Debt Network Governance: A Second Path to Debt Resolution

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Abstract

Traditional debt governance focuses on the solvency of individual nodes and relies heavily on monetary payments. The mismatch between this "node-based governance" and the "networked reality" of creditor-debtor relationships is one of the deep-rooted causes of the periodic accumulation of "triangular debts". This paper proposes a "debt network governance" paradigm, shifting the debt resolution logic from "incremental capital dependence" to "stock structure optimization". Theoretically, we distinguish between "monetary flow liquidity" and "network structural liquidity", coin the unifying concept of "network settlability", and construct a two-layer measurement system of "theoretical settlability - actual digital settlement rate (DSR)" to quantify the endogenous multilateral offset potential of debt networks. Instrumentally, we design a collaborative tool system consisting of a Closed-loop Debt Clearing algorithm (CDC) and Standardized Digital Obligation Certificates (SDOC): the former realizes automated multilateral offset of stock debts based on the principle of closed settlement relationships and minimum amount netting; the latter guides the circulation of commercial credit within a controllable range by converting stock credit into payment instruments. Together, they form an enhanced loop of "dredging - ring creation - re-dredging". In the initial stage, applications focus on business-to-business (B2B) and government-to-business (G2B) payment and settlement fields, while exploring the feasibility of extending to private payment areas. This

paper is a forward-looking theoretical exploration. The core hypothesis that "debt networks contain a large amount of endogenous offset potential that can be activated by algorithms" remains to be verified by large-scale real data. The research contribution lies in providing a "second path" for debt resolution distinct from the traditional incremental model for global economies, which is particularly valuable for economies with complete industrial chains such as China.

1. Introduction

Debt resolution has become a core challenge for global macroeconomic governance and microeconomic operation. From local government debt restructuring and extension to the clearance of inter-enterprise "triangular debts", traditional debt resolution practices have always followed the core logic of "using incremental funds to relieve stock pressure". In China, for example, the accounts receivable of industrial enterprises above designated size had reached 27.43 trillion yuan by the end of 2025, and the debt scale still shows a periodic expansion trend. This phenomenon raises a profound question: why has continuous liquidity injection failed to fundamentally solve the problem of debt accumulation? We argue that the core limitation of the traditional debt resolution model lies in the governance mismatch between "monetary flow thinking" and the "network structure" of debt relationships. When creditor-debtor relationships form a complex dynamic network, the debt problem is not only a "funding gap" problem but also a "network structure obstruction" problem. In addition to "monetary flow liquidity" that relies on external injection, there also exists "network structural liquidity" condensed in the topological structure of debt networks—that is, the endogenous settlement potential realized through multilateral debt offset. The traditional model completely ignores this potential.

Against the background of high global macro leverage and narrowing monetary policy space, the path of continuing to rely on incremental funds to resolve stock debts is unsustainable. The core research question of this paper is: can we release endogenous liquidity to resolve stock debts by optimizing the topological structure of debt networks without relying on large-scale monetary payments? To answer this question, we construct the Debt Network Governance (DDG) paradigm, systematically demonstrating it from three dimensions: theoretical foundation, tool design, and

practical path. This paradigm provides a "second path" for debt resolution for global economies.

2. Theoretical Framework: Debt Networks and Settlability Theory

2.1 Topological Characteristics of Complex Creditor-Debt Networks

The modern economic operation system can be abstracted as a complex network with economic agents as nodes and creditor-debtor relationships as directed edges. Its topological characteristics have a decisive impact on debt governance:

1. **Heterogeneous connectivity and super-node effect**: A small number of core enterprises, local governments, and financial institutions act as "super nodes" connecting hundreds to thousands of upstream and downstream entities. Their solvency has systemic risk attributes. Traditional financial assessment frameworks only focus on the financial status of nodes themselves, ignoring the risk transmission effect brought by their network positions.
2. **Small-world property and cross-domain risk transmission**: The average path length between any two nodes in the debt network is short, and local liquidity shocks can spread across industries and regions through indirect paths such as "customers of customers" and "suppliers of suppliers". Traditional risk control is difficult to penetrate to the indirect association layer, leading to underestimation of systemic risks.
3. **Community structure and local governance potential**: Industrial agglomeration forms network communities with "high cohesion and weak coupling". The internal debt relationships within communities are dense, and the probability of closed-loop formation is high, making them suitable for local settlement governance; connections between communities are sparse, forming a natural buffer zone for risk contagion.
4. **Digital mirror foundation**: The popularization of computerized accounting has made all accounts receivable and payable structured and digitally stored, providing a data foundation for building a global debt map. However, current enterprise ERP systems form "data islands", making the global network structure invisible.

2.2 Two Types of Liquidity and Governance Effectiveness

We distinguish between two fundamentally different types of liquidity in the economic system:

- **Monetary flow liquidity**: It depends on the injection of external currency and is transmitted transaction by transaction along bilateral trading relationships, forming the basis of traditional debt resolution models.
- **Network structural liquidity**: It is not a transferable fund but an endogenous offset potential condensed in the topological structure of debt networks. Its existence is based on directed closed-loop structures in the network, and its release requires a system that can discover these closed loops and coordinate multilateral synchronous netting.

Traditional debt resolution models almost entirely rely on monetary flow liquidity, and their governance effectiveness can be approximated as $G \approx f(L)$, where L represents external money supply. The DDG paradigm introduces the effectiveness of structural liquidity, expanding the governance effectiveness function to: $G = f(L) + g(DSR) + h(L, DSR)$ where $g(DSR)$ represents the independent effectiveness increment brought by structural liquidity, derived from the topological optimization of debt networks; $h(L, DSR)$ represents the synergistic effect of the two types of liquidity, where monetary injection and network settlement promote each other and amplify governance effects.

This reconstruction shows that debt resolution should not only rely on "blood transfusion" but also release endogenous liquidity by "dredging" the network structure, achieving an organic combination of "blood transfusion" and "hematopoiesis".

2.3 Two-Layer Measurement System of Network Settlability

To quantify the endogenous settlement potential of debt networks, we construct a two-layer measurement system of "theoretical settlability - actual digital settlement rate":

1.Theoretical settlability: It refers to the potential settlement capacity determined by the network topological structure. From a graph theory perspective, any directed closed loop in the debt network implies the mathematical feasibility of multilateral debt offset. The minimum value of each edge in the closed loop can be cleared through one synchronous netting without external capital intervention. Theoretical settlability has a nonlinear relationship with network density: when the network density is below a critical threshold, closed loops are sparse, and theoretical settlability approaches zero; once the threshold is crossed, the probability of closed-loop formation increases significantly, and theoretical settlability rises rapidly.

2.Actual Digital Settlement Rate (DSR): It measures the real settlement capacity after being empowered by institutions and technologies. The formula is: $DSR = \text{Standardization Rate} \times \text{Algorithm Settlement Rate}$ where the standardization rate is the ratio of standardized debt to total debt in the network, reflecting the coverage of institutional rules on stock debts; the algorithm settlement rate is the ratio of algorithm-clearable debt to standardized debt, reflecting the processing efficiency of technical tools on standardized debts.

This decomposition framework provides a basis for precise policy implementation: if DSR is low due to insufficient standardization rate, priority should be given to improving debt standardization rules and legal systems; if it is due to low algorithm settlement rate, the focus should be on algorithm optimization and computing power improvement.

2.4 The De-intermediation Essence of Debt Network Governance and the Evolution of Monetary Functions

Traditional monetary theory holds that money is a medium for paying debts. The core insight of debt network governance is that **equal debts do not necessarily need to be paid with money and can be offset mathematically.** This mechanism is essentially a "de-intermediated" settlement method that does not rely on any third-party payment medium and can complete value transfer only through the topological structure of debt relationships. From a broader perspective, debt network governance is an advanced form of bookkeeping settlement. With the advancement of digitalization, the space for physical currency use is continuously shrinking, and the functions of money are undergoing profound evolution: **the unit of account (medium of value measurement) will become the most important function of money** (the two are essentially unified: the unit of account is the concrete manifestation of the value measurement function in accounting), while the functions of medium of exchange and means of payment will be partially undertaken by distributed debt settlement networks. Regardless of how the form of money evolves in the future (such as central bank digital currencies), this basic trend will most likely not change.

Furthermore, debt network governance and financial institution bookkeeping settlement are not oppositional but complementary relationships. The centralized bookkeeping system of traditional financial institutions and the distributed ledger system of debt networks

will form a complement: the former is responsible for final fund settlement, while the latter is responsible for pre-positioned debt offset and daily transactions. This integration reflects the trend of "de-financialization"—returning part of the settlement functions originally monopolized by financial institutions to real economic entities.

3. Collaborative Governance Mechanism: CDC Algorithm and SDOC

The tool system of debt network governance consists of the Closed-loop Debt Clearing algorithm (CDC) and Standardized Digital Obligation Certificates (SDOC), which respectively undertake the functions of "stock dredging" and "incremental ring creation", forming a complementary enhanced loop.

3.1 Closed-loop Debt Clearing Algorithm (CDC)

The core design logic of the CDC algorithm is "algorithm-empowered autonomy of will", transforming high-cost manual multilateral negotiation into an automated process. The algorithm is only responsible for discovering closed loops, pushing solutions, and executing write-offs, while the final settlement decision belongs to each participating entity. It operates following three principles:

1. **Closed settlement relationship principle**: Netting is possible as long as the creditor-debtor chain forms a directed closed loop, regardless of whether the amounts are equal.
2. **Synchronous execution principle**: All debts of participating parties must be written off simultaneously to avoid new credit risks caused by differences in execution order.
3. **Privacy protection principle**: Enterprise raw data is retained locally, and only encrypted summary information is submitted to the protocol layer. Closed-loop paths are only visible to participating parties.

The standardized operation process of the CDC algorithm includes four steps:

1. **Trusted data anchoring**: Enterprises upload standardized debt data that has been confirmed to the permissioned debt map network through standard API interfaces. Raw data does not leave the domain, and only verifiable encrypted summaries are submitted.

2. **Automatic closed-loop matching**: The system scans the dynamic debt map in real time and uses a depth-first search algorithm to identify directed closed loops. For overlapping closed loops, the clearing priority is determined according to the principles of "amount priority" and "term priority".
3. **Multilateral consensus confirmation**: The system pushes the clearing plan to all entities in the closed loop, and each entity independently authorizes it with a digital signature. If any entity vetoes, the closed-loop plan is shelved without affecting other closed loops.
4. **Automatic execution and evidence storage**: Closed loops with full authorization automatically trigger synchronous write-offs, generate legally effective electronic settlement vouchers, and synchronize to enterprise financial systems and regulatory backup nodes in real time.

3.2 Standardized Digital Obligation Certificates (SDOC)

SDOC is a digital payment instrument that converts confirmed accounts payable into transferable certificates. Its core is "paymentization of stock credit" rather than creating new credit. **The most practically feasible initial application scenario of SDOC is local government debt resolution in China**: local governments can issue SDOC based on their accounts payable to engineering contractors, who can then use SDOC to pay taxes or purchase within designated industrial chains. This model utilizes government credit endorsement and the deduction mechanism of fiscal and tax revenues, naturally forming a G2B2B debt closed loop, which can effectively alleviate the current fiscal expenditure pressure of local governments while avoiding new implicit debts.

Compared with commercial bills, SDOC has essential differences: commercial bills are right-creating securities that create independent bill rights, and the holder can recourse to all prior parties; SDOC is right-certifying securities that only prove the existing creditor-debtor relationship, and the payment obligation is only borne by the original issuer, cutting off the reverse transmission of risks.

The full life cycle management of SDOC includes three stages:

1. **Issuance stage**: The debtor generates SDOC in the system based on real transaction background and confirmed accounts payable. The issuance scale shall not exceed the debtor's accounts payable balance and must meet credit rating and balance limit requirements.

2. **Transfer stage**: The original creditor can use SDOC to pay upstream suppliers. Each transfer is completed through digital endorsement by smart contracts, and the whole process is traceable and tamper-proof. Transfer conditions such as industrial chain scope, payment purpose, and transfer times can be set through smart contracts.
3. **Clearing stage**: When SDOC matures, the original debtor pays with monetary funds; if a debt closed loop is formed during the transfer process, SDOC can participate in CDC multilateral offset and complete clearing in advance.

In the initial stage, applications focus on B2B and G2B fields, while actively exploring the feasibility of extending to private payment areas. The participation of private entities will form a complete economic cycle from production to consumption, significantly increasing the probability of network closed-loop formation, releasing residents' consumption potential, and promoting a virtuous economic cycle.

3.3 "Dredging - Ring Creation - Re-dredging" Enhanced Loop

CDC and SDOC form a mutually reinforcing positive feedback loop in operation:

1. **Dredging stage**: The CDC algorithm identifies and clears existing debt closed loops, reduces the scale of stock debts, and releases enterprise credit space.
2. **Ring creation stage**: SDOC converts originally isolated bilateral debts into transferable standardized certificates, increases network connection density, and creates new debt closed loops.
3. **Re-dredging stage**: The formation of new closed loops triggers a new round of CDC clearing, further improving network settlement efficiency, attracting more enterprises to access the system, and expanding the coverage of the debt map.

The triggering of this enhanced loop requires crossing a critical scale threshold, that is, the coverage rate of standardized debts in the network reaches a certain level, making the probability of closed-loop discovery shift from "occasional" to "frequent".

3.4 Technical Foundation: Distributed Ledger System

The underlying technical foundation of debt network governance is the distributed ledger system, whose core idea is to connect the independent ledgers of economic entities through technical and institutional protocols to form a globally visible and verifiable unified ledger. In this system, each participant retains their own original ledger, while synchronizing transaction information to the entire network through

encrypted summaries, realizing "data does not leave the domain, information can be shared".

Blockchain technology is one of the important ways to implement distributed ledgers. The debt network governance system can adopt a permissioned chain architecture, utilizing the immutable and traceable characteristics of blockchain to store transaction information and settlement vouchers, ensuring the legal effect and auditability of settlement results. The ideological core of distributed technology is highly consistent with debt network governance: both emphasize decentralization, multi-party collaboration, and consensus mechanisms, and both are committed to reducing trust costs and improving system operation efficiency through technical means.

4. Empirical Observation and Theoretical Deduction: Endogenous Offset Potential of China's Debt Network

To verify the core hypothesis of this paper, we conducted a preliminary empirical analysis based on the financial data of more than 5,000 listed companies in China in 2024. We constructed a debt network with listed companies as nodes and their top five customer and supplier relationships as edges, and only found 1 valid closed loop after scanning.

There are two possible explanations for this result:

1. **Information island shielding effect**: In the absence of a unified networked governance framework and data standards, potential multilateral offset opportunities are masked by highly dispersed financial information islands. We can only observe the debt relationships between listed companies and their top five customers and suppliers, but cannot obtain data from a wider range of upstream and downstream enterprises, leading to the omission of a large number of potential closed loops.
2. **Industrial chain structure characteristics**: The high degree of specialization in the modern economy leads most industrial chains to present a unidirectional tree structure, and closed loops are naturally sparse.

This paper tends to the first explanation, but the final verification of the core hypothesis depends on the analysis of the global debt map covering all enterprises. From theoretical deduction, when the network coverage expands to all enterprises in the economy that have implemented computerized accounting, the probability of closed-loop formation will increase significantly. Especially for China, an economy with a complete

industrial system, cross-industry and cross-regional debt closed loops exist in large numbers, but are currently invisible.

The participation of super nodes has a decisive impact on releasing the endogenous potential of the network. When the core super nodes (large core enterprises, local governments, financial institutions) in the network are all connected, even if the overall coverage rate is only 50%, the theoretical settlability can reach a relatively high level. This is because super nodes connect a large number of upstream and downstream enterprises, and their access can greatly improve the connectivity of the network and the probability of closed-loop formation.

5. Practical Path and Policy Implications

Debt network governance provides new ideas for global economies to resolve debt dilemmas. Combining the institutional environment and development stage of various countries, this paper proposes the following practical paths and policy recommendations:

5.1 Gradual Implementation Strategy

1.First Stage: National Unified Standards and Key Guidance (1-2 years)

- Formulate national unified debt standardization rules and data sets, and clarify the legal attributes, accounting treatment, and tax specifications of SDOC.
- **Guide central and state-owned enterprises to take the lead in accessing** the debt network, leverage their super node role, and rapidly improve network connectivity.
- Establish a pilot regulatory framework to verify algorithm effectiveness and the DSR measurement system.

Local pilots are difficult to achieve expected results because industrial chains are national or even global, and the probability of closed-loop formation in local networks is extremely low. Only by focusing on guiding core entities to access and gradually expanding network coverage can we cross the critical scale threshold and release the endogenous offset potential of the network.

2.Second Stage: Large-scale Promotion and System Integration (3-5 years)

- Realize docking with the central bank payment system, credit reporting system, and tax system.
- Establish a national unified debt map infrastructure and incorporate DSR into the macroeconomic regulation indicator system.

- Improve the macro-prudential monitoring system to prevent systemic risks.

3. Third Stage: Cross-border Exploration and International Cooperation (Long-term)

- Extend the DDG network to regional trade networks such as the Belt and Road Initiative and RCEP, and promote multilateral debt settlement denominated in RMB.
- Explore a new path of "value scale first" for RMB internationalization.

5.2 Core Policy Recommendations

1. **Transform debt resolution thinking**: Shift from "incremental capital dependence" to "stock structure optimization", and incorporate debt network governance into the macroeconomic governance toolbox.
2. **Strengthen institutional construction**: Improve the legal and regulatory system for debt confirmation, offset, and transfer to provide legal protection for the DDG paradigm.
3. **Promote data interconnection**: Formulate unified financial data standards, promote secure interconnection between enterprise ERP systems, and break data islands.
4. **Establish a cross-departmental regulatory coordination mechanism**: Clarify the regulatory responsibilities of the People's Bank of China, finance, taxation, market supervision and other departments to form regulatory synergy.
5. **Prevent new risks**: Implement hierarchical access and balance ceiling management for SDOC issuers, strengthen data security and trade secret protection, and prevent algorithm abuse risks.

6. Profound Impact on the Monetary System

If debt network governance can be popularized, it will form a new pattern of "paying debts with money" and "settling debts with networks" in parallel, which will have a profound impact on the existing monetary system.

6.1 Re-division of Monetary Functions

Under the dual settlement system, the functions of money will be re-divided:

- **Unit of account and medium of value measurement**: Remain the most important functions of money, providing a unified pricing benchmark for all debts and transactions.
- **Final means of payment**: Used to settle net positions that cannot be offset by the settlement network.

- **Medium of exchange and means of payment**: Part of the functions will be undertaken by the distributed debt settlement network.
  This division will improve the operation efficiency of the entire economic system and reduce the demand for the total amount of money.

6.2 New Dimensions of Monetary Competition

Debt network governance will change the essence of monetary competition. Future monetary competition will no longer be just competition in exchange rates and currency values, but more importantly, **competition in units of account and media of value measurement**. The currency that can become the main pricing unit of the global debt network will dominate the international monetary system.

This provides a new path for RMB internationalization: by promoting RMB as the pricing unit of regional trade and debt networks, gradually realizing RMB internationalization.

7. Prospects for Private Participation

At present, the application scope of debt network governance mainly focuses on B2B and G2B fields, but in the long run, **the comprehensive participation of the private sector will make the overall economic network more complete.**

The end products of industrial chain production are ultimately to meet private consumption needs, and private income also corresponds to the debts of the economy. If private entities can join the debt network, a complete closed loop from production to consumption will be formed, greatly improving the settlability of the network. Just as everyone has a bank account to record their income and expenditure, the future debt network can also record the receivables and potential payables of private entities.

Private participation will bring the following benefits:

1. **Increase the probability of closed-loop formation**: As the terminal nodes of the economic cycle, the participation of private entities will significantly improve the connectivity of the network and form more debt closed loops.
2. **Release consumption potential**: Private individuals can resolve part of their debts through multilateral offset, increase disposable income, and release consumption potential.

3. **Improve economic operation efficiency**: Realize full-chain settlement optimization from production to consumption, reduce capital precipitation, and promote a virtuous economic cycle.

However, private participation also faces many challenges such as data security, privacy protection, and consumer rights protection, which require adequate preparation at the institutional and technical levels. Therefore, private participation should be regarded as a long-term development direction and gradually promoted after achieving success in B2B and G2B fields.

8. Conclusion and Future Research

This paper proposes a new paradigm of debt network governance to address the structural dilemma of traditional debt resolution models. The research shows that there exists "network structural liquidity" condensed in the topological structure of debt networks in the economic system. By activating this potential through institutional and technological innovation, stock debts can be systematically resolved without relying on large-scale monetary payments.

We construct a two-layer measurement system of "theoretical settlability - actual digital settlement rate", design a collaborative tool system of CDC and SDOC, propose an enhanced loop mechanism of "dredging - ring creation - re-dredging", and discuss the profound impact of debt network governance on the monetary system. This paradigm provides a brand-new "second path" for debt resolution for global economies, helping to solve the problem of periodic debt accumulation and improve the operation efficiency and resilience of the economic and financial system.

The core limitation of this paper is the insufficient empirical foundation, and the core hypothesis remains to be verified by large-scale practical tests. Future research should focus on the following directions:

1. **Empirical research**: Build a global debt map based on full-scale enterprise financial data, and measure the theoretical settlability and actual DSR of different industries and regions.
2. **Institutional refinement**: Improve debt standardization rules, clarify the legal attributes and regulatory framework of SDOC, and formulate accounting and tax treatment specifications for closed-loop clearing.
3. **Risk research**: Analyze the transmission mechanism of risks such as SDOC issuer concentration and network key node failure through simulation modeling.

4. **Cross-border application**: Explore the application mode of DDG networks in cross-border trade settlement and promote the construction of regional multilateral clearing systems.
5. **Private participation research**: Study the feasibility, institutional design, and risk prevention and control measures for private entities to join the debt network.

Debt network governance is an important direction for the evolution of financial infrastructure in the digital era. The formation of a parallel pattern of "paying debts with money" and "settling debts with networks" is not only an innovation in debt resolution models but also a profound reflection of economic governance thinking. Through continuous theoretical exploration and practical verification, this paradigm is expected to provide important support for global financial stability and sustainable development.

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