Bitcoin Makes Time Travel Possible*

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1st April, 2026

Abstract

Reinganum (1986) argued informally that inexpensive time travel would drive nominal interest rates to zero. We formalise that claim in a dated-commodity model built on a Lewisian distinction between calendar time and personal time. Costless two-way transport of dollars across dates makes dated dollars technologically interchangeable, so the law of one price implies a zero nominal risk-free rate. The same logic does not carry over unchanged to native on-chain Bitcoin. Here, a Bitcoin position is modelled as an immediate control claim over a specific unspent transaction output (UTXO) in the realised blockchain history. A valid date-s claim, therefore, requires the relevant output already to exist by s and the applicable script and timelock conditions already to be satisfied. Future-created outputs cannot, in general, be transported backwards. Even allowing same-date substitution into older outputs does not restore Reinganum's conclusion because the admissible stock of backward-transportable Bitcoin outputs is history-dependent and capacity-constrained. A restricted same-output result survives for already-existing outputs whose control conditions are satisfied at both dates, but that result is too weak to force Bitcoin-denominated interest rates to zero under time travel in general.

Journal of Economic Literature Classification Numbers: E43; G12; N1; O33

Keywords: time travel; interest rates; Bitcoin; arbitrage; UTXO model

*The authors appreciate the helpful research assistance of ChatGPT 5.4. Kominers is a Research Partner at a16z crypto (for general a16z disclosures, see https://www.a16z.com/disclosures/). Notwithstanding, the ideas and opinions expressed herein are those of the authors, rather than of a16z or its affiliates. Gans and Kominers each own digital assets, including a de minimis amount of Bitcoin. Neither of them owns a time machine. Any errors or omissions remain the sole responsibility of the authors.

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1 Introduction

Reinganum (1986) made a striking claim: if inexpensive time travel existed, nominal interest rates would be driven to zero, thereby implying that time travel will not be invented. The underlying intuition is simple. If a nominal dollar promised at date t can be carried back to an earlier date $s < t$ at zero cost, any non-zero nominal wedge across dates creates an arbitrage opportunity. The rise of digital bearer assets raises a further question: Does the same conclusion extend to Bitcoin?

This paper has three aims. First, it formalises Reinganum's informal argument as a no-arbitrage result in a dated-commodity setting. Second, it makes explicit the time-travel framework that the result requires. Following Lewis (1976), time travel is represented by a divergence between external time and personal time: an agent may leave date t and arrive at date $s < t$ while still moving forward in their personal chronology. The paper adopts a *single-history consistency condition*: an action taken after travel to an earlier calendar date is part of the one realised history rather than the beginning of a separate branch. That assumption is enough for pricing; no deeper physical theory is needed.

Third, the note shows that the same theorem does not automatically extend to native on-chain Bitcoin. Native on-chain Bitcoin is not merely "money at date t." Rather, it is a collection of claims over specific transaction outputs in a blockchain history. Inputs reference prior unspent outputs; each output can be spent only once, and spendability depends on the relevant script conditions and any applicable timelocks (Nakamoto, 2008; Narayanan et al., 2016; Bitcoin Developer Documentation, 2026; Todd, 2014; Friedenbach et al., 2015; BtcDrak et al., 2015; Wuille and Friedenbach, 2015). Those features block the universal backwards transport technology that Reinganum's argument requires. A narrower result survives for already-existing outputs, but it is too weak to imply that Bitcoin-denominated interest rates must be zero in general. The paper is about native on-chain claims. A custodial liability or other off-chain Bitcoin-denominated contract may behave differently.

2 Framework

Let T be a set of calendar dates. For each $t \in T$, let m_t denote one nominal dollar available at date t. Let $p_t > 0$ be the equilibrium price of m_t in a common numeraire.

The paper uses a Lewisian account of time travel (Lewis, 1976). Calendar time indexes when an object is located in the external world. Personal time indexes the sequence of experiences of the traveller or the transported object. A traveller may therefore take a dollar from date t to date $s < t$ while the dollar moves forward in personal time. To avoid paradoxes in asset pricing, the model imposes a single-history consistency condition: if an object arrives at date s, that arrival is already part of the unique history observed at all later dates.

A time-travel technology is a feasible transformation between dated commodities. The benchmark case considered by Reinganum (1986) can be written as follows.

Assumption TT. For every $s, t \in T$, there exists a constant-returns, zero-cost technology that transforms one unit of m_t into one unit of m_s, and vice versa.

The competitive equilibrium condition is standard. Under free entry, no zero-cost technology may earn strictly positive profit in equilibrium. Assumption TT is stronger than mere time travel by persons. It requires transport of nominal purchasing power itself, with no deterioration, no quantity limits, no default risk, and no transactions wedge; that is the knife-edge environment in which Reinganum's conclusion lives.

For $s < t$, let $q_{s,t}$ denote the date-s price of one riskless nominal dollar delivered at date t. In dated-commodity notation,

$$q_{s,t} = \frac{p_t}{p_s}.$$

The associated gross nominal return is $R_{s,t} = 1/q_{s,t}$ and the nominal interest rate is $i_{s,t} = R_{s,t} - 1$.

3 Formalising Reinganum

The informal claim in Reinganum (1986) is that, under Assumption TT, non-zero nominal interest rates are inconsistent with no-arbitrage. The formal statement is immediate.

Proposition 1. *Suppose Assumption TT holds and zero-cost technologies satisfy the no-positive-profit condition under free entry. Then, for every $s, t \in T$,*

$$p_s = p_t.$$

Hence, for every $s < t$,

$$q_{s,t} = 1, \qquad R_{s,t} = 1, \qquad i_{s,t} = 0.$$

Proof. Fix any $s, t \in T$. Because one unit of m_t can be transformed into one unit of m_s at zero cost, the profit from operating that technology at unit scale is

$$\pi_{t \to s} = p_s - p_t.$$

Free entry and no positive profit imply $\pi_{t \to s} \leq 0$, so $p_s \leq p_t$.

The reverse zero-cost technology transforms one unit of m_s into one unit of m_t. Its unit profit is

$$\pi_{s \to t} = p_t - p_s.$$

Again, no positive profit implies $\pi_{s \to t} \leq 0$, so $p_t \leq p_s$.

Combining the two preceding inequalities gives $p_s = p_t$. Since s and t were arbitrary, the equality holds for all pairs of dates. Therefore, for every $s < t$,

$$q_{s,t} = \frac{p_t}{p_s} = 1.$$

It follows that $R_{s,t} = 1/q_{s,t} = 1$ and $i_{s,t} = R_{s,t} - 1 = 0$. □

The intuition here is the law of one price applied to dated nominal units. Assumption TT erases the scarcity of calendar location; once that happens, a dollar next year and a dollar today are technologically interchangeable, so their relative price must be one-for-one.

The proposition also shows why the sign of the interest rate is irrelevant in Reinganum's note. If dated dollars can be moved both forwards and backwards in time, then positive rates can be arbitraged by carrying future dollars backwards, while negative rates can be arbitraged by carrying present dollars forwards. The theorem compresses both possibilities into the equalities above. In this sense, the result is stronger than the familiar claim that backward time travel destroys positive carry: it destroys any risk-free nominal wedge across dates.

The conclusion is conditional, not metaphysical. The proposition need not hold if time travel is costly, quantity-constrained, monopolised, or available only to persons rather than to nominal purchasing power. Reinganum (1986) explicitly notes that monopoly control of time travel weakens the zero-rate conclusion. The formal proof here isolates the source of the result: a competitive, zero-cost, two-way transport technology for money.

4 Using Bitcoin instead of Fiat Money

Bitcoin is often described as digital cash, but for the present question, that description is too coarse. Native on-chain Bitcoin is not a homogeneous dated commodity in the same sense as fiat money in Section 2. It is a set of immediate control claims over specific transaction outputs recorded in a blockchain history. Inputs reference prior outputs by outpoint; an output can be spent only once, and outputs are controlled by locking scripts that may require one or more signatures, redeeming scripts or witness elements, hash preimages, and compliance with absolute or relative timelocks (Nakamoto, 2008; Narayanan et al., 2016;

Bitcoin Developer Documentation, 2026; Todd, 2014; Friedenbach et al., 2015; BtcDrak et al., 2015). The chain is ordered by blocks whose headers contain miner-supplied timestamps subject to consensus constraints; for time-based locktime calculations, the protocol uses median time past rather than literal wall-clock time (Bitcoin Developer Documentation, 2026; Wuille and Friedenbach, 2015). The broader cryptographic idea of timestamped records goes back to Haber and Stornetta (1991).

Let H_t denote the realised valid blockchain history inspected at calendar date t. Let U_t be the set of UTXOs that exist and are unspent in H_t. For a UTXO u, let $v(u) > 0$ denote its value in satoshis, and let $c(u)$ be its creation date, meaning the calendar date on which the transaction that created u first appears in the realised valid chain. Let $\sigma_t(u) \in \{0, 1\}$ indicate whether, relative to the holder under consideration, an immediate valid spending transaction for u can be constructed at date t, conditional on $u \in U_t$. Thus $\sigma_t(u) = 1$ requires that the relevant script conditions are satisfiable at t; where time-based restrictions are present, it also requires that those restrictions have matured by t. Define the set of immediately exercisable date-t outputs by

$$I_t = \{u \in U_t : \sigma_t(u) = 1\}.$$

A date-t Bitcoin control claim over a specific output u is denoted by $b_t(u)$, where $u \in I_t$. This is an immediate, output-specific claim, not a claim to generic Bitcoin purchasing power.

The dollar proof in Proposition 1 relied on a universal operator that removed the date index from the asset. For Bitcoin, the first relevant question is whether such an operator can exist even for output-specific claims.

An operator $\tau^B_{t \to s}$ is *output-preserving* if, whenever $b_t(u)$ lies in its domain, $\tau^B_{t \to s}(b_t(u)) = b_s(u)$.

Proposition 2. *Fix dates $s < t$. Suppose there exists $u^\star \in I_t$ with $c(u^\star) \in (s, t]$. Then there is no universal output-preserving zero-cost operator $\tau^B_{t \to s}$ whose domain is all valid date-t Bitcoin control claims.*

Proof. Because $u^\star \in I_t$, the claim $b_t(u^\star)$ is well defined. Because $c(u^\star) > s$, the output $u^\star$ is absent from the realised chain at date s, so $u^\star \notin U_s$. Therefore, $b_s(u^\star)$ is not well defined.

Assume, for the sake of seeking a contradiction, that there exists a universal output-preserving zero-cost operator $\tau^B_{t \to s}$ on all valid date-t Bitcoin control claims. Universality implies that $b_t(u^\star)$ lies in the domain of $\tau^B_{t \to s}$. Output preservation then implies

$$\tau^B_{t \to s}(b_t(u^\star)) = b_s(u^\star).$$

But $b_s(u^\star)$ is not well defined because $u^\star \notin U_s$; this contradiction shows that no such operator exists. □

This is the precise point at which the dollar proof breaks. Proposition 1 requires a universal operator that makes the same asset available at either date. For native on-chain Bitcoin, the date index is partly constitutive of the claim itself: an output created after date s is not merely hard to reach at s; it is absent from the chain state that determines what can be spent at s.

A natural objection is that, although output-specific claims are non-identical, satoshis are economically fungible. Perhaps a holder of a late-created output at date t could first exchange it at date t for an older output and then send that older claim backwards instead. To analyse that possibility, we consider the set of outputs that support immediate control claims at both dates:

$$A_{s,t} = \{u : u \in U_s \cap U_t,\ \sigma_s(u) = 1,\ \sigma_t(u) = 1\}.$$

For any finite set of outputs S, let

$$V(S) = \sum_{u \in S} v(u)$$

denote total value in satoshis.

Proposition 3. *Fix dates $s < t$. Suppose there exists $u^\star \in I_t$ with $c(u^\star) \in (s, t]$ and $v(u^\star) > 0$. Then*

$$V(A_{s,t}) < V(I_t).$$

Consequently, any backwards-transfer scheme that works only by bringing to date s control over outputs in $A_{s,t}$, with optional re-spending after arrival, is capacity-constrained. It cannot furnish a universal, quantity-unconstrained, one-for-one transport technology for all spendable date-t on-chain Bitcoin.

Proof. Because $u^\star \in I_t$ and $c(u^\star) > s$, the output $u^\star$ does not belong to U_s, hence $u^\star \notin A_{s,t}$. Therefore $A_{s,t} \subsetneq I_t$. Since $v(u^\star) > 0$,

$$V(A_{s,t}) \leq V(I_t) - v(u^\star) < V(I_t).$$

Now consider any scheme that operates only by carrying to date s control over outputs in $A_{s,t}$, possibly followed by immediate re-spending after arrival. By single-history consistency, the same output cannot be used twice as the source of native on-chain purchasing power.

Moreover, Bitcoin transactions conserve value at the level of inputs and outputs: re-spending an imported output cannot create outputs whose aggregate value exceeds the value of the imported output, apart from transaction fees reducing that value (Bitcoin Developer Documentation, 2026). Hence, the maximum total value that such a scheme can import to date s is bounded above by $V(A_{s,t})$.

Since $V(A_{s,t}) < V(I_t)$, the scheme cannot transport all spendable date-t on-chain Bitcoin one-for-one to date s. Therefore, it is not universal and not quantity-unconstrained in the sense required by Assumption TT. □

The point is not that no backwards movement is ever possible. The point is that native on-chain Bitcoin does not endogenously supply Reinganum's universal transport technology. At best, it allows transport of same-output claims over a subset of outputs and, even with same-date substitution into older outputs, only up to a history-dependent capacity bound.

5 Information-based Bitcoin Time Travel

The set $A_{s,t}$ identifies the domain on which a narrower, same-output result survives. For $u \in A_{s,t}$, the immediate control claims $b_s(u)$ and $b_t(u)$ are both well defined.

Now impose the following restricted transport assumption.

Assumption BT. For any $u \in A_{s,t}$, the holder's control bundle for u can be carried costlessly between dates s and t, without exercising the claim and while preserving single-history consistency.

Under Assumption BT, time travel can move control information over the same already-existing output, even though it cannot create a universal transport technology for native on-chain Bitcoin as such.

Proposition 4. *Fix dates $s < t$ and let $u \in A_{s,t}$. Let $P_s(u)$ and $P_t(u)$ denote the equilibrium prices of the same unexercised immediate control claim over u at dates s and t respectively. Under Assumption BT and free entry into zero-cost transport of control information,*

$$P_s(u) = P_t(u).$$

Proof. Because Assumption BT allows the control bundle for u to be carried from date t to date s at zero cost, the unit profit from that transport technology is

$$\Pi_{t\to s}(u) = P_s(u) - P_t(u).$$

No positive profit implies $P_s(u) \leq P_t(u)$.

The reverse movement from date s to date t is also feasible at zero cost, so

$$\Pi_{s \to t}(u) = P_t(u) - P_s(u) \leq 0.$$

Hence $P_t(u) \leq P_s(u)$.

Combining the inequalities yields $P_s(u) = P_t(u)$. □

The economic meaning of the proposition is narrower than the dollar result. It applies only to the same already-existing output and only when the claim is immediately exercisable at both dates. The proposition compares the price of the same unexercised control claim across dates; actual exercise at date s would ordinarily remove u from later UTXO sets under single-history consistency, so such exercise is outside the proposition's domain.

That difference matters for compounding. Reinganum's arbitrage mechanism requires the trader to roll the proceeds forward repeatedly. With native on-chain Bitcoin, the proceeds of an interest-bearing position will typically be new outputs created after date s. Those outputs fall outside $A_{s,t}$. The restricted proposition is, therefore, not closed under the reinvestment step that makes the dollar arbitrage self-reinforcing.

The restricted result also excludes many ordinary on-chain claims. Absolute timelocks can render an output unspendable until a specified block height or time, and relative timelocks can require the output to age before spending (Todd, 2014; Friedenbach et al., 2015; BtcDrak et al., 2015; Wuille and Friedenbach, 2015). A traveller may carry keys or other control information backwards, but time travel does not disable Bitcoin script.

One implication is worth separating out.

Corollary 1. *The existence of costless time travel for controlling information over already-existing Bitcoin outputs does not imply that Bitcoin-denominated interest rates must be zero in general.*

Proof. By Proposition 4, time travel equalises prices only for the same unexercised control claim on the restricted domain $A_{s,t}$. By Propositions 2 and 3, native on-chain Bitcoin does not admit the universal, quantity-unconstrained, one-for-one backwards transport technology required by Proposition 1. Therefore, the dated-commodity proof that forced $q_{s,t} = 1$ for dollars does not extend to native on-chain Bitcoin as such, and no general zero-interest conclusion follows. □

The corollary does not say that Bitcoin is immune to every time-travel arbitrage. It says only that native on-chain Bitcoin does not satisfy the universal premise of Reinganum's theorem. A Bitcoin-denominated custodial liability or other off-chain claim may behave more like an ordinary dated contract. The argument in this note is about native on-chain claims defined by the ledger itself. In other words, there is room for time travel innovation here, but that is left for "future work."

6 Conclusion

Reinganum's central insight survives formalisation. In a single-history model with competitive, zero-cost, two-way transport of nominal purchasing power, the law of one price collapses nominal wedges across dates. Time travel removes the scarcity of calendar location, and interest is the price of that scarcity.

Native on-chain Bitcoin is different because the relevant asset is not defined independently of chain history. Immediate control over a specific UTXO depends on whether that output already exists in the realised chain and on whether its script conditions are satisfied at the earlier date. Future-created outputs, therefore, cannot be carried wholesale into the past. Same-output control over some already-existing outputs may be transportable across dates, and same-date substitution into older outputs may sometimes be possible, but neither mechanism reproduces the universal, quantity-unconstrained transport technology required by Reinganum's theorem.[1]

The broader lesson is that the economics of time travel depends on the ontology of the asset being moved. For fiat money in a frictionless dated-commodity model, time travel erases intertemporal nominal wedges. For native on-chain Bitcoin, the ledger reintroduces chronology at the level of the claim itself. We conjecture, therefore, that this may provide the first actual and distinctive use case for Bitcoin over traditional money. Time will tell.

[1] To be sure, Reinganum couldn't have known about Bitcoin 40 years ago unless he is playing some n-dimensional chess with us and is actually a time traveller who invented Bitcoin to create arbitrage opportunities. Nonetheless, any speculation that Reinganum is actually Satoshi is just that.

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