3.2 Causation

My second example targets Colyvan's definition at its core. His definition entails that some not obviously dispensable parts of our theories are trivially dispensable. It thus fails to satisfy the desideratum. The basic idea, in line with the lesson from geometry, is that Colyvan's definition wrongly identifies a theory's privileged content.

Suppose a ball is thrown at a window and the window shattered. Our best science explains that the throwing of the ball caused the window to shatter. Many of our best scientific theories include such causal explanations. For simplicity, let's assume that if one accepts a theory that contains a causal explanation, they are committing to the *structure* of causation (rather than, e.g., the existence of causal forces). And let's assume that the relata of causal relations are events.

Let T^1 be the theory that contains just the above causal explanation that the throwing of the ball caused the window to shatter. Some trivial consequences follow from T^1, like that the throwing of the ball occurred, and that the shattering of the window occurred, and they occurred in sequential order. Some non-trivial consequences also follow from T^1. First, that the two events are not merely sequentially ordered. There is a difference between mere temporal sequencing and causation, and T^1 entails that the throwing of the ball and shattering of the window are not mere temporal sequences. Second, that events which are causally related are nomologically entangled. There's a sense in which if the first event occurred, the second *had* to occur. It was no accident that the window shattered following the throwing of the ball.

I will now show that Colvyan's definition entails that causation is trivially dispensable to T^1. It is a live question in the literature whether causation is dispensable to our best scientific theories, and philosophers carefully examine such theories to see what indispensable role causation might play.[9] But Colyvan's definition *trivially* entails the dispensability of causation in our theories.

Here's how. We construct an alternative theory, T^{1-}, which is comprised of only the trivial consequences identified above. It will entail that the throwing of the ball occurred, that the shattering of the window occurred, and that these two events occurred in sequential order. Crucially, it will not entail that there is a difference between causation and mere sequential ordering, and it will not entail that the two events occurred with nomological necessity. T^{1-} will be comprised of exactly those consequences of T^1 that are non-causal.

At first glance at least, T^{1-} meets Colyvan's conditions for dispensing with causation. First, it does not appeal to causation, satisfying i. We have genuinely eliminated the structure of causation in T^{1-}. Second, it is em-

[9] Cf. Woodward (2015) and Weaver (2019).

pirically equivalent to T^1, satisfying *ii*. Every empirical consequence entailed by the original theory will be entailed by T^{1-}. In both theories, the observations and predictions are identical: *if* the ball is thrown at the window, then the window shatters; and these events will occur sequentially. There's good reason for their empirical equivalence. A necessary condition on causation is sequential ordering of events. And the only empirical consequences of causal explanations are the sequential ordering and occurrence of the events. So, as long as a theory entails the same sequential ordering and occurrence consequences as some theory with causal explanations (and there are no other differences between the two), the two are empirically equivalent. Accordingly, T^{1-} satisfies Colyvan's condition *ii*. And this simple causation dispensing theory is not egregiously unattractive in terms of unification, fruitfulness, etc. (We will examine this in detail shortly.) It preliminarily satisfies *iii*.

This simple dispensing procedure is generalizable. Every scientific theory that appeals to causation has a variant that is empirically equivalent, does not appeal to causation, and is sufficiently attractive. So, Colyvan's definition of dispensability permits the trivial dispensing of causation, and the dispensability principle entails that we ought not commit to the structure of causation. Something has gone wrong. It seems like, regardless of whether causation is actually dispensable to our best scientific theories, we cannot show this via the simple dispensing method. Thus, we should reject Colyvan's definition because it fails this desideratum.

3.3 Colyvan's Reply

There's a conspicuous response on behalf of Colyvan: the simple causation dispensing theory just isn't attractive and so T^{1-} does not dispense. There are two versions of this objection, and we shall treat each separately.

The first version of the attractiveness objection goes like this: A condition on a successful dispensing theory is that it is not objectionably unattractive, and T^{1-} is objectionably unattractive, so it does not dispense with causation. For this objection to have any force, we must identify features of T^{1-} that explain why it is unattractive. It cannot be that T^{1-} fails to make the appropriate predictions or observations, since we crafted the theory to have exactly the same empirical content. So we cannot complain that the simple causation dispensing theory fails on any grounds that impinge on the empirical. Nor is T^{1-} inconsistent or incoherent. T^{1-} also

does not fail on aesthetic virtues like simplicity, beauty, or unification; it is more simple than T^1 and explains more phenomena using fewer theoretical posits.

The only thing that Colyvan could identify to justify the claim that T^{1-} is objectionably unattractive is that it fails to preserve the non-trivial consequences of T^1. T^{1-} doesn't distinguish between cases of mere temporal sequencing and cases of causation. The theory doesn't even have the linguistic resources to distinguish them. Moreover, T^{1-} doesn't tell us how, when there is a causal relation between two events, we think that their occurrences hold with nomological necessity. *This* is the sense in which T^{1-} is objectionably unattractive.

Colyvan (or one sympathetic to Colyvan's definition), however, is not privy to this objection. It is inconsistent with a core tenet of his view. Recall that part of Colyvan's view is that the privileged content of a theory is the *empirical content* of that theory. Colyvan's definition is suited toward an empirically-minded philosopher who wishes to be maximally conservative over the empirical. Condition ii of his definition was meant to guarantee that the dispensing theory captured the privileged content, which is exactly only its empirical consequences. Colyvan cannot then object to T^{1-} on the grounds that it does not preserve T^1's privileged content, since by his own standard it does. T^{1-} is empirically equivalent to T^1, and Colyvan's definition presupposes that the privileged content is preserved if two theories are empirically equivalent.[10] Accordingly, Colyvan would impugn his own view if he said that T^{1-} did not capture the privileged content of the original theory.

I endorse the claim that T^{1-} does not preserve the privileged content of T^1, and for this reason it does not dispense with causation. But Colyvan cannot give this response to the simple causation dispensing theory.

The second version of the attractiveness objection goes like this. Colyvan can concede that T^{1-} is suitably attractive, but instead strengthen condition iii. It is not the case that a dispensing theory must be suitably attractive; rather, it must be at least as attractive as the original theory. The idea behind this objection is intuitive. We ought to accept the best theory available. T^1 is a *more attractive* theory than T^{1-}, so even if we can "get by"

[10]Strictly speaking, Colyvan's definition does not—as written—*say* that the privileged content is the empirical content, as it is simply a definition. Rather, the spirit of, and the motivation for, the definition presuppose that the priveleged content is the empirical content.

without causation, this isn't enough to show that causation is dispensable. Of course, this is a concession to my argument, but it is not ad hoc.

The response is to replace condition *iii* with the following:

iii+ T^- is at least as attractive as T.

This would likely respond to the counterexample. It is plausible that T^{1-} is slightly less attractive than T^1, and if our definition of dispensability had condition *iii*+, T^{1-} would not dispense with causation.

There are, however, independent reasons to reject *iii*+ as a condition on dispensing. My argument here takes us into considerations about dispensability in general. In particular, if our definition of dispensability requires that a dispensing theory be no less attractive than the original theory, then (in)dispensability arguments collapse into arguments only about theory choice. And I will argue this is a bad result.

Suppose that (in)dispensability arguments collapse into arguments about theory choice. By this I mean that once we determine which theory is the best among a slate of alternatives, all entailments of dispensability and indispensability are settled: the entities that are appealed to in the best theory are indispensable (to that theory), the entities not appealed to in the best theory are dispensable (to that theory). There is nothing more to be said about the (in)dispensable parts of that theory. If so, then (in)dispensability considerations are redundant. Once we determine which theory is the best, no new metaphysical entailments can be gained by asking which parts of the theory are dispensable or indispensable.

However, dispensability and indispensability considerations are *not* redundant. We can accept that some theory is our best—that there are no alternatives that are more attractive according to the theoretical virtues like simplicity, fruitfulness, etc.—and still have questions about whether all the entities and structure that are appealed to within that theory are *required* in order to formulate the theory. The idea here is that the virtues which determine the best theory may not perfectly match the reasons for metaphysical commitment. If some theory is less cognitively cumbersome to humans, or is more beautiful, or is more likely to generate novel predictions, which are all theoretical virtues, this doesn't entail that the metaphysics of that theory is more correct than the alternatives. This isn't to say that theoretical virtues play no part in determining the correct metaphysics of science, just that they are not perfect determiners.

There are examples in the history of science where, plausibly, some theory is deemed our best, but we are hesitant to endorse some entity as indispensable. At the turn of the 20th century, chemists debated the existence of atoms despite their appearance in our best theories. The theories atoms appeared in were incredibly well confirmed, fruitful, unifying, and had all the relevant theoretical virtues we take to be indicative of true scientific theories; they were among our best. Yet many chemists were reluctant to commit to the existence of atoms until Perrin's 1913 experiment showing that atoms were responsible for Brownian movement, at which point the consensus around atoms shifted. It seems plausible that scientists justifiably accepted that the theories in which atoms appeared were the best explanations of the relevant phenomena, but they believed we didn't have enough to show that atoms were *indispensable*.[11] If this story is correct, then (in)dispensability considerations are not redundant. We should not demand that a dispensing theory is at least as attractive as the original theory, only that it should be attractive enough. As a result, this second version of the attractiveness response should be rejected.

My resulting picture of dispensability looks like this. Determining whether some entity is dispensable or indispensable is not tantamount to looking only to the *most attractive theory* and seeing which entities are appealed to within that theory. Rather, we use the theoretical virtues to identify a collection of candidate best theories in some domain. These theories will all be share the privileged content, and otherwise will differ similarly to how T^{1-} and T^1 do—in the theoretical structure and entities involved. These theories must be suitably attractive, meeting some threshhold for candidates for belief.[12] And we need not assume that the theoretical virtues will single out a unique *best* theory. Once we have identified this collection of theories, we can determine the dispensable and indispensable parts. The indispensable parts are the entities and structure that are shared among all candidate best theories. Some entity or structure is *dispensable* if there is at least one candidate theory that does not appeal to that entity or structure.

[11] Cf. Maddy (1997), Castro (2013), Brown (2015), and Boyce (2018).

[12] Craigean theories, e.g., will plausibly not meet this threshhold.

4 SOME LESSONS

We ought to reject Colyvan's definition. *ii* is the wrong condition for guaranteeing that a dispensing theory preserves all a theory's priveleged content. Sometimes, a dispensing theory must preserve more than just the original's empirical consequences, e.g., a candidate dispensing theory for causation must preserve the nomological necessity between events linked by causation (or we must explain why we don't need to preserve this). Our rejection of Colyvan's definition has profound impacts on the way we understand dispensability and indispensability arguments.

The first impact is, in a sense, dialectical. The traditional picture of dispensability or indispensability is this:

> We aim to determine the metaphysical import of our scientific theories. A successful indispensability argument will show that some entity or structure's existence is "given by", or follows from, our best scientific theories. A successful dispensability argument will show that some entity or structure's existence is not given by, does not follows from, our best scientific theories. In this way, sound dispensability and indispensability arguments tell us what *science says exists*.

If my arguments against Colyvan's definition are sound, though, this traditional picture is undermined. For recall: T^{1-} fails to dispense because it does not preserve all of T^1's privileged content. There are, then, two steps to any dispensability or indispensability argument. The first step, absent in the traditional picture and smuggled into Colyvan's condition *ii*, is to determine a theory's privileged content. The privileged content of theories of space and time might be different than the privileged content of a theory with causal explanations. For the case of T^1, the privileged content included the non-trivial consequences about causation. Before we can even adjudicate whether some dispensability or indispensability argument succeeds, we must have a univocal answer on the theory's privileged content. The second step is to determine what else we must commit to. We are committed to whatever is required to explain a theory's privileged content.

It is understandable why the traditional picture included condition *ii*. Colyvan, and many others who were concerned with dispensability, is an

empiricist who traces his roots to Quine. Naturally for him, we are only committed to whatever else is required to explain the empirical phenomena. But for those of us who do not share these proclivities, we must first have an answer to the question of what the privileged content of a given theory is.

The second impact of our rejection of Colyvan's definition is that it clarifies the three ways one may respond to a given dispensability or indispensability argument. The first way is to reject that the argument succeeds in establishing that some entity or structure is dispensable or indispensable, in the sense that the conditions for dispensing haven't been met. The second way is to reject the relevant dispensability or indispensability principle. If one is not an austere naturalist, they may reject some dispensability argument on the grounds that they don't accept the relevant dispensability principle. The third way to reject a dispensability or indispensability argument is illustrated by my arguments here. We may reject a putative dispensability or indispensability argument on the grounds that the argument presupposes the wrong privileged content for dispensing. We might, e.g., agree that causation is dispensable to capturing some theory's empirical consequences, while simultaneously claiming that a successful dispensing theory must preserve more than just the empirical consequences. This response constitutes a rejection of the dispensability argument.

Some big picture worries remain. Whatever problems Colyvan's picture had, at least it provided a complete picture of dispensability. It provides an algorithm for determining what the significant content of a theory is. Everyone agrees that the empirical content is significant and metaphysically committing. But what else beyond that? Colyvan's picture says that the other significant content is whatever is needed to explain the empirical stuff. But I am proposing a rejection of Colyvan's view in favor of one which says that, sometimes, in some theories, the significant content is the empirical stuff, *plus* some other "privileged" content, and additionally whatever is needed to explain all of that. How do we know what this privileged content is? How do we know, e.g., that a theory of causation must preserve some extra-empirical content?

These are deep and difficult questions about the project of the metaphysics of science. The tools that we have at our disposal for determining a theory's significant content seem to be, on the one hand, Colyvan's empiricism, and on the other, *a priori* metaphysics. Metaphysics of science

must forge a middle ground, providing rational reconstruction of scientific theories that is neither pure empiricism nor pure *a priori* metaphysics. What I have done here is provide an argument for this middle ground.

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