MODEL FOR REGULATING THE REPRODUCTION PROCESS IN THE ECONOMY

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Abstract. The authors analyze the regulation of the reproduction process in the real and financial sectors of the economy by variations in the amount of cash in circulation and through the investment policy of the state, as well as the consequences of the collapse of the market value of securities. The production sphere is shown to unite the production system (production), banking system, market system, domestic households, and the rest of the world. It is shown that the regulators of the economic reproduction are the banking system that provides credits to production and the necessary amount and velocity of money in the real sector, the financial sector that is selling securities for cash and investing in production, and the state that pursues an investment policy for the expanded reproduction of production capital. The reproduction process of the economy of Ukraine is modeled for 2022–2024 by the statistical data of 2020 and 2021.

Keywords: reproduction, economy, regulation, market, equilibrium, labor, capital, money, interest rate, exchange rate, crisis, inflation, targeting.

INTRODUCTION

The foundation of a country’s economy and the source of its growth in the reproduction process is the production sphere of the real sector in conjunction with the financial sector. In accordance with Robinson’s hypothesis concerning the leading role of the real sector demand, demand acceleration in the real sector leads to an additional demand for financial sector services caused by the economic investment needs exceeding the capabilities of individual investors and the businesses’ own money reserves [1]. The financial sector of the economy created based on the real sector is usually divided into the two following parts: the banking system that ensures the functioning of the real sector and financial corporations that increase the value of securities in speculative operations. Note that the increase of financial market importance in the economy and the possibility of uncovering negative consequences due to ineffective functioning are general. Significant differences take place around the position on the necessity of state and supra-state regulation [2, p. 75]. The authors believe that the banking system is part of the real sector and that, in view of this, the financial and the real economy sectors have to be separated. If, at first, financing in economic relations was of a derivative nature (financial mediation), then financing is accumulating potential value in the modern time. It is independent of the real economic sector and can transform factors of time and waiting and socio-economic and political parameters of a country into value [2]. Beginning from the 1980s, the financial sector as a speculative money accumulation source for investment into production become a significant source for the growth of production factors and of the gross domestic product (GDP) in the developed countries. As a result of the overproduction crisis in 1980–1981, the real GDP of the developed countries decreased by 7–8%, exposing a long-term trend of production capital overaccumulation and the crediting possibility limitations of the banking system. To overcome the crisis through the investment volume increase by the...
financial sector, new worldwide neoliberal monetary regulations limiting the regulatory role of the state in the economy and liberating markets from the state control [3] were introduced. The need of the developed countries for investments for the expanded reproduction caused a sharp increase of assets in the financial sector created by the USA and other developed countries, ensuring their 1970s stagflation and 1980–1981 crisis recoveries, as well as their explosive economic growth until 2007. During the explosive growth of monetary mass due to the hypertrophied speculative financial sector expansion, the developed countries transformed into the highly developed countries. However, only 5% of the financial sector is covered by deposits and the banks’ own capital, while the other 95% of its assets are comprised of the secondary and tertiary securities of investment and mortgage banks, clearing houses, and stock exchanges. This led to the economic collapse in 2008 due to the credit crisis of the banking system that developed into the global worldwide systemic financial crisis continuing to this day and that coincided with the crisis of 2020 conditioned by the COVID-19 pandemic. A country’s economy in the state of recession or depression can either stably grow due to changes in inflation within the expanded reproduction of production factors or it can enter the state of deflation [4, 5]. By decreasing the amount of cash in circulation in the real sector, the financial sector decreases inflation and can cause deflation, while the amount of cash that increases during the fall of the market value of securities and their selling on the market by their owners can lead to hyperinflation. The possibilities of the neoliberal monetary order were depleted by 2008 because of the lack of financial sector investments into production due to its falling revenue and due to the significant increase of the securities speculation revenue. Due to restricting the regulatory role of the state that led to the financial sector transforming into the revenue source based on securities speculation and harming the production sphere, the highly developed countries could not reach a sustainable economic growth for 12 years being in the state of depression and the global financial crisis. “The conflict between the key goals of the state economy regulation stipulates the objective necessity to streamline economic interests and to coordinate the efforts of all the interested subjects of the economy. One of the most important tasks of modern state politics in relation to securing a sustainable economic growth for a country is to determine efficient integration directions and to harmonize the interests of subjects of different economic systems. The economic relation structure includes multilevel systems and subsystems whose main feature is the plurality of needs of subjects, i.e., carriers of different interests” [6, p. 43–44].

This article examines reproductive process regulation in the interaction of the real and financial sectors in a country’s economy due to changes in the cash amount in circulation and the investment and regulatory state policies, as well as determines the consequences of securities value collapse.

ECONOMIC STRUCTURE

The economic structure is depicted in Fig. 1. The real economy sector consists of production and non-production spheres. The non-production sphere (the state) includes state regulation, the army, science, education, medicine, and other state institutions. The state receives taxes from the production $H_{pr}$, domestic households $H_{hh}$, and financial sector markets $H_{FS}$, which is the source of the budget revenue. It buys the necessary goods and services $C_{s}$ from the goods and services market and it hires workers from the labor market of the value $WN (1 - \xi)$ with the nominal wage rate $W$ and the number of workers $N (1 - \xi)$ where $N$ is the number of workers in the economy and $\xi$ is the number of workers in production.

The production sphere combines the production system (production), the banking and market systems, foreign countries, and domestic households [4, p. 86–87]. “The production sphere is a combination of the production system (production), the market and banking systems.” [5, p. 189]. Domestic households encompass the whole population of a country in the form of familial household units whose activity is aimed at ensuring the functioning of the economy, consuming goods and services of the value $C_{hh}$, raising children (i.e., reproducing a country’s population), and increasing their own prosperity [7]. Depending on the number of workers in the economy $N$, domestic households are paid a wage $WN$, pay state income taxes $H_{hh}$, get a retirement (live) provision $L$ and a social provision $P$ from the state, consume goods and services from the goods and services market of the value $C_{hh}$, and buy securities $\Phi_{hh}$ at the financial sector market with cash. Foreign countries influence the economy through buying and export $E$ of goods and services on the goods and services market, as well as their selling and import $Z$ and currency operations on the money market. Money streams, towards which goods streams are directed, are designated by arrows in Fig. 1.
The financial sector is a sector of financial corporations. It includes securities markets that function on account of loans for stocks $\Xi$ and other primary securities issued to production by commercial banks that testify to the ownership rights over production capital. Through stock exchanges, clearing houses, and mortgage and investment banks of the financial sector, commercial banks offer primary securities available to them due to issued loans for sale to financial sector corporations for the sum of $\Xi$. On the basis of the bought primary securities, financial corporations issue and sell their secondary and tertiary securities for cash for the sum $\Phi n$. The purpose of the financial sector is the redistribution of free cash money in the economy between its subjects. The driving force of the financial sector is the speculatory factor of economic subject demand for securities in order to generate profit under their exchange rate growth.

**REPRODUCTION PROCESS REGULATORS**

Domestic households are property (production capital) owners in the production sphere, with each of them entitled to their own share proportional to the value of their stocks. That is why they are the owners of the net gain $\Psi$ from the
capital involved in production. To create and sell goods and services in the production sphere, there exist companies registered in accordance with the current registration. To increase their own prosperity in the future, domestic households direct a part of their net profit from the capital to the expanded reproduction in the form of net investments. The hired entrepreneurs who run companies strive for the maximum stock market value providing stockholders with maximum income. Stock prices are the indicator of a company’s management quality. If stockholders are displeased with the results of their company’s management, they can sell their stocks and invest their money into a different and more successful company or into buying financial sector securities. Companies that produce and sell goods and services buy means of production on the goods and services market of the value \( R = J + A \) that is equal to the sum of investments \( J \) and depreciation of the involved capital \( A \). They buy work objects of the value \( u \) and hire workers on the labor market of the value \( \Pi \) in accordance with the nominal wage rate \( W \) and the number of workers \( \Pi \). Companies enjoy tax benefits determined by the budget law, namely, tax-free investments, and discounts on the accelerated amortization rate that exceeds the real amortization rate in the economy, as well as the fact that interest payments on loans are part of the directed production expenses. Companies determine production volumes under the condition of obtaining the profit if the consumer demand conjuncture is present. The results of companies selling their goods and services, namely, their aggregate product of the value \( q \) with the deduction of the price \( o \) of the work objects paid for by them, determine the value added by the production, i.e., the nominal GDP of the country \( \omega = q - o \) that is equal to the nominal consumer demand of all the subjects of the economy within the considered time period as follows:

\[
\omega = P \Omega = C_{hh} + J + A + C_s + E - Z,
\]

(1)

where \( \Omega \) is the real GDP and \( P \) is the GDP deflator, i.e., the index of the price level within the considered period.

The real GDP growth within the considered period \( t \) is determined by the function \( \delta_t = \Omega_t / \omega_{t-1} - 1 \). Price index variation as compared to the index of the previous period that is taken to be a one determines the inflation as \( p = P - 1 \) [4, 5, 7–11]. The nominal GDP value that is equal to the product of the amount \( M1 \) and the velocity \( \mu \) of money circulation in the real sector determines and constrains the nominal consumer demand on the goods and services market [4, 5, 7–12] as follows:

\[
\omega = M1 \mu = P \Omega.
\]

(2)

The amount of money circulation in the real sector is equal to the sum of cash \( M0_{RS} \) and deposits \( D1 \) on demand, \( M1 = M0_{RS} + D1 \). The equilibrium on the goods and services market is sustained by the fact that the value of the goods and services sold by the entrepreneurs is equal to the value of goods and services bought by all subjects of the economy in accordance with (1) and that it is feasible in case of inflation, \( p = P - 1 > 0 \) [4, 5, 7, 8, 11]. After deducting the depreciation \( A \), the production tax \( H_{pr} \), and the paid wages \( W \Pi \) from the nominal GDP value, the net profit in the production sphere is determined as follows:

\[
\Psi = \omega - A - W \Pi - H_{pr}.
\]

(3)

The main production investment source is the depreciation \( A = P \theta K \) of the involved in production capital of the value \( K \) with respect to the depreciation rate \( \theta \). Entrepreneurs who use depreciation for other purposes destroy their production due to the capital devouring. The real net profit is determined in accordance with (3) with the rate \( \chi \) of the tax \( H_{pr} = \chi Y \) on the production profit \( Y = \omega - A \), \( \Psi = \Psi / P = (1 - \chi)(\Omega - \theta K) - w \Pi \) where \( w = W / P \) is the real wage rate. In accordance with the depreciation rate of the simple capital reproduction \( \tilde{\theta} = [\Omega - w \Pi / (1 - \chi)] / K \), the net profit is equal to zero, and the real net profit law is determined as follows:

\[
\Psi = K (1 - \chi) (\tilde{\theta} - \theta).
\]

(4)

There is an optimal rate of the production profit tax \( \chi_{opt} \), for that the tax is equal to the net profit \( H_{pr} = \chi_{opt} Y = \Psi^* \), ensuring a continuous yearly production and state budget profit growth [13]. In accordance with the depreciation rate of the simple capital reproduction, \( \theta = \tilde{\theta} \), as well as investments that are lower than the depreciation, \( R_{pr} < A \), only contracted capital reproduction is feasible, i.e., capital devouring takes place. The depreciation rate
boundary is the capital retirement norm \( \theta_{ret} \) determined by its physical deterioration and obsolescence. Within the limits of \( \theta_{ret} < \theta < \bar{\theta} \), the accelerated capital depreciation takes place, stimulated by the tax benefits. The depreciation rate lower than the capital retirement norm \( \theta < \theta_{ret} \) reduces the available in the production sphere capital by the underdepreciation value, \( \Delta = (\theta_{ret} - \theta)KP \). The net profit is used by the companies for net investments \( J_n \), capital profit payments to domestic households \( \Pi_{hh} \), and securities acquisition \( \Phi_{pr} \). Net investments \( J_n = \psi KP(1 - \chi)(\bar{\theta} - \theta) = \psi \Pi \) are regulated by the state in accordance with (4) by the rate \( \psi \) of the net profit through incentive taxation. The state regulates investments \( R \) for the purpose of expanded production capital reproduction through production investment benefits \( R_{pr} = J_n + A \), direct state budget investment into production \( J_s \), tax-free financial sector investment \( J_{FS} \), tax on issuing secondary and tertiary securities \( H \). The tax on securities \( H \) is necessary to eliminate contradictions between the real and financial sectors. Investment regulation by the state through tax benefits can standardize financial sector investments \( J_{FS} \) into production through the ratio \( J_{FS}/\Phi_{pr} \) that is, for example, no less than 30%.

The market value feedback, namely, inflation \( p \), facilitates equilibrium self-regulation on the goods and services market through consumer demand (1) restricted by the amount of money in the banking system. The feedback fluctuates due to the consumer demand conjecture that is equal to the product of the market and risks and stimuli conjectures. The monetary security of the real sector is determined by the banking system state that ensures market equilibrium under the expanded production capital reproduction through inflation within the limits determined by the Central Bank, as well as the real GDP growth [4, 5]. In accordance with the volume of previously produced goods and services, the entrepreneurs determine the market conjuncture \( \mathbb{A}_m = \delta_{t-1} - \delta_{t-2} + 1 \) that is changed proportionally to the conjecture of risks and stimuli \( \mathbb{R}_{rs} \) and form the conjuncture of demand in the analyzed period \( \mathbb{R} = \mathbb{A}_m \mathbb{R}_{rs} \) [4, 5, 7, 8, 11, 12]. The entrepreneurs change the number of workers for the period \( t \) proportionally to the conjuncture of consumer demand \( \Pi_t = \Pi_{t-1} \mathbb{A}_t \) and the coefficient of use of the available in production capital \( v_t \) is proportionally changed as a result as follows:

\[
v_t = v_{t-1} \Pi_t / \Pi_{t-1} = v_{t-1} \mathbb{A}_t. \tag{5}\]

The value of the available in production capital \( K_{pr} \) is determined by function [4, 5, 7, 8, 11, 12] as follows:

\[
K_{pr} = P_{t-1}K_{pr\ t-1} + R_{t-1} - \Delta_{t-1}. \tag{6}\]

From here, the value of the involved in production capital is determined in accordance with (5) and (6) as \( K = v_{t-1} \mathbb{A}_t K_{pr} \). Fluctuations of the conjuncture of consumer demand cause periodic fluctuations of the worker number and the available and involved in production capital, which results in the real GDP and its nominal value fluctuating through inflation [14]. Production obtains a monetary reward for the sold goods and services that is equal to the product of the real GDP \( \Omega \) and the price level \( P \) in accordance with (2). Based on the deflator value of the GDP \( P \), the Central Bank determines the inflation within the considered period \( p = P - 1 \) and targets inflation in the future period based on the target value by changing the amount of money in circulation \( M1\mu \) [4, 5].

There are the following economy reproduction regulators:

- the banking system that issues loans to production and ensures the amount of money in circulation \( M1 \) and its circulation velocity \( \mu \) for the considered time period in the real sector in order to guarantee monetary security;
- the financial sector that sells securities \( \Phi_{pr} \) for cash, invests into production \( J_{FS} \), and pays taxes on issuing securities \( H_{FS} \);
- the state that implements investment policies for the expanded production capital reproduction of the value \( R = J_n + A + J_s + J_{FS} \).

**FUNCTIONING OF THE REAL SECTOR**

Creation of money in the real sector by the dual bunking system is determined by the monetary base \( H \), minimum reserves \( M_m \), surplus reserves \( H_m \), bank loans \( \Xi \) and deposits \( D \), and cash \( M0_{RS} \). Bank deposits combine deposits on demand \( D_1 \), fixed-term deposits \( D_2 \), and long-term deposits \( D_3 \), \( D = D_1 + D_2 + D_3 \) [4, 5, 7, 8, 10–14]. Monetary mass
includes three aggregates in the real sector where \( M_1 = M_{0RS} + D_1 \) is the sum of cash and on-demand deposits, \( M_2 = M_1 + D_2 \), and \( M_3 = M_2 + D_3 \). The money creating process is determined by the following equation in accordance with the banking system equilibrium \( \varepsilon \) and the loans \( \Xi \) issued by the bank: 
\[
H = M_{0RS} + M_m + H_m \quad \text{and} \quad \varepsilon = M_3 - H - \Xi.
\]
If coefficients \( \alpha = (M_m + H_m) / D_1 \) (the determined reserve norm) and \( \beta = M_{0PC} / D_1 \) (cash to on-demand deposit ratio) are introduced, we obtain \( M_{0RS} = M_1 \beta / (\beta + 1) \), and the process of creating money by the banking system is determined by the following equations:
\[
H = (\alpha + \beta)D_1; \quad \Xi = M_3 - H - \varepsilon.
\] (7)

From here, the equivalence of the sum of cash and on-demand deposits to the product of the money multiplier \( m = (1 + \alpha) / (\alpha + \beta) \) and the monetary base \( H \) \([4, 5, 7, 8, 11, 12]\) follows:
\[
M_1 \equiv mH. \quad (8)
\]

The sum of cash and on-demand deposits \( M_1 = M_{0RS} + D_1 \) does not depend on the monetary base changes. If the money reserve \( \varepsilon > 0 \) is present, bank loans that enable the functioning of the financial sector do not exceed the loan base \( \Xi \) in accordance with (7) that is equal to the deposit sum with deducting the reserves, \( \Xi = D - M_m - H_m \) \([4, 5, 7, 8, 11–14]\). If the loans \( \Xi \) issued by commercial banks are higher than the bank deposits \( D \), then, in accordance with (7), \( (\varepsilon < 0 \text{ for } \Xi > D) \) becomes the banking system equilibrium \( \varepsilon = \Xi - \Xi \). Then, the credit crisis takes place, i.e., a situation when depositors have no possibility to have their deposits returned to them, banks stop issuing loans to production and to each other, and the Central Bank remains the only lender. The banking system equilibrium in the country that is determined by the presence of the money reserve \( \varepsilon > 0 \) is feasible under the condition of the presence of commercial bank loans \( \Xi \) in accordance with (7) that do not exceed different monetary masses and bases
\[
\Xi \leq M_3 - H \text{ for } \varepsilon > 0. \quad (9)
\]

By accumulating the monetary base \( H \) by increasing surplus reserves, Central Banks decrease the loan base, deepening the credit crisis. In accordance with the issued loans \( \Xi \), we obtain the sum of cash and on-demand deposits \( M_1^* \) that is minimally necessary to conduct purchase and sale transactions \( M_1^* + D_2 + D_3 \geq \Xi + H \). Thus, the money amount in circulation \( M_1^* = mH - \varepsilon \) that is minimally necessary to conduct purchase and sale transactions is determined in accordance with (7) and (8) \([4, 5, 7, 8, 11–14]\). If the reserve \( \varepsilon \geq 0 \) that is formed using cash, i.e., inflation, is present, then, in accordance with (8), the speculative demand for securities \( \Phi \) does not influence the sum \( M_1 \) necessary for purchase and sale transactions on the goods and services market as \( M_1 \equiv mH \geq M_1^* \), as well as the functioning of the real sector. This allowed the financial sector to accumulate securities speculation volumes under the neoliberal order without violating the monetary safety of the real economy sector for 30 years till the credit crisis of 2008. During the loan crisis, the reserve \( \varepsilon < 0 \) does not exist. Thus, the available amount of money is lower than the money amount in circulation that is necessary to conduct purchase and sale transactions on the goods and services market and to repay the banks for their issued loans \( M_1 \equiv mH < M_1^* - \varepsilon \) for \( \varepsilon < 0 \), leading the real sector to enter the state of depression due to the monetary security violation. Thus, deflation takes place \([5, 7, 8]\). In accordance with (9), overcoming the credit crisis is feasible by increasing the amount of money in circulation and deposits in the necessary amount to conduct purchase and sale transactions and by paying back loans, i.e., with the growth of inflation. The financial sector investments conducted by the USA could not ensure the expanded economic reproduction after 2007. As a result, the credit crisis took place, which transformed into the global financial crisis, leading to the financial market collapse. In order to facilitate economic recovery, state regulation was introduced through injecting money by means of the United States Department of the Treasury and the Federal Reserve (Fed) buying up bank loan debt (toxic debt) and securities (dubbed quantitative easing) \([15]\). In January 2015, the European Central Bank (ECB), led by the example of the Fed, adopted and started in March of the same year the belated by six years massive quantitative easing program in the amount of 1.1 trillion Euros and in the volume that allowed a monthly asset acquisition valued at 60 billion Euros \([16]\). In March 2016, the quantitative easing was increased to 80 billion Euros per month. In December 2016, the Governing Council of the ECB left interest rates at zero and confirmed the program continuation in relation to buying assets. “The Governing Council decided to restart net purchases under its asset purchase programme (APP) at a monthly pace of 20 billion Euros as from
1 November 2019. We expect them to run for as long as necessary to reinforce the accommodative impact of our policy rates, and to end shortly before we start raising the key ECB interest rates” [17]. To recover from the financial market collapse and the economic downturn triggered by the COVID-19 pandemic in 2020, state regulation measures were implemented. “After the sharp collapse triggered by the pandemic, through the unprecedented stimulation programs implemented by governments (valued at around 12 trillion USD by the IMF) and Central Banks (with the balance of the largest world Central Banks increasing by more than 8 trillion USD starting from February), financial markets found themselves overflowing with cheap liquidity, as well as the assuredness that even companies with deep financial problems will be provided assistance in order to support employment and to prevent mass bankruptcies. This became a very fertile ground for the renewed securities demand” [18]. However, overflowing liquidity leads to higher inflation. In November 2021, consumer market prices in the US rose by 0.8% a month and by 6.8% in a year, making it the maximum indicator since June 1982. “Inflation acceleration can push the Fed to cut asset acquisition in half, i.e., to 30 billion USD per month starting from January. This will allow the Fed to start raising interest rates in spring 2022” [19].

Money market equilibrium is feasible under the condition that the money amount $M1\mu$ in circulation that is analyzed within the time period is equal to the nominal consumer demand $P_{mn}$

$$M1\mu = P_{mn}\Omega,$$  

(10)

where $\Omega$ is the real consumer demand and $P_{mn}$ is the money deflator.

If the money deflator is less than one, then the nominal consumer demand is not satisfied without raising the money value. Thus, money market equilibrium is violated and money deflation takes place $P_{mn} = P_{mn} - 1 < 0$. Inflation-free cash $\overline{M}0$, i.e., cash under zero inflation ($p = 0, P = 1$) within the considered time period, is determined in [4, 5, 8, 11, 12] by the following function:

$$\overline{M}0 = \Omega(1 - \varphi)^{1/\ln k_0} / (\mu(\beta + 1)),$$  

(11)

where $\varphi$ is the actual unemployment level, $1/\ln k_0$ is the production technology coefficient, $k_0 = K / \Pi_0$ is the equilibrium capital intensity of labor, and $\Pi_0 = \xi N_0$ is the number of workers in production under the full population employment $N_0$ in the economy. The difference between the full employment $N_0$ and the actual number of workers $N$ determines the actual unemployment $f_a = N_0 - N$ and its level as follows:

$$\varphi = (N_0 - N) / N_0.$$  

(12)

It can be assumed that the optimal labor supply $N^S$ is equal to the full population employment number $N_0 \approx N^S \left[ w / (1 + n) \right] = 0.46T$ where $w = W_{th} / (TP)$ is the real domestic household profit from capital per citizen, $T$ is the population number, and $n$ is the income retirement tax rate [4, 5, 7, 8, 11–14]. Thus, in accordance with (12), the unemployment level is determined if the population $T$ and the worker numbers $N$ in the economy are known.

The real GDP is approximated by the following function of the worker number engaged in production $\Pi_0$ and the involved capital value $K$:

$$\Omega = \sigma Q = \sigma Q 1^{1/\ln k_0} K^{1-1/\ln k_0},$$  

(13)

where $Q = q / P$ is the real aggregate product and $\sigma = \omega / q$ is material intensity of production, i.e., the nominal GDP share in the aggregate product [4, 5, 7, 8, 11–14].

The real consumer demand $\overline{\Omega}$ is measured by the real GDP under the full population employment in the economy $N = N_0$, i.e., according to (12) and (13)

$$\overline{\Omega} = \sigma Ke^{-1},$$  

(14)

where $e = 2.71828$ is the natural logarithm base [4, 5, 7, 8, 11–14].

Under the condition of goods and services market equilibrium, the nominal consumer demand $P_{mn} \overline{\Omega}$ is equal to the optimal monetary supply of goods and services $P\Omega$

$$\omega = P_{mn} \overline{\Omega} = P\Omega.$$  

(15)
The market equilibrium takes place under the equilibrium condition on the money and goods and services markets and the presence of unemployment on the labor market \([4, 5, 7, 8, 10–14, 20, 21]\). The production deflator is determined in accordance with (13) and (15) through the ratio of the real consumer demand to the real GDP \([4, 5, 7, 8, 11–14]\)

\[
P_{pr} = \frac{\bar{\Omega}}{\Omega} = \left(\frac{N_0}{N}\right)^{1/k_0} = (1-\varphi)^{-1/k_0},
\]

as well as the GDP deflator that is equal to the product of the money and production deflators \(P = P_{mn} P_{pr}\). The GDP deflator or the inflation \(p = P - 1\) taking place as a result of the Central Bank regulating the amount of money in circulation and the inflation self-regulation of the equilibrium on the goods and services market is the following function of the money deflator and the unemployment level:

\[
P = P_{mn} (1-\varphi)^{-1/k_0}.
\]

Depending on the determined by the Central Bank interest rate \(i\) and if there is demand for money \(M_1\) in the real sector, the money circulation velocity is determined in \([4, 5, 7, 8, 11–14]\) by the function

\[
\mu = \sqrt{2i/b}.
\]

where \(b = b/\bar{\Omega}\) is the normed cost of money withdrawal from a bank account and \(b\) is the real cost of money withdrawal from a bank account.

If the amount of money in circulation in the real sector \(M_1\) and the ratio \(\beta\) of cash \(M_{0RS}\) to on-demand deposits \(D_1\) are present, the cash in circulation \(M_{0RS} = M_1\beta / (1+\beta)\) is determined within the considered period. Within the considered period, the cash \(M_{0cc}\) (currency cash) that decreases inflation is spent on the currency operations of the country’s money market. Increasing the amount of cash in circulation \(M_{0RS}\) leads to inflation growth, while expenses for the currency cash can lead to money deflation. Based on the exchange rate \(\lambda\) (UAH/USD), the necessary amount of currency cash \(M_{0cc}\) for conducting currency operations depending on the currency balance \(S = \gamma E_e + E_{CB} + E_t - Z_{CB} - Z_z\) is determined in \([4, 5, 9, 12]\) as follows:

\[
M_{0cc} = \lambda S = \lambda(\gamma E_e + E_{CB} + E_t - Z_{CB} - Z_z),
\]

where \(E_e\) is the exporter’s currency gain, \(\gamma\) is the coefficient of currency inflow into the market from exporters, \(E_{CB}\) is the market currency inflow from the Central Bank, \(E_t\) are transfers from abroad and foreign investments, \(Z_{CB}\) is the demand for the Central Bank currency, and \(Z_z\) is the demand for the importer’s currency. For the sake of simplicity, let us assume that the demand for the currency of loan payers \(S_z\), foreign economy investors \(U_z\) and population \(L_z\) evens out by the currency supply, i.e., by borrowers of foreign loans \(S_e\), foreign investors \(U_e\), and population \(L_e\), i.e., \(S_z + U_z + L_z = S_e + U_e + L_e\).

In accordance with (17), (10), and (11), the real sector cash \(M_{0RS}\) to the inflation-free cash \(\bar{M}0\) ratio is equal to the GDP deflator

\[
M_{0RS} / \bar{M}0 = P_{mn} (1-\varphi)^{-1/k_0} = P.
\]

The necessary cash amount in the real sector within the considered time period \(t\) is determined by the Central Bank regulation (targeting) of the inflation \(p\) and actions on the currency market in accordance with (19) \([4, 5, 9]\). The sum of the cash obtained through currency market actions \(M_{0cc}\) and the cash obtained through inflation regulation \(M_{0ic}\) (inflation cash) is equal to the difference between the available cash \(M_{0RS}\) and the cash \(M_{0RS,t-1}\) from the previous period \(t-1\)

\[
M_{0cc} + M_{0ic} = M_{0RS} - M_{0RS,t-1}.
\]

The inflation cash is equal to the difference between the available cash \(M_{0RS}\) and the cash for the inflation-free consumer demand

\[
M_{0ic} = M_{0RS} - \bar{M}0 = M_{0RS} - M_{0RS,t-1} - M_{0cc}.
\]
From (20) and (22), the inflation \( p = P - 1 = (M_{0_{RS}} - \bar{M}_0) / \bar{M}_0 = M_{0_{ic}} / \bar{M}_0 \) is determined. From here, in accordance with (11), (14), and (21) and based on the production technology coefficient \( 1 / \ln k_0 \), the inflation function is determined based on the cash amount in the real sector, cash to on-demand deposit ratio, currency cash, interest rate, the value of the involved in production capital, the production input-output coefficient, and the unemployment level [5] as follows:

\[
p = \frac{e(M_{0_{RS}} - M_{0_{RS},-1} - \lambda S)(1 + \beta) \sqrt{2i/\bar{b}}}{\beta \sigma K (1 - \varphi)^{1/\ln k_0}}.
\]  

(23)

INFLATION DEPENDENCE ON THE FINANCIAL SECTOR CASH

Financial sector cash is determined by the sum of securities bought by subjects of the economy with its investments flowing into production

\[
M_{0_{FS}} = \Phi n_{cb} + \Phi n_{hh} + \Phi n_{pr} - J_{FS}.
\]  

(24)

The real sector cash decreases by the value \( M_{0_{FS}} \) as compared to the cash in the economy \( M_0 \)

\[
M_{0_{RS}} = M_0 - M_{0_{FS}}.
\]  

(25)

If it is assumed for the sake of research simplification that production demand for securities is balanced through financial sector investments \( \Phi n_{pr} = J_{FS} \), then, in accordance with (24) and (25), we obtain the value of cash in the real sector and the variation of cash amount in the financial sector \( \Delta M_{0_{FS}} \) within the considered period (usually a year) as follows:

\[
M_{0_{RS}} = M_0 - \Phi n_{cb} - \Phi n_{hh};
\]

\[
\Delta M_{0_{FS}} = M_{0_{FS}} - \Phi n_{cb, t-1} - \Phi n_{hh, t-1} \quad \text{for} \quad \Phi n_{pr} = J_{FS}.
\]  

(26)

In accordance with (23), inflation decreases proportionally to the increase of the cash amount of the financial sector \( \Delta M_{0_{FS}} > 0 \), and it increases proportionally to its decrease \( \Delta M_{0_{FS}} < 0 \) as follows:

\[
p = \frac{e(M_0 - M_{0_{RS}, t-1} - \Delta M_{0_{FS}} - \Phi n_{cb, t-1} - \Phi n_{hh, t-1} - \lambda S)(1 + \beta) \sqrt{2i/\bar{b}}}{\beta \sigma K (1 - \varphi)^{1/\ln k_0}}.
\]  

(27)

The highest inflation is feasible in the case of financial market collapse as a result of the market value fall and securities being returned to their owners within a year, i.e., in the case of financial sector cash decreasing to the value \( \Delta M_{0_{FS}} = -\Phi n_{cb, t-1} - \Phi n_{hh, t-1} \) from the previous year

\[
p_{\text{max}} = \frac{e(M_0 - M_{0_{RS}, t-1} - \lambda S)(1 + \beta) \sqrt{2i/\bar{b}}}{\beta \sigma K (1 - \varphi)^{1/\ln k_0}}.
\]  

(28)

If the amount of cash in the economy did not increase at the beginning of the considered year, i.e., \( M_0 = M_{0_{RS}, t-1} + \Phi n_{cb, t-1} + \Phi n_{hh, t-1} \), we obtain the minimally feasible maximum inflation value in accordance with (26) and (28)

\[
p_{\text{min}} = \frac{e(\Phi n_{cb, t-1} + \Phi n_{hh, t-1} - \lambda S)(1 + \beta) \sqrt{2i/\bar{b}}}{\beta \sigma K (1 - \varphi)^{1/\ln k_0}}.
\]  

Let us assume that the doubled securities value, namely, \( M_{0_{FS}} = 2(\Phi n_{cb, t-1} + \Phi n_{hh, t-1}) \), \( \Delta M_{0_{FS}} = \Phi n_{cb, t-1} + \Phi n_{hh, t-1} \) stipulates the minimum inflation value as follows:

\[
p_{\text{min}} = \frac{e(M_0 - M_{0_{RS}, t-1} - 2(\Phi n_{cb, t-1} + \Phi n_{hh, t-1}) - \lambda S)(1 + \beta) \sqrt{2i/\bar{b}}}{\beta \sigma K (1 - \varphi)^{1/\ln k_0}}.
\]  

(29)
As a result of the securities value variation under the condition of cash availability, the inflation can change from its minimum to its maximum value, i.e., from deflation to hyperinflation. Zero inflation $p = 0$ with the doubled securities value is feasible in accordance with (29) for $M_0 = M_{0,RS} + 2(\Phi n_{cb,t-1} + \Phi n_{lh,t-1}) + \lambda S$. If the securities value does not change, then, in accordance with (27), deflation takes place $p = -\lambda S / \bar{M}_0$ for $M_{0,RS} = 0$ and $M_{0,RS} = M_{0,RS,t-1}$. In the case when financial sector cash decreases by the currency balance value, i.e., $M_0 = M_{0,RS} + 2(\Phi n_{cb,t-1} + \Phi n_{lh,t-1}) + \lambda S$, zero inflation $p = 0$ is feasible for $\Delta M_{0,FS} = -\lambda S$ and $M_{0,RS} = M_{0,RS,t-1}$ in accordance with (26) and (27).

The graph of dependence of the inflation $p$ on variations of the cash amount in the financial sector $\Delta M_{0,FS}$ is presented in Fig. 2.

As is evident, increasing the financial sector cash $\Delta M_{0,FS}$ by the currency balance value $\lambda S$ leads to deflation $p = -2\lambda S / \bar{M}_0$, while decreasing the cash by the currency balance value $\lambda S$ leads to zero inflation. Thus, in accordance with (27) and (11), the inflation function depends on the variation of the cash amount in the financial sector $\Delta M_{0,FS}$ as follows:

$$p = -\lambda S / \bar{M}_0 - \Delta M_{0,FS} / \bar{M}_0 \text{ if } M_{0,RS} = M_{0,RS,t-1}.$$ 

Therefore, to insure the targeted inflation $p_T$, the banking system has to change the amount of cash in the economy $\Delta M_0 = M_0 - M_{0,t-1}$ in accordance with (27) and proportionally to the cash amount variation in the financial sector $\Delta M_0 = p_T \bar{M}_0 + \lambda S + \Delta M_{0,FS}$. Under the constant cash amount in the economy, inflation decreases proportionally if the financial sector cash and currency balance increase.

Feasible (predicted) macroeconomic coefficients for the economy of Ukraine for 2022–2024 based on statistical data of 2020–2021 [22–24] are presented in Table 1.

The Table 1 analysis shows that the value of securities $\Phi n$ does not exceed the banking system equilibrium $\varepsilon$; thus, the financial sector of the Ukrainian economy does not influence the real sector.
TABLE 1

| Economic Indicators | Feasible Economic Indicators by Years | 2020 | 2021 | 2022 | 2023 | 2024 |
|---------------------|--------------------------------------|------|------|------|------|------|
| Output Data         |                                      |      |      |      |      |      |
| Population $T$, million people |                                      | 41.7 | 41.5 | 41.3 | 41.1 | 39.9 |
| Results of Modeling |                                      |      |      |      |      |      |
| Production capital $K_{pr}$, billion UAH |                                      | 29777.25 | 33313.64 | 42052.92 | 47766.87 | 51292.86 |
| Market conjecture $m_{pr}$ |                                      | 1    | 0.928 | 1.066 | 1.0045 | 1    |
| Conjecture of risks and stimuli $R_{xy}$ |                                      | 0.95 | 1.09  | 0.95  | 1.01  | 1.01  |
| Conjecture of demand $R$ |                                      | 0.95 | 1.012 | 1.0127 | 1.0145 | 1.01  |
| People employed in production $N_{pr}$, million |                                      | 10.89 | 11.02 | 11.16 | 11.32 | 11.43 |
| Capital involvement coefficient $v$ |                                      | 0.786 | 0.795 | 0.805 | 0.817 | 0.825 |
| Involved capital $K$, billion UAH |                                      | 23394.5 | 26848.34 | 33852.6 | 39025.5 | 42316.61 |
| People employed in the economy $N$, million |                                      | 14.52 | 14.69 | 14.88 | 15.1  | 15.24 |
| Balanced work $N_{br}$, million people |                                      | 19.182 | 19.09 | 19.00 | 18.906 | 18.35 |
| Actual unemployment level $\varphi$ |                                      | 0.243 | 0.23  | 0.217 | 0.202 | 0.17  |
| Production technology coefficient $1/\ln k_0$ |                                      | 0.0699 | 0.0693 | 0.0681 | 0.0674 | 0.0669 |
| Real GDP $\Omega$, billion UAH |                                      | 3799.31 | 4305.38 | 5512.97 | 6366.98 | 6922.98 |
| Real consumer demand $\bar{\Omega}$, billion UAH |                                      | 3872.86 | 4384.37 | 5604.16 | 6460.51 | 7005.34 |
| Real GDP variation $\delta$, % |                                      | –4.0 | 2.65  | 3.1   | 3.11  | 2.58  |
| Production deflator $P_{pr}$ |                                      | 1.0196 | 1.0183 | 1.0165 | 1.0153 | 1.0122 |
| Target Values of the Targeted Inflation |                                      |      |      |      |      |      |
| Money in circulation $M1$, billion UAH |                                      | 1050 | 1260 | 1460 | 1690 | 2100 |
| Cash to on-demand deposits ratio $\beta$ |                                      | 1.1  | 1.25 | 1.2  | 1.15 | 1.175 |
| GDP deflator $P$ |                                      | 1.104 | 1.242 | 1.12  | 1.06  | 1.05  |
| Interest rate $i$ |                                      | 8    | 9    | 9    | 8    | 6    |
| Money circulation velocity $\mu$ |                                      | 4    | 4.24 | 4.24 | 4    | 3.46  |
| Nominal GDP $\omega$, billion UAH |                                      | 4194.44 | 5347.28 | 6174.53 | 6749  | 7269.15 |
| Aggregate product $q$, billion UAH |                                      | 9267.13 | 11882.85 | 12978  | 14998 | 16153.7 |
| Money deflator $P_{mn}$ |                                      | 1.083 | 1.22  | 1.1   | 1.046 | 1.037 |
| Investments $J_{ns} + J_{cs}$, billion UAH |                                      | 556.53 | 809.78 | 836.86 | 854.1 | 911.145 |
| Capital underdepreciation $\Delta$, billion UAH |                                      | 116.97 | 132.4 | 169.26 | 195.12 | 211.58 |
| Cash in circulation $M0_{RS}$, billion UAH |                                      | 550  | 700  | 796.36 | 903.95 | 1134.48 |
| Inflation-free cash $\bar{\Omega}0$, billion UAH |                                      | 531.25 | 564.16 | 709.04 | 850.87 | 1080.23 |
| Currency cash $M0_{cc} = \lambda S$, billion UAH |                                      | 69.05 | 14.16 | 9.04  | 54.51 | 176.28 |
| Inflation cash $M0_{ic}$, billion UAH |                                      | 18.75 | 135.84 | 87.32 | 53.08 | 54.25 |
| Monetary mass $M3$, billion UAH |                                      | 1950 | 2 360 | 2 490 | 2850 | 3370 |
| Monetary base $H$, billion UAH |                                      | 477.5 | 596  | 674  | 787  | 893  |
| Loans $\Xi$, billion UAH |                                      | 1 328 | 1450 | 1490 | 1570 | 1830 |
| Monetary balance $\epsilon$, billion UAH |                                      | 144.5 | 314  | 326  | 493  | 647  |
| Value of securities $\Phi_n$, billion UAH |                                      | 87   | 135  | 250  | 360  | 510  |
CONCLUSIONS

The foundation of the expanded economic reproduction is the production sphere of the real sector under the relation to the financial sector. The production sphere consists of the production system, banking system, market system, foreign countries, and domestic households. The financial sector is a sector of financial corporations that issue and sell secondary and tertiary securities. It encompasses securities markets and functions on account of loans for shares issued to production by commercial banks that testify to the ownership rights over production capital and other material assets of real sector borrowers.

As an additional money accumulation source for investment into production, the financial sector is an important tool for increasing production factors and the gross domestic product in developed countries. The explosive rise of the demand for securities under the condition of their rising rate is determined by the speculative factor. The financial sector influences the real sector through investments into efficient production spheres where high profit is predicted and through variations of the amount of cash in circulation.

Contradictions between the real and financial sectors based on the lack of production investments due to its decreasing profitability and a significant increase of profitability of securities speculation can be eliminated through tax benefits. Security amount can be accumulated by the financial sector without influencing the real one within the limits of the positive financial balance being present in the banking system. Increasing the financial sector cash proportionally decreases inflation, while its decrease leads to an inflation increase. Thus, to target inflation under the determined limits, the banking system has to change the amount of cash in the economy proportionally to the cash amount variation in the financial sector if the cash amount in the financial sector exceeds the financial balance of the banking system. In the case of the constant cash amount in the economy, inflation decreases proportionally if the financial sector cash and currency balance increase. A sharp increase of surplus cash, together with the financial market collapse, leads to the catastrophic rise of inflation.

Economic reproduction regulators are as follows:
the state that pursues investment policies in order to expand the production capital reproduction through benefits for production investment and direct investment into production from the state budget;
the banking system that provides loans to production and changes the amount and velocity of money in circulation according to the inflation that has to be targeted in order to ensure the monetary safety of the real sector;
the financial sector that changes the amount of cash in circulation, accumulates cash, invests the expanded reproduction of production capital, and pays state taxes from issuing securities.

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