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Assessment of decentralized system of smart-contacts effect on total output in digital economy

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Abstract. The digitization of economic activity creates new opportunities for increasing the goods production level in conditions of severe resources limitation. Significant optimization can be achieved due to, firstly, reduction the costs of transactions, and, secondly, engagement in the economic turnover of poorly low nondistributable assets (for example, real estate). The paper studies the problems regarding applicability of smart contract in economic activities at the regional and federal levels. An attempt is being made to form a decentralized system of smart contracts. Based on the component-based analysis, the key trends of this system effect on the gross output at the federal and regional levels are determined. The authors propose a quantitative assessment of the impact of each of these factors. The macroeconomic model IS-LM is used, which takes into account the impact of digitalization processes in terms of implementing the smart contracts system, on the aggregated output indicators of the economic system.

1. Introduction

The smart contract concept was proposed by Nick Sabo in 1994 [1]. However, at that time there was no technological solution to ensure its functioning. The emergence of the Bitcoin ecosystem in 2008 [2], and Etherium [3] in 2015 provided the opportunity for the practical implementation of the Sabo’s ideas.

Currently, the smart contracts concept is tried to be applied when working with various social and economic projects in a wide range of public relations. The smart contract is really capable of solving certain institutional problems of contracting processes management, transaction costs reduction, and ensuring a high degree of confidence in the transaction participants.

It should be recognized that there are serious limitations: firstly, it has certain technical difficulties in implementation in practice, and, secondly, there is no clear understanding, how the smart contract system can affect the macroeconomic indicators of a particular region and country as a whole.

In the framework of the study, we will focus on analyzing the macroeconomic aspect of the problem. For this purpose, we will assume that the technical and legislative problems of writing and implementing the smart contracts have already been resolved.
2. Study method

To obtain macroeconomic results, we will analyze the smart contracts system at the micro level and then we will try to aggregate the results and summarize them.

There are a huge number of approaches to the smart contract definition [4–7], in the framework of this paper we will not focus on their analysis, comparison, search for advantages and disadvantages, since they all have approximately the same value. In the framework of this paper, we will understand that a smart-contract is a computer algorithm written in a blockchain autonomously carrying out certain operations embedded in its code.

Let’s distinguish the advantages of transactions made using the smart contracts:
- autonomy and self-sufficiency;
- protection against unauthorized changes;
- transparency;
- resistance to opportunism;
- high performance rate due to the automation.

We have mentioned a partial list of the smart contract advantages, but they are quite enough to understand, how transaction costs are reduced, which impede the market mechanism functioning and create a “frictional force” in the economy.

Let’s consider the main restrictions containing in the smart contracts:
- transparency may not always be an advantage, as it provides access to confidential information;
- the “Oracle” problem (adding information to the blockchain not included in it, but is necessary for smart contract implementation);
- costs for smart contract executing (commission for blockchain validators) may vary depending on its length and the chosen platform;
- low scalability of blockchain technologies on the basis of which the smart contracts are built (several dozen operations per second).
- an error containing in the smart contract cannot be corrected if this function is not foreseen in advance, but if it is foreseen, then it becomes possible to manipulate its implementation [8].

All the considered smart contract limitations affect mainly its technical aspect. However, if we take into account the last remark about the relative impossibility of errors correction, then it becomes necessary to analyze the relations in the framework of an autonomously executable code in terms of the contracts theory. Most generally, such an approach implies the separation of perfect (“complete”) [9] and imperfect contracts [10].

The perfect contract is a contract that establishes absolutely all the parties’ rights and obligations in the future, and also distributes costs and results for all possible outcomes. The presented algorithm could form the basis of a smart contract code and function effectively in business processes. However, due to information imperfection, lack of complete rationality and limitation of computational ability of economic agents, as well as under conditions of a high level of uncertainty, it is impossible to conclude a perfect contract in practice. Therefore, in actual practice the scope of application of the smart contract is significantly limited.

It is advisable to talk about control with the help of a smart contract of individual relations within the contract as a whole (“subcontract” conclusion).

The greatest prospects for application of smart contracts are in the financial part of transactions, as well as in the relations of the parties related to the terms of obligations fulfillment (benefits, costs, penalties). Since the blockchain technology, on the basis of which the smart contracts are implemented, allows users to manage their wallets, it is possible to automate the cash transaction process, which cannot be changed. Escrow services are created that will minimize the transaction parties’ opportunism, since the facts regarding fulfillment of the obligations and their payment are key parameters of any contract (figure 1).
Figure 1 shows that at the commencement of works, the Seller has a full guarantee of financial obligations fulfillment by the Buyer, if it does not violate the goods delivery terms and quality requirements. After the Buyer confirms receipt of the goods, the funds through the smart contract are transferred to the Seller.

This pattern of interaction between participants in contractual relationships does significantly reduce their opportunism at the behavioral level. The Seller is interested in meeting the deadlines and the quality of obligations fulfillment, the Buyer is interested in timely payment, which it will not be able to block or delay in case of goods acceptance. In addition, the penalties automatically imposed and paid in the smart contract will encourage both parties to fully implement the contract as a whole.

If we imagine a chain of these smart contracts during the production of high-tech complex goods, it will gain additional stability and efficiency by reducing the level of uncertainty and opportunism of the participants. On the other hand, having a sufficiently long size, such a chain can have a negative impact on the position of its first sections. Since fulfillment of financial obligations by the second and each subsequent participant will depend on the actions of the third and all other subjects of transactions throughout the chain. Thus, despite the reduction in the opportunism of the system as a whole, there may be significant cash gaps for organizations of participants in the smart contracts chain.

This problem has a fairly simple solution through financial institutions (currently, these are the banks), which are able to eliminate the emerging liquidity squeeze. In this case, due to the system of concluded “subcontracts” (smart contracts in the financial part of the basic contract), financial intermediaries minimize their risks in terms of non-payment of loans provided.

In addition to the production part of economic activity, the smart contract may also be effective in terms of the consumption aspect. Trilateral relations between the manufacturer, the consumer and the financial institution, which are based on the smart contract, increase the transaction transparency and reduce the possibilities of opportunism for all its participants. Thus, due to the expansion of consumer lending, as well as a reduction in interest rates, due to reduced risks, consumption of goods and services produced by the region / country’s economy will increase.

The smart contracts can increase the consumption of not only private, but also public and partially public goods. Increasing the transparency of the processes for creation of such goods will promote the formation of crowdfunding mechanisms for their financing, especially in the Housing and utilities infrastructure.

Thus, the decentralized system of smart contracts available only in the new conditions of the digital economy will consist of:

1) smart contracts chain during production of complex high-tech products;
2) smart contracts in consumption of public and private goods;
3) smart contract systems for taxation and provision of public services.

3. Results
To determine the consequences of the smart contracts system implementation, we use the macroeconomic model of the commodity-money balance IS-LM. Changes in consumer spending, investment, and government procurement will shift the IS curve, while the formation of digital
financial assets (BFA) will have a significant impact on the money supply ($M_s$) in the economy, which will be reflected in the movement of the $LM$ curve (figure 2).

![Diagram of LM curve](image)

**Figure 2.** The process of the smart contracts system effect on the commodity-money balance.

Figures 2a and 2b represent the results of economic growth in the absence of the smart contract system. Figures 2c and 2d represent the GDP increment ($Y$) with a similar resource potential at the input, but under the conditions of functioning of the decentralized smart contract system.

Figures 2a and 2c show that assets digitalization will more significantly expand real cash reserves. This will lead to increasing the elasticity of money supply, since a share of money created by commercial banks (as compared with the money of the Central Bank) will increase, as well as to its shift to the right downward by a greater value than in the absence of smart contracting ($\Delta \frac{M}{P}$ figure 2a less than $\Delta \frac{M}{P}$ figure 2c). In figures 2b and 2d one can see a more significant increase in GDP.

To assess the possible trends of the smart contracting impact on the economic system, let’s consider the gross domestic product (GDP) indicator [11–15]. To assess it, let’s use the equation (1):

$$Y = C + I + G + N_x,$$

where $Y$ is a value of GDP, $C$ is consumer spending of households, $I$ is an amount of gross investment, $G$ is a size of government purchases, $N_x$ is net export.
Component analysis of the formula (1) allows identifying the main sources of GRP growth. Let us start with an analysis of investment potential.

Consumer spending will be based on two sources of growth: an increase in household incomes due to increased production and advanced lending opportunities. Herewith, there will be an increase in consumption of private and public goods.

Let’s determine a potential amount of additional consumption in the Russian Federation, which is able to provide smart contracting. For the purposes of this analysis, we will assume that digital financial assets (DFA) are in the field of legal regulation and can be a subject to civilian circulation. The most significant contribution to the GDP growth will be provided by the consumption of durable goods with high added value. The growth in consumption of such products can be achieved through the digitalization and tokenization of the population’s assets.

Dwelling as one of the most expensive assets of citizens often requires significant funds for its maintenance. The creation of digital assets tied to the value of an individual dwelling, will, firstly, increase the liquidity of the real estate asset, and, secondly, ensure its divisibility. In other words, at any time, when the consumer (the apartment owner) needs funds, he/she can use tokens secured by the value of the own property. Conceptually, even very low-value goods can be purchased with these funds, since the DFA, unlike real estate, can be divided into many small parts.

While releasing their own DFA, the property owner sells them to the bank. From the point of view of a credit organization, this operation has the same consequences as landing that is the money supply in the country increases due to the creation of “credit money” by a commercial bank, which, unlike the DFA, can act as a legal tender in the Russian Federation.

To assess the money supply growth potential due to the processes of assets digitalization, let's consider the total cost of dwelling in our country. According to the Federal State Statistics Service in the Russian Federation, at the end of 2017, 65.9 million apartments with an average area of 55.3 m² were registered in the country [16]. The average cost of apartment per 1 m² for the same period was 52,350 rubles [17]. The product of these three quantities makes it possible to assess a potential amount for DFA creation, which amounts to 190.8 trillion. rub. Herewith, a debt for residential loans according to the Central Bank of the Russian Federation at the beginning of 2018 is 5.2 trillion. rub. (about 3% of the total cost of dwelling) [18].

Herewith, it is necessary to understand that the realization of the consumption potential due to the 100% digitization of population’s assets is associated with high risks. Citizens may miscalculate a credit risk and lose their most expensive asset - dwelling through the smart contract. This can lead to serious social consequences. Thus, operations regarding digitization of citizens’ assets should be strictly controlled at the legislative level and have a limited list of trends for the use.

For example, due to the DFA release, the owners of an apartment building can modernize the utility systems, which will lead to savings in the maintenance and operation of real estate. These savings can be oriented to the redemption of their own tokens from the bank.

The formation of the “residential” tokens market in the future will allow to rent the own dwelling at a time when it is not used by the owner (for example, during a vacation or business trip). As a result, we will get an additional source of GDP growth. In the same way other assets of citizens can be used: transport vehicles, furniture, household appliances, etc.

Effective demand and additional incomes of the population (through savings taking into account the multiplication effect) will promote a new expanded wave of investments, which will provide another increase in income, consumption and savings [21]. This process will be cyclical.

The next component of GDP, which is considered in the equation (1), is gross investments. On the basis of the analogy with the consumer potential, we use statistical data to assess a potential amount by which the organizations of the Russian Federation are capable of releasing the DFA. At the end of 2017, the fixed assets of the Russian Federation at full accounting value amounted to 197.3 trillion rub. [19]. A loans amount granted to legal entities including individual entrepreneurs at the beginning of 2018 amounted to 30.5 trillion rub. [20]. Therefore, an amount of fixed assets free of the loan is
equal to 166.8 trillion rub. The creation of “money” by commercial banks through the buyout of enterprises' DFA will proceed in the same way as in the case of consumers.

A huge development potential has the development of the fixed assets tokens market in the future. Specific equipment, as a pledge subject to the existing method of lending to enterprises, has very low liquidity; therefore, it cannot be either collateral at all, or a very large discount is applied to its value.

In the case when a bank acquires the company DFA issued on the basis of its fixed assets, it receives the right to use these funds for a certain period, which can be implemented through a sale to third parties. Now it is not necessary to find a buyer for a specific asset, it is enough that there is a periodic need for a product obtained by using such a resource. This operation will be as follows. First of all, the company creates the DFA as an obligation to provide the right to use its fixed assets in the agreed time frame. These liabilities are acquired by a commercial bank from which the assets of the balance are increased by this amount. In the liabilities increases the deposit of the company - seller of tokens. If we abstract for a time from charging of obligations interest, since the economic essence of such relations will not change due to this. The money supply in the economy has increased, and this increase has occurred, in essence, at the expense of “credit money”. The organization now has the funds to make investments that should be oriented:

- to fixed assets,
- to the human capital of the company.

Investing “new” money will create an opportunity to expand gross output in the country.

On the other hand, the smart contract will improve the structure of the enterprises balance by reducing the size of overdue receivables, revenues increasing and uncertainty reduction in the field of short-term debt. As well as this will have a positive effect on the level of investments in fixed assets and stocks.

The smart contract can be used in the field of taxation. Earlier, we showed that digitalization of only immovable assets of citizens (excluding multiplication) is able to accumulate the funds amount that exceeds the federal budget of the Russian Federation by ten folds. Thus, the process of creating separate public goods can be carried out by local residents. In this case, such activity can be promoted by exempting citizens participating in it from a part of tax payments.

For example, residents decide to build a roads network in their own city. They release digital tokens provided with their own vehicles. Banks consortium buys these DFA, creating deposits for citizens, which will be spend to build the network of roads. In this case, citizens receive:

1) high-quality road surface in the city (saving on repairs and maintenance of vehicles, reducing accidents and traffic congestion, etc.);
2) zero rate for transport tax and gasoline excise;
3) savings on the administration of budgetary funds (tax collection, redistribution processes, corruption, ineffective management in financial administration, etc.).

In the same way, schools, hospitals, kindergartens, the entire social infrastructure, housing and utilities facilities, etc. can be created. In this case, the state role can be limited, as it is supposed, to the arbitrator role, who exclusively applies the right to violence, as well as who ensures the national defense.

The gross output increase that has been justified earlier will allow increasing a share of exports in the foreign trade balance. Thus, a value of \( N_x \) from the formula (1) will also increase.

The decentralized smart contracts system (in the areas of consumption, investment and taxation) can have a significant impact on GDP increase. Let’s try to estimate the growth rates of this output in advance, focusing on the potential volumes of funds generated by commercial banks as a result of the DFA acquisition obtained in section 3.

The consumers' DFA excluding the encumbered assets value amounted to 185.6 trillion rub., we estimated this indicator at a rate of 166.8 trillion rub. for enterprises. Taking into account the money multiplier, which is estimated at 2.4 for our country, as well as a discount rate of 0.4 applied by commercial banks to the collateral value when issuing loans, we get (2):
We assume that the smart contract system implementation will take at least 20 years to update technology it is based on, to adapt it among the consumers, manufacturers and government agencies, and restructure the processes of consumption and production. Then a size of Russian GDP being 92 trillion rub. in 2017 amounted to 507.5 trillion rub. In 2037, it should be growing at a rate of 8.9% per year. In this paper, we showed that all the necessary financial resources to ensure these high rates of GDP growth are available. The only question is that how these resources will be spent, whether the necessary level of investment in fixed assets and human capital of enterprises of all forms of ownership will be secured.

4. Conclusions
The performed analysis shows that the smart contract system cannot fully replace the contracting system due to the incompleteness of all existing contracts. However, their implementation into the financial part of transactions can have a significant positive impact on the macroeconomic indicator of GDP by transparency increasing, reducing the uncertainty level and minimizing the opportunism costs.

The used macroeconomic model IS-LM makes it possible to clearly assess the consequences of assets digitalization and smart contracts system implementation, which will be expressed in the GDP growth acceleration. It is important to note that this growth will be of an intensive type, since its implementation does not require an increase in the stock of available resources.

5. Trends of further studies
Based on the results of this study, it is further planned to analyze the conditions that may have a negative impact on GDP growth in the process of resident assets digitization. As well as the issue of quantitative and qualitative sufficiency of non-financial resources available in the Russian Federation shall be considered to ensure the growth of the gross output calculated above. It is also necessary to develop the DFA markets functioning models under the sharing economy.

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