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Tracing Cross-Chain Transactions Between EVM-Based Blockchains: An Analysis of Ethereum-Polygon Bridges: Open Review

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Reviewers: Reviewer A, Reviewer B

Abstract. The final version of the paper "Tracing Cross-Chain Transactions Between EVM-Based Blockchains: An Analysis of Ethereum-Polygon Bridges" can be found in Ledger Vol. 10 (2025) 113-134, DOI 10.5195/LEDGER.2025.433. There were two reviewers involved in the review process, neither of whom has requested to waive their anonymity at present, and are thus listed as Reviewers A and B. After initial review by Reviewers A and B, the submission was returned to the authors with minor feedback for revision (1A). The authors replied to the reviewers' comments (1B) and resubmitted their work. The editors determined the revisions sufficient, and the paper was subsequently accepted for publication, thus ending the peer review process.

1A. First Round of Review

Reviewer A

Does this paper represent a novel contribution to cryptocurrency or blockchain scholarship?

Yes, important contribution(s)

Please briefly explain why you think the paper makes or does not make a novel contribution.

This is one of the very few papers that empirically examined bridges - critical components of the blockchain ecosystem

Is the research framed within its scholarly context and does the paper cite appropriate prior works?

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Yes

Please assess the article's level of academic rigor.

Good (not excellent but a long way from poor)

Please assess the article's quality of presentation.

Excellent (the motivation for the work is clear, the prose is fluid and correct grammar is used, the main ideas are communicated concisely, and highly-technical details are relegated to appendixes).

How does the quality of this paper compare to other papers in this field?

The paper ranks highly but it may not be among the most authoritative references in the field.

Please provide your free-form review for the author in this section.

The paper makes novel contributions on the important topic of bridges, empirically evaluating them within Ethereum and EVM chains, which are critical due to their high user adoption. It is well written with a solid methodology.

My only concern is that the research appears incomplete, as it did not achieve a 100% match of bridged transactions. A discussion section on potential enhancements to the algorithm would be beneficial.

Reviewer B

Does this paper represent a novel contribution to cryptocurrency or blockchain scholarship?

Yes, incremental contribution(s)

Please briefly explain why you think the paper makes or does not make a novel contribution.

See comments

Is the research framed within its scholarly context and does the paper cite appropriate prior works?

Yes

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Please assess the article's level of academic rigor.

Good (not excellent but a long way from poor)

Please assess the article's quality of presentation.

Good (not excellent but a long way from poor)

How does the quality of this paper compare to other papers in this field?

The paper ranks highly but it may not be among the most authoritative references in the field.

Please provide your free-form review for the author in this section.

The manuscript explores an important and timely issue related to cross-chain transactions, specifically focusing on transactions between Ethereum and Polygon. The study presents a heuristic algorithm for tracing these transactions and provides a comprehensive empirical analysis of cross-chain transaction patterns. Given the increasing adoption of Layer 2 scaling solutions and cross-chain bridges, the research contributes valuable insights into asset flows and bridge efficiency.

I would favourably support this article for publication following the minor revisions below:

1) Abstract: It would be helpful to explicitly mention the dataset size and the methodology used to provide readers with a clearer understanding of the study’s scope.

2) Generalisation: While the manuscript briefly mentions the potential application of the method to other EVM-based blockchains, it would be beneficial to elaborate on the extent to which the proposed algorithm could be adapted to non-EVM chains. Addressing potential challenges (e.g., differing address formats, transaction structures, or consensus mechanisms) would strengthen the discussion.

3) Governance: The paper would benefit from a discussion on the governance of the bridges examined, as this has direct implications for security, censorship resistance, and systemic risks. Are these bridges operated by a single entity (e.g., Polygon Labs), or is there a decentralised governance model? How are smart contract upgrades handled? Has the bridge experienced governance-related issues, such as frozen assets, withdrawal delays, or protocol changes affecting users? Given the role governance plays in cross-chain transaction transparency and security, adding this discussion would enhance the paper.

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I hope these comments help improve this article, which I found insightful and well-structured.

1B. Authors' Response to First Round of Review

Reviewer A

Comment 1: the paper makes novel contributions on the important topic of bridges, empirically evaluating them within Ethereum and EVM chains, which are critical due to their high user adoption. It is well written with a solid methodology. My only concern is that the research appears incomplete, as it did not achieve a 100% match of bridged transactions. A discussion section on potential enhancements to the algorithm would be beneficial.

Reply: Firstly, in theory, there does not exist a unique string or identifier that can perfectly match cross-chain transactions by exhaustively checking all transaction fields. Our goal is to identify cross-chain transactions from a third-party perspective. While bridge operators themselves may achieve a 100% match rate since their validators record all relevant information, but they currently do not make such data publicly available. From our standpoint, we address this issue by introducing a subsection titled "High overall match rates despite imperfections" in the Results section. There, we explain the reasons why our algorithm does not reach a perfect match rate and discuss potential enhancements to further improve matching accuracy.

Reviewer B

Comment 2: Abstract: It would be helpful to explicitly mention the dataset size and the methodology used to provide readers with a clearer understanding of the study's scope.

Reply: In the Abstract, we add the following content to mention the methodology and dataset size.

"It leverages the unique feature of users' addresses, which can be shared on EVM-based blockchains. By combining transaction time, value, and token identification, a matching heuristic algorithm is developed to link transactions between the source chain and the target chain. We apply this methodology to analyze over 2 million cross-chain transactions spanning from August 2020 to August 2023, achieving matching rates of up to 99.65% for deposits and 92.78% for withdrawals across different asset types (Ether, ERC-20 tokens, and NFTs)."

Comment 3: Generalisation: While the manuscript briefly mentions the potential application of the method to other EVM-based blockchains, it would be beneficial to elaborate on the extent to which the proposed algorithm could be adapted to non-EVM

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chains. Addressing potential challenges (e.g., differing address formats, transaction structures, or consensus mechanisms) would strengthen the discussion.
Reply: Thank you for this constructive suggestion regarding the generalization of our methodology. We have expanded our discussion on the adaptability of our algorithm to non-EVM chains by adding a detailed paragraph in the Discussion section. This addition addresses the significant challenges in extending our approach beyond the EVM ecosystem, including address format differences (like Bitcoin's Base58 vs. Ethereum's hexadecimal format), structural variations between UTXO-based and account-based models. We also discuss how the absence of native address consistency across non-EVM chains, a key feature our algorithm leverages in EVM environments, would require alternative approaches such as bridge-specific address mapping or cross-chain identity solutions. While acknowledging these substantial challenges, we outline how the core principles of our methodology (temporal proximity, value equivalence, and token identification) could potentially serve as a foundation for chain-specific adaptations.

Comment 4: Governance: The paper would benefit from a discussion on the governance of the bridges examined, as this has direct implications for security, censorship resistance, and systemic risks. Are these bridges operated by a single entity (e.g., Polygon Labs), or is there a decentralised governance model? How are smart contract upgrades handled? Has the bridge experienced governance-related issues, such as frozen assets, withdrawal delays, or protocol changes affecting users? Given the role governance plays in cross-chain transaction transparency and security, adding this discussion would enhance the paper.

Reply: Thank you for this valuable suggestion regarding bridge governance. We have addressed this important aspect by adding a new subsection (7.2) to our Discussion section titled "Governance model and security implications." This addition examines the Polygon PoS Bridge's semi-centralized governance structure operated by approximately 105 validators, discussing how this relatively small validator set impacts transaction security and finality. We identified instances where governance decisions directly affected cross-chain behavior, notably during the Ethereum Merge when bridge operations were suspended. We also highlight how the extended confirmation windows observed in withdrawals (median 95-265 minutes, extremes reaching 6.4 days) expose users to governance-related risks including potential transaction censorship. This new discussion significantly enhances our analysis by connecting governance structures to the observed transaction patterns and security implications in our dataset.

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