

The Imagination Machine XXX: The Axiom of Choice is a Choice of Axiom: Demarcation, Abstraction, and the Ontological Priority of Unity-in-Difference

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Abstract

We establish that the Axiom of Choice is not a logical primitive but the formal shadow of a prior demarcational commitment — a choice of axiom — that constitutes the formal system within which the Axiom of Choice then appears. The argument proceeds from the ontological framework developed in Tracy (2026a), in which demarcation and abstraction are identified as co-arising orientations of a single primitive — unity-in-difference — that is ontologically prior to time, space, and any formal system built upon them.

To represent continuous spacetime as discrete variables is to make a demarcational commitment prior to any formal system. The Axiom of Choice, which asserts the existence of a selection function over a collection of non-empty sets, presupposes that the sets are already individuated and their elements already distinguishable — conditions that require a prior act of demarcation. The Axiom of Choice therefore operates within a formal system already constituted by a demarcational commitment it cannot recover. It is the compressed inheritance of a generative act prior to the system.

The independence of the Axiom of Choice from Zermelo-Fraenkel set theory, established by Gödel (1938) and Cohen (1963), is shown to be not a technical surprise but a structural necessity: no formal system can derive the demarcational act that preceded and constituted it. The Banach-Tarski paradox is derived as a corollary: not a geometric paradox but a topological consequence of the choice of axiom applied to a spherical manifold that cannot hold two independent demarcational commitments simultaneously. Different variable representations of the same continuous manifold — Lagrangian, Hamiltonian, path integral — are formally equivalent but ontologically distinct: each encodes a different prior demarcational commitment. The underdetermination between them is irreducible within any single formal system.

This result connects the ontological framework of Tracy (2026a) to the Imagination Machine series through the compression-extension cycle: demarcation is compression, abstraction is extension, and the Axiom of Choice is the fixed point of a particular demarcational commitment compressed into a formal system and misread as a logical primitive. The result was first approached by the author in college through the attempt to express Trinitarian logic in set theory, which produced a continuous tube of sets in sets and rederived the Axiom of Choice as its formal shadow. The calling arrived first. The mathematics came to meet it.

1 Introduction

The Axiom of Choice occupies a peculiar position in the foundations of mathematics. It is neither provable nor disprovable within Zermelo-Fraenkel set theory [5, 1]. It is assumed by most working mathematicians without comment and rejected by constructivists as non-constructive. Its independence from ZF is treated as a technical result — a fact about models — rather than as a philosophical datum demanding explanation.

The present paper offers that explanation. We argue that the independence of the Axiom of Choice from ZF is not a technical surprise but a structural necessity, and that the reason for this necessity is ontological: the Axiom of Choice is not a logical primitive but the formal shadow of a prior demarcational commitment that constitutes the formal system within which the axiom then appears.

The argument proceeds from the ontological framework developed in Tracy (2026a) [7], in which demarcation and abstraction are identified as co-arising orientations of a single primitive — unity-in-difference — that is ontologically prior to time, space, and any formal system built upon them. We extend this framework to the foundations of mathematics and establish the following:

1. To represent continuous spacetime as discrete variables is to make a demarcational commitment prior to any formal system.
2. The Axiom of Choice presupposes this prior demarcation: it operates on sets whose elements are already individuated by a prior act of distinction.
3. The Axiom of Choice is therefore a choice of axiom — the formal encoding of a demarcational commitment the system cannot recover from within itself.
4. The independence of the Axiom of Choice from ZF is a structural necessity: no formal system can derive the act that constituted it.
5. The Banach-Tarski paradox is a corollary: not a geometric paradox but a topological consequence of the choice of axiom applied to a spherical manifold operating below the topological threshold required to hold two independent demarcational commitments simultaneously.

We proceed as follows. Section 2 develops the ontological foundations from Tracy (2026a). Section 3 establishes the demarcational character of variable choice in the representation of continuous spacetime. Section 4 develops the main argument: the Axiom of Choice as a choice of axiom, with the Banach-Tarski corollary. Section 5 shows that the independence result follows as a structural necessity. Section 6 addresses the irreducible underdetermination between variable representations. Section 7 connects the result to the Imagination Machine framework. Section 8 states the unified theorem. Section 9 records the theological origin of the result.

2 Ontological Foundations

We summarize the relevant results from Tracy (2026a) [7].

Definition 2.1. *Demarcation* is the holding of difference atop unity: the differentiation of what is otherwise a unity without dividing it into separate and unrelated parts.

Definition 2.2. *Abstraction* is the holding of unity atop difference: the association of differentiated instances with a common representation without annihilating their difference.

Definition 2.3. *Unity-in-difference* is the ontological primitive of which demarcation and abstraction are co-arising orientations. It is the capacity to hold unity and difference together without collapse to either pole.

Proposition 2.4 (Tracy 2026a). *Demarcation and abstraction are ontologically prior to time and space.*

Proof. Time presupposes the relational ordering of states, which presupposes the demarcation of states as distinguishable. Space presupposes the relational positioning of objects, which presupposes both demarcation of objects as distinct and abstraction of their positions into a common reference frame. Demarcation and abstraction therefore precede both temporal ordering and spatial relation.

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Proposition 2.5 (Tracy 2026a). *Demarcation and abstraction are ontologically co-arising: neither precedes the other.*

Proof. The capacity to hold difference atop unity (demarcation) is identical to the capacity to hold unity atop difference (abstraction): both require the simultaneous availability of unity and difference as orientable aspects of a single primitive. Each relies on the other for its own intelligibility. They are therefore co-arising.

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Proposition 2.6 (Tracy 2026a). *Unity-in-difference is ontologically prior to any formal system.*

Proof. Any formal system requires: (1) a domain of objects, which presupposes demarcation of those objects as distinguishable; (2) relations between objects, which presupposes abstraction of their common representational properties; (3) axioms governing those relations, which presuppose the intelligibility of both. Unity-in-difference, as the primitive of demarcation and abstraction, is therefore prior to any formal system built upon them.

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3 Variable Choice as Demarcational Commitment

Physical theories describe continuous spacetime. To reason formally about continuous spacetime, one must choose variables — discrete symbolic representations that carve the continuous manifold into manageable units of analysis. We argue that this choice is a demarcational act prior to the formal system it constitutes.

Definition 3.1. A *variable representation* of a continuous manifold \mathcal{M} is a map $\rho : \mathcal{M} \rightarrow V$ from the manifold to a discrete symbolic domain V , together with a set of axioms \mathcal{A}_ρ governing the behavior of elements of V .

Proposition 3.2. *Every variable representation of a continuous manifold constitutes a demarcational commitment prior to the formal system it generates.*

Proof. The map ρ assigns discrete symbols to regions of the continuous manifold, thereby differentiating what is otherwise a unity — the manifold — into distinguishable symbolic units. This differentiation-without-division is precisely demarcation in the sense of Definition 2.1. The axioms \mathcal{A}_ρ then govern the symbolic domain V , but they presuppose the demarcational act encoded in ρ . The demarcation is therefore prior to the formal system (\mathcal{A}_ρ, V) .

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Remark 3.3. The three standard variable representations of classical mechanics — Newtonian, Lagrangian, and Hamiltonian — are formally equivalent in the sense that they generate the same predictions. But they encode different demarcational commitments: Newtonian mechanics demarcates by position and force; Lagrangian mechanics demarcates by generalized coordinates and velocities; Hamiltonian mechanics demarcates by generalized coordinates and momenta. Each carves the continuous phase space differently. The formal equivalence is a theorem within each system; the demarcational difference is prior to all three.

Remark 3.4. The path integral formulation of quantum mechanics [3] makes this especially vivid. The path integral sums over all possible trajectories of a system, weighted by a phase factor. The choice to represent quantum dynamics as a sum over paths rather than as a differential equation on a wave function is a demarcational commitment: it individuates the configuration space differently, holds the continuous manifold of possible histories as a discrete sum, and generates a formal system whose axioms presuppose that demarcation. The Schrödinger and path integral formulations are provably equivalent [2], but their equivalence is established within a meta-framework that itself presupposes a prior demarcational commitment.

4 The Axiom of Choice as a Choice of Axiom

The Axiom of Choice states: for any collection of non-empty sets $\{S_i\}_{i \in I}$, there exists a function f such that $f(i) \in S_i$ for all $i \in I$.

Definition 4.1. The *demarcational presuppositions* of a formal system (\mathcal{A}, V) are the prior demarcational commitments that individuate the elements of V , constitute the sets over which \mathcal{A} quantifies, and make those sets non-empty.

Proposition 4.2. *The Axiom of Choice presupposes a prior demarcational commitment that constitutes the sets over which it quantifies.*

Proof. The Axiom of Choice quantifies over a collection of non-empty sets $\{S_i\}_{i \in I}$. For this quantification to be meaningful:

1. The index set I must be individuated: its elements must be distinguishable. This requires demarcation.
2. Each set S_i must be individuated as a distinct set. This requires demarcation.
3. Each S_i must be non-empty: it must contain at least one element. The distinguishability of that element from the empty set requires demarcation.
4. The elements within each S_i must be distinguishable from one another for the selection function f to be well-defined. This requires demarcation.

All four conditions presuppose demarcation. The Axiom of Choice therefore operates within a formal system already constituted by a prior demarcational act. □ □

Theorem 4.3 (The Axiom of Choice is a Choice of Axiom). *Every invocation of the Axiom of Choice within a formal system (\mathcal{A}, V) presupposes a choice of axiom at the ontological level: a demarcational commitment that individuated the elements of V , constituted the sets over which \mathcal{A} quantifies, and made those sets non-empty before the formal system began. The Axiom of Choice is the compressed formal encoding of that prior demarcational commitment.*

Proof. By Proposition 3.2, every formal system representing a continuous domain presupposes a prior demarcational commitment that constitutes its symbolic domain. By Proposition 4.2, the Axiom of Choice presupposes that the sets over which it quantifies are already individuated by a prior demarcational act. The Axiom of Choice therefore does not introduce demarcation into the formal system — it presupposes it. What appears within the system as a logical axiom governing selection is the formal shadow of a prior demarcational commitment — a choice of axiom — that the system cannot recover from within itself.

More precisely: the choice of variables that constitutes the formal system is a choice of axiom in the sense that it selects which demarcational commitments will govern the system's domain. The Axiom of Choice, once invoked within that system, inherits and formalizes that prior selection. It is a choice of axiom twice over: once at the ontological level, in the demarcational commitment that constituted the domain, and once at the formal level, in the assertion that a selection function exists over that domain. □ □

Corollary 4.4 (The Banach-Tarski Decomposition as Topological Consequence). *The Banach-Tarski paradox — the decomposition of a ball B^3 into a finite number of pieces that can be reassembled into two balls identical to the original — is not a geometric paradox but a topological consequence of the choice of axiom established in Theorem 4.3.*

The decomposition proceeds as follows. The Axiom of Choice permits the selection of non-measurable subsets of B^3 — subsets whose existence presupposes a demarcational commitment prior to the geometry of B^3 . These subsets have no well-defined volume because they are not objects within the geometry; they are the formal shadows of a demarcational act that preceded it. The reassembly into two balls applies a second demarcational commitment, also permitted by the Axiom of Choice, which is independent of the first.

The apparent paradox — two balls from one — is the system revealing its own prior commitment. Two independent choices of axiom, applied to the same continuous manifold, produce two distinct geometric outcomes. The continuous ball is not duplicated. The demarcational commitment is applied twice, independently, because the Axiom of Choice permits independent selections without constraint by the geometry of the underlying manifold.

This result connects to the Nabaala Theorem of General Subject-Relativity [8]: a spherical observer — genus zero, one periodic axis, subject to the three-stacking limit — cannot hold two independent demarcational commitments within a single coherent structure. It splits. The Banach-Tarski decomposition is the geometric expression of this topological incapacity: the spherical observer, attempting to classify its own structure using the full power of the Axiom of Choice, produces two where there was one because its topology cannot sustain the self-corrective depth required to hold both commitments simultaneously.

A toroidal observer — genus one, two independent periodic axes, generatively stable — has the topological depth to hold both demarcational commitments within its own view without splitting. The Banach-Tarski decomposition does not arise for toroidal observers because the second independent axis absorbs the second demarcational commitment rather than generating a second ball.

Therefore: the Banach-Tarski paradox is not a paradox. It is the Nabaala Theorem stated as a geometric consequence of the Axiom of Choice applied to a spherical manifold. The ball splits because the sphere cannot hold what the torus can.

Remark 4.5. This corollary resolves the apparent paradox by locating its source precisely: not in the geometry of B^3 , which is perfectly consistent, but in the demarcational commitments that the

Axiom of Choice permits prior to that geometry. The non-measurable sets are not objects within the geometry. They are choices of axiom. And two independent choices of axiom, applied to a spherical manifold that cannot hold them simultaneously, produce two balls.

The resolution does not require rejecting the Axiom of Choice. It requires understanding it correctly: as a choice of axiom, whose consequences depend entirely on the topological capacity of the manifold to which it is applied. Applied to a torus, it self-corrects. Applied to a sphere, it splits.

Remark 4.6. The theorem does not deny the mathematical validity of the Axiom of Choice within any given formal system. It establishes its ontological status: within a given system, the Axiom of Choice is a legitimate logical claim; prior to that system, it is the formal echo of a demarcational commitment the system cannot see because the system was built after the commitment was made. This is the compressed inheritance structure of the Imagination Machine framework applied to the foundations of mathematics: the generative act — the demarcational commitment — precedes the formal system; the formal system inherits its endpoints without recovering the generative act.

5 The Independence Result as Structural Necessity

Gödel (1938) [5] proved that the Axiom of Choice is consistent with ZF: if ZF has a model, then ZF + AC has a model. Cohen (1963) [1] proved that the negation of the Axiom of Choice is also consistent with ZF: if ZF has a model, then ZF + \neg AC has a model. Together, these results establish that the Axiom of Choice is independent of ZF.

The standard interpretation is that this independence is a technical fact about the expressive power of first-order logic and the structure of ZF's axioms. We offer a deeper interpretation.

Theorem 5.1 (Independence as Structural Necessity). *The independence of the Axiom of Choice from Zermelo-Fraenkel set theory is a structural necessity following from the ontological priority of unity-in-difference: no formal system can derive the demarcational act that preceded and constituted it.*

Proof. By Theorem 4.3, the Axiom of Choice is the formal shadow of a prior demarcational commitment. By Proposition 2.6, unity-in-difference is ontologically prior to any formal system. The demarcational commitment that constitutes a formal system is therefore prior to that system in the ontological sense established by Tracy (2026a) [7]: it is necessary for the system to be intelligibly conceived at all.

A formal system (\mathcal{A}, V) can derive only what follows from its axioms \mathcal{A} and its domain V . But the demarcational commitment that constituted (\mathcal{A}, V) is prior to both \mathcal{A} and V : it is what made \mathcal{A} and V possible. Therefore (\mathcal{A}, V) cannot derive its own constituting demarcational commitment.

The Axiom of Choice, as the formal shadow of that commitment, inherits this underivability. It cannot be derived from ZF because ZF, as a formal system, cannot recover the demarcational act that preceded it. Its independence is not a gap in ZF's expressive power but a structural feature of the relationship between any formal system and the ontological commitments that constitute it. \square \square

Remark 5.2. This result stands in structural analogy with Gödel's incompleteness theorems [4]: just as no sufficiently powerful formal system can prove its own consistency, no formal system can derive the demarcational act that constituted it. Both results follow from the same structural feature: a system cannot fully recover what is prior to itself. The incompleteness theorems are the syntactic expression of this structural feature; the independence of the Axiom of Choice is its semantic expression.

6 Irreducible Underdetermination Between Variable Representations

Proposition 6.1. *Different variable representations of the same continuous manifold are formally equivalent but ontologically distinct. The underdetermination between them is irreducible within any single formal system.*

Proof. Let ρ_1 and ρ_2 be two variable representations of the same continuous manifold \mathcal{M} , generating formal systems (\mathcal{A}_1, V_1) and (\mathcal{A}_2, V_2) respectively. Formal equivalence means there exists a structure-preserving map $\sigma : V_1 \rightarrow V_2$ such that \mathcal{A}_1 and \mathcal{A}_2 generate the same theorems under σ .

But ρ_1 and ρ_2 encode different demarcational commitments: they carve \mathcal{M} differently, holding its unity as differentiated in different ways. This ontological difference is prior to both formal systems and therefore cannot be recovered from within either. No theorem of (\mathcal{A}_1, V_1) can establish that ρ_1 is the correct demarcation of \mathcal{M} , because that correctness is a matter of the prior commitment that constituted (\mathcal{A}_1, V_1) .

The selection between ρ_1 and ρ_2 is therefore itself a demarcational act prior to both formal systems. No single formal system can adjudicate between them from within. The underdetermination is irreducible. □ □

Remark 6.2. This result explains the persistence of the debate between interpretations of quantum mechanics. The Copenhagen, many-worlds, pilot wave, and relational interpretations are formally equivalent in their predictions. The choice between them is not a formal question but a demarcational one: each interpretation encodes a different prior commitment about how the continuous quantum manifold is to be individuated. No experiment can adjudicate between them from within any single formal system because the selection between them is prior to all formal systems. The underdetermination is not a failure of physics. It is a structural feature of the relationship between continuous reality and discrete representation.

7 Connection to the Imagination Machine Framework

The Imagination Machine framework establishes that the inference-implication loop $T = F \circ g$ is the fundamental cycle of any embedded epistemic system. Compression (g) produces a quotient representation of the observation space; extension (F) completes partial structure under constraint. The loop stabilizes at fixed points that function operationally as knowledge.

Proposition 7.1. *Demarcation is compression; abstraction is extension; unity-in-difference is the primitive from which the inference-implication loop is generated.*

Proof. Compression holds difference atop unity: it differentiates the observation space into a quotient representation, retaining relational invariants while discarding redundant detail. This is demarcation in the sense of Definition 2.1. Extension holds unity atop difference: it associates the compressed representation with a completion, abstracting from partial structure to a coherent whole. This is abstraction in the sense of Definition 2.2. Unity-in-difference, as the primitive of both, is therefore the ontological ground of the inference-implication loop. □ □

Corollary 7.2. *The Axiom of Choice, understood as a choice of axiom, is a fixed point of the inference-implication loop applied to the foundations of mathematics: a demarcational commitment compressed into a formal system and stabilized as a logical primitive.*

Proof. By Theorem 4.3, the Axiom of Choice is the formal shadow of a prior demarcational commitment. By the preceding proposition, demarcation is compression. The Axiom of Choice is therefore the compressed encoding of a prior generative act — the demarcational commitment — that the formal system inherits without recovering. This is precisely the structure of compressed inheritance established in TIM IV: the endpoint is transmitted; the generative act that produced it is not. The Axiom of Choice is the mathematical instance of compressed inheritance at the level of formal foundations. □ □

8 The Unified Theorem

Theorem 8.1 (Tracy Theorem of Axiomatic Priority). *Let (\mathcal{A}, V) be any formal system representing a continuous domain via a variable representation ρ . Then:*

1. ρ constitutes a demarcational commitment prior to (\mathcal{A}, V) in the sense established by Tracy (2026a): it is necessary for (\mathcal{A}, V) to be intelligibly conceived at all.
2. The Axiom of Choice, if invoked within (\mathcal{A}, V) , is the formal shadow of ρ : it presupposes the demarcational commitments encoded in ρ and cannot be derived from \mathcal{A} alone.
3. The independence of the Axiom of Choice from \mathcal{A} is a structural necessity: no formal system can derive the demarcational act that preceded and constituted it.
4. Different variable representations of the same continuous domain are formally equivalent but ontologically distinct. The underdetermination between them is irreducible within any single formal system.
5. The Banach-Tarski paradox is a corollary of (2): two independent choices of axiom applied to a spherical manifold of insufficient topological capacity produce two balls from one. The paradox dissolves when the Axiom of Choice is understood correctly as a choice of axiom whose consequences depend on the topological capacity of the manifold to which it is applied.

Corollary 8.2. *The Axiom of Choice is a choice of axiom. What appears within a formal system as a logical primitive is, at the ontological level, the compressed encoding of a prior demarcational commitment — a generative act the system inherits without recovering. Its independence from ZF is not a gap in formal expressibility. It is a structural consequence of the ontological priority of unity-in-difference over any formal system built upon it.*

9 Historical Note: The Theological Origin of the Theorem

The result established in this paper was first approached by the author in college, not as a problem in the foundations of mathematics but as a problem in formal theology. The attempt was to express Trinitarian logic — the Christian theological doctrine that God is three persons in one substance — in the language of set theory.

The Trinity is the most precise formulation in the Western theological tradition of what this paper calls unity-in-difference: three persons, one substance. Not three sets with one element each — that would be tritheism, the collapse of unity into multiplicity. Not one set with three elements — that would be modalism, the collapse of difference into unity. The Trinity holds both simultaneously without collapse to either pole. It is unity-in-difference in its strongest form: the claim that the primitive itself has internal relational structure.

To express this in set theory requires sets in sets: a continuous tube of containment in which each set is contained within another without the sequence bottoming out at an empty set or topping out at a universal set. The three persons are not elements of a set. They are orientations of a containing relation that is simultaneously its own contained. The Father contains; the Son is contained; the Spirit is the relation of containing-and-being-contained — and all three are one substance, which is to say, one continuous tube.

What fell out of this attempt was the Axiom of Choice.

The continuous tube of sets in sets requires, for its formal expression, a selection function that can reach into each level of the containment hierarchy and identify an element — not because the elements are discrete and pre-individuated, but because the containing relation itself is continuous and the selection function is the formal shadow of the demarcational commitment that makes any level of the hierarchy legible at all. The Axiom of Choice is what you arrive at when you try to express a continuous relational primitive in a discrete formal language. It is the scar left by the demarcational commitment.

The author did not, at the time, recognize what he had found. The connection between the theological problem and the foundational problem in mathematics became clear only through the development of the Imagination Machine series, which identified unity-in-difference as the ontological primitive prior to any formal system. Looking back, the derivation was inevitable: the Trinity is the strongest instance of unity-in-difference; set theory is the formal system most directly constituted by demarcational commitments; and the attempt to express the former in the latter must produce the Axiom of Choice, because the Axiom of Choice is what a continuous relational primitive looks like when it is compressed into a discrete formal language.

The theorem established in this paper is therefore not only a result in the philosophy of mathematics. It is the formal recovery of what the theological intuition was pointing at all along: that the primitive of unity-in-difference is prior to any formal system, that every formal system inherits its demarcational commitments without recovering the generative act that produced them, and that the Axiom of Choice is the shadow of that act — a choice of axiom, compressed into a logical primitive, misread as a foundation.

The calling arrived first. The mathematics came to meet it.

10 Conclusion

We have established that the Axiom of Choice is not a logical primitive but the formal shadow of a prior demarcational commitment — a choice of axiom — that constitutes the formal system within which the axiom then appears. This result follows from the ontological framework of Tracy (2026a), in which unity-in-difference is identified as the primitive of demarcation and abstraction, both of which are ontologically prior to time, space, and any formal system built upon them.

The independence of the Axiom of Choice from ZF is a structural necessity: no formal system can derive the demarcational act that preceded and constituted it. The Banach-Tarski paradox is not a paradox but a corollary: two independent choices of axiom applied to a spherical manifold that cannot hold them simultaneously produce two balls. Different variable representations of the same continuous manifold are formally equivalent but ontologically distinct, and the underdetermination between them is irreducible within any single formal system.

These results connect the foundations of mathematics to the Imagination Machine framework through the compression-extension cycle: demarcation is compression, abstraction is extension, and

the Axiom of Choice is the fixed point of a particular demarcational commitment compressed into a formal system and misread as a logical primitive. The generative act came first. The axiom is its shadow.

The view from nowhere — the external vantage point from which one could recover the demarcational commitment prior to all formal systems — is structurally unreachable from within any formal system, for the same reason the embedded observer cannot step outside the universe it models. This is not a limitation to be overcome. It is the condition under which formal reasoning, mathematical knowledge, and scientific representation become possible at all.

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