Macroeconomic impacts of COVID-19 pandemic first wave in the world

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Abstract. The paper seeks to identify the essential global-economic macro-shocks resulting from efforts by consumers, firms, or government policies to reduce social distancing, which caused a sharp temporary change in the world economy during the pandemic outbreak in the second quarter of 2020. The purpose is fulfilled using a simple two-period real-business cycle model. The observed reaction of the global economy in the second period of 2020 is measured by the deviation of the time series of GDP and its components, labor, labor income, and average labor product in the USA and EU from the log-quadratic trend. The model can replicate the observed economic response by reducing the total factor productivity, labor demand, and labor supply—no need to assume sticky prices. As a sudden drop in performance is supposed, followed by a modest recovery already in the following period, it is not assumed that the government would be able to avert it in time with fiscal or monetary policy. Moreover, the assumption of variable prices and supply-side shocks does not support such a policy.

Keywords: global economy, pandemic economic impacts, the first wave, the second period of 2020, two-period real-business cycle model

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1. Introduction

The outbreak of the COVID-19 pandemic's first wave had a significant impact on the responses of the global economic time series in the second quarter of 2020. This period is associated with a sharp short-term decline in real GDP, consumption, labor, investment, and wages. What makes this period different from other recessions in history is that in the next period, the mentioned indicators increased again. In most cases, they still need to reach their original level.

Although only a short time has passed since the pandemic outbreak, there is already a large and growing body of research analyzing the economic impacts of the pandemic and the corresponding policy responses.

This work differs in that it seeks to identify the essential global-economic macro-shocks resulting from efforts by consumers, firms, or government policies to reduce social distancing, which caused a sharp temporary change in the world economy in one period. This purpose can be fulfilled using a simple two-period real-business cycle model. We are interested in the decisions of a representative firm and a representative consumer in the present period, which corresponds to the second quarter of 2020, considering consumer and investment plans for the future.

Our paper assumes that the outbreak of the COVID-19 pandemic can be reduced in the two-period real-business cycle model by implementing shocks on the economy's supply side. It

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is a simultaneous decrease in demand and supply of labor and total factor productivity. The pandemic outbreak can be linked to an increase in the level of uncertainty in the markets. In the model framework, this increase corresponds to pessimistic expectations of a further significant decrease in labor and productivity.

2. Literature review

In their project, Dück et al. [8] concentrate on the most important works regarding the COVID-19 macroeconomic effects, which use models based on microeconomic principles. In the following paragraphs, we develop in more detail the ideas of the papers [8] most related to our research.

The decline in labor demand follows directly from the ordinary theoretical pandemic model, in which the population can go through different pandemic states; Suspected, Infected, and Recovered, what named the SIR model. [2] used the SIR model to forecast the further course of the pandemic in the next 12-18 months. Note that [21] introduced the SIR model already in 1927. The labor demand will decrease as a result of the diseases of the infected and the death of the recovered. In addition, the labor demand and supply will decrease due to voluntary or forced social-distancing restrictions.

We are unaware of many papers that assume changes in total factor productivity due to the pandemic [1, 6, 7]. We assume that there exist sectors demanding social interaction. In these sectors, the achievements of information technology can be used to develop remote work or customer meetings. However, their effect is less significant than real meetings. Therefore, total factor productivity in these sectors will decrease.

On the contrary, many studies assume demand shocks are associated with a decrease in consumption [9, 10, 11, 12, 14, 20, 23, 24]. In dynamic stochastic general equilibrium models, consumption can also be reduced in the following ways: by changing the substitution effect between consumption and leisure, by changing the intermediate substitution effect of consumption, and by frictions on financial markets. In our paper, the decrease in the demand for labor is realized by adjusting the substitution effect between consumption and leisure. If the consumer decides to work less due to voluntary or forced social distancing, he also substitutes consumption with leisure.

[4] predicted a decline in consumption due to "forced savings". Financial frictions can be formulated by increasing the interest rate gap. Such adjustments in a two-period real-business cycle model do not correspond to the observed reactions of the investigated variables unless we assume sticky prices. [1] pointed to the fact that consumers were prone to substitute the consumption of products in sectors demanding social interaction for other products, thus eliminating the intermediate substitution effect. We also do not assume that financial frictions cause economic changes during the pandemic. However, they result from a higher degree of uncertainty, which in our model, will be reflected in pessimistic future expectations.

3. Model

This paper uses a simple real-business cycle model for the short-term analysis of the impact of the pandemic. Over the four decades of development of this class of economic models came extensions based on stable prices (current Keynesian dynamic stochastic general equilibrium models), rest-of-the-world effects (small open economy models), and others. The analysis refers to the global economy (represented by the US and EU economies), in which we do not need to consider openness. Likewise, given the high volatility of economic activity, there is no reason to believe that economic shocks from the pandemic outbreak are associated with constant prices. Unlike other research, we will focus on explaining the collapse of the global economy in one period (the second quarter of 2020). A simple macroeconomic model in two periods is sufficient.

The basis for our analysis is a contemporary simple macroeconomic model based on microeconomic theory optimizing agents' behavior. Instead of the commonly used Cobb-Douglas production function, we used the form of the production function with constant elasticity of substitution. Furthermore, we proposed a way for the model to replicate the response of the global economy to the shocks associated with the outbreak of the COVID-19 pandemic. These shocks correspond to a persistent decrease in the total factor productivity, labor demand, and supply. The total factor productivity is presented in the model as a separate parameter. Shifts in labor supply correspond to changes in the scaling parameter in the consumers' utility function. We used a particular parameter adjusting the corresponding first-order condition for labor demand shifts. With this combination, we obtained a model result corresponding to the global economy's actual response, which includes the observed changes in output, consumption, investment, labor, the average product of labor and labor income in the given period.

We consider a real economy with a consumer, firm and government in two periods. We formulate the model from a centralized point of view. The consumer's dynamic utility function has the form:

$$U_{max} = \max_{C_1, N_1, C_2, N_2} U(C_1, N_1, C_2, N_2), \tag{1}$$

where consumption is denoted by the symbol C and labor by the symbol N, the subscripts $\{1,2\}$ denote the first or second period. The utility function U is a twice differentiable increasing concave function of consumption in both periods and a twice differentiable decreasing convex function of labor.

Resource constraints in two periods can be written in the form:

$$C_1 + K_2 - (1-\delta)K_1 + G_1 = A_1 F(K_1, N_1), \tag{2}$$

$$C_2 + \delta K_2 + G_2 = A_2 F(K_2, N_2), \tag{3}$$

where consumption is denoted by C, labor by N, capital by K, government purchases by G, the constant capital depreciation rate by δ , and total factor productivity by A. The firm's production function in both periods is:

$$Y_t = A_t F(K_t, N_t); \quad t \in \{1, 2\}, \tag{4}$$

where Y denotes output. The production function F is a twice differentiable increasing and concave function of capital and labor. Investment I in the first period serves to repair and increase the value of existing capital:

$$I_1 = K_2 - (1-\delta)K_1. \tag{5}$$

The resource constraint (2) and (3), together with the specification of production (4) and investment (5), fit the expenditure method of the gross domestic product calculation. The latter equals the sum of all final consumption expenditures ($Y = C + I + G$), whereas, since the second period is finite, investment in the second period is reduced only to repair the existing capital stock ($I_2 = \delta K_2$).

The firm's profit function P in both periods is in the form:

$$P_t = Y_t - (r_t + \delta_t)K_t - w_t N_t; \quad t \in \{1, 2\}, \tag{6}$$

where r denotes interest rate, while w denotes wage rate.

Given the predetermined capital stock and interest rate K_1, r_1, government purchases G_1, G_2, and total factor productivity A_1, A_2, competitive equilibrium is an allocation $\{C_t, N_t, Y_t, I_1\}_{t=1,2}$ and price set $\{r_2, w_t, \}_{t=1,2}$ so that the consumer maximizes his utility function (1) given the resource constraints (2), (3); the firm maximizes its profit function in both periods (6).

Consumer and firm behave competitively, so they take the price set as given. The corresponding necessary conditions are:

$$-\frac{\frac{\partial U(C_1,N_1,C_2,N_2)}{\partial N_t}}{\frac{\partial U(C_1,N_1,C_2,N_2)}{\partial C_t}} - w_t = 0; \quad t \in \{1,2\}, \tag{7}$$

$$\frac{\frac{\partial U(C_1,N_1,C_2,N_2)}{\partial C_1}}{\frac{\partial U(C_1,N_1,C_2,N_2)}{\partial C_2}} - (1+r_2) = 0, \tag{8}$$

$$A_t \frac{\partial F(K_t,N_t)}{\partial N_t} - w_t = 0; \quad t \in \{1,2\}, \tag{9}$$

$$A_2 \frac{\partial F(K_2,N_2)}{\partial K_2} - (r_2+\delta) = 0. \tag{10}$$

Conditions (7) and (8) correspond to the consumer's behavior, and conditions (9) and (10) correspond to the firm's behavior. According to condition (7), the negative value of the marginal rate of substitution of labor for consumption equals the wage rate in both periods. The intertemporal marginal rate of substitution equals the by-index-expressed interest rate (8); the marginal product of labor equals the wage rate in both periods (9), and the second-period marginal product of capital equals the gross income from capital (10).

3.1. Function forms

The Cobb-Douglas production function form has been commonly used in macro models. However, [22] and [18] pointed out that, in reality, the elasticity of input substitution is lower than one and that the Cobb-Douglas production function with unit elasticity of substitution distorts the relationship between labor demand and labor price. Therefore, a production function with constant elasticity of substitution (CES) is used in the form:

$$Y_t = A_t \left[\pi_0 K_t^{\frac{\sigma_y - 1}{\sigma_y}} + (1-\pi_0) N_t^{\frac{\sigma_y-1}{\sigma_y}}\right]^{\frac{\sigma_y}{\sigma_y - 1}}; \quad t \in \{1,2\}, \tag{11}$$

Correctly using the CES function requires normalization [18, 21]. According to the strategy of [22], we assume that the basic normalization point corresponds to a steady state. Therefore, the inputs K, N, and the output Y are expressed as shares in their steady states, and A denotes total factor productivity. The symbol π_0 denotes the normalized value of the capital share on GDP (distribution coefficient); the constant elasticity of substitution of inputs is $\sigma_y < 1$.

The utility function form corresponds to the consumer's risk aversion [22]:

$$U(C_1,N_1,C_2,N_2) = \frac{C_1^{1-\sigma_c}}{1-\sigma_c} - \nu_1 \frac{N_1^{1+\varsigma}}{1+\varsigma} + \beta \left[\frac{C_2^{1-\sigma_c}}{1-\sigma_c} - \nu_2 \frac{N_2^{1+\varsigma}}{1+\varsigma}\right], \tag{12}$$

where the inverse value of the intertemporal elasticity of substitution of consumption σ_c expresses the consumer's aversion to risk, ν is a scaling parameter matching different labor N and consumption C units. The discount factor β expresses how the consumer values the future. The inverse of the Frisch elasticity of labor supply is ς.

Substituting the first derivatives of the production and utility functions into the first-order conditions (6)–(10), we obtain the multi-equation system:

$$\nu_t N_t^{\varsigma} C_t^{\sigma_c} - w_t = 0; \quad t \in \{1,2\}, \tag{13}$$

$$\frac{C_2^{\sigma_c}}{\beta C_1^{\sigma_c}} - (1 + r_2) = 0, \tag{14}$$

$$\epsilon_t (1 - \pi_0) A_t^{\frac{\sigma_y - 1}{\sigma_y}} \left(\frac{Y_t}{N_t} \right)^{\frac{1}{\sigma_y}} - w_t = 0; \quad t \in \{1,2\}, \tag{15}$$

$$\pi_0 A_2^{\frac{\sigma_y - 1}{\sigma_y}} \left(\frac{Y_2}{K_2} \right)^{\frac{1}{\sigma_y}} - (r_2 + \delta) = 0, \tag{16}$$

where $\epsilon_t = 1$ represents in equation (15) a parameter that we will use in the model to implement a shock associated with a shift in labor demand.

Given the values of predetermined capital, the time sequence of government purchases, the total productivity of factors and parameters $\{K_1, G_t, A_t, \nu_t, \epsilon_t, \sigma_y, \sigma_c, \varsigma, \delta, \beta, \pi_0\}_{t=1,2}$, the competitive equilibrium is obtained by solving the system equations (2), (3), (5), (11), and (13)–(16).

Given the current computational possibilities, the given set of nonlinear equations is countable. Nevertheless, to simplify parameter calibration, it will be helpful to define a steady state.

3.2. Steady-state

The property of stability characterizes a steady state. The values of the variables are constant in both periods, and the following applies:

$$X_1 = X_2 = X_{ss}; \quad X \in \{C, N, Y, K, w\}, \tag{17}$$

where the subscript ss denotes the steady state.

The base point of the normalized CES production function (5) corresponds to the steady state. An elegant way of normalization is to set the inputs and outputs of the steady-state production function equal to 1 [22]:

$$Y_{ss} = K_{ss} = N_{ss} = 1, \tag{18}$$

The assumption of a steady state (17) is fulfilled in the system (2), (3), (11), (13)–(16), and (18) if

$$C_{ss} = 1 - G_{ss} - \delta, \tag{19}$$

$$I_{ss} = \delta, \tag{20}$$

$$A_t = \epsilon_t = 1; \quad t \in \{1,2\}, \tag{21}$$

$$w_{ss} = 1 - \pi_0, \tag{22}$$

$$r_{ss} = \pi_0 - \delta, \tag{23}$$

$$\beta = \frac{1}{1 + \pi_0 - \delta}, \tag{24}$$

$$\nu = \frac{1 - \pi_0}{(1 - G_{ss} - \delta)^{\sigma_c}}. \tag{25}$$

With the chosen method of production function normalization, consumption, investment, and government purchases are expressed as shares of GDP, and input prices as shares of inputs in GDP.

3.3. Model shocks

We assume that the outbreak of the COVID-19 pandemic was manifested by a decrease in total factor productivity and a simultaneous shift of the labor demand and supply curves to the left. These shocks correspond to a decrease in A and ϵ and an increase in ν.

The persistence rate expresses how permanent the shocks are expected to be. The rate is interpreted as the serial correlation coefficient ρ expressed as follows:

$$(A_2 - 1) = \rho(A_1 - 1), \tag{26}$$

$$\left[\nu_2 - \frac{1-\pi_0}{(1-G_{ss}-\delta)^{\sigma_c}}\right] = \rho\left[\nu_1 - \frac{1-\pi_0}{(1-G_{ss}-\delta)^{\sigma_c}}\right], \tag{27}$$

$$(\epsilon_2 - 1) = \rho(\epsilon_1 - 1). \tag{28}$$

While the deviations from the values of the parameters assuming a steady state in the first and second periods are in the brackets of relations (26) – (28). For simplicity, we assume that the autocorrelation rate ρ is the same for different shocks. For our purposes, this simplification is sufficient. Moreover, we cannot theoretically distinguish the values of the autocorrelation coefficients.

In economic interpretation, the serial correlation coefficient corresponds to the firm's and consumer's expectations. The more persistent the shock is expected to be, the higher the serial correlation coefficient. We interpret the assumption of pessimistic expectations as uncertainty. A high serial correlation coefficient corresponds to a high degree of uncertainty.

4. Data

The paper aims to calibrate the parameters' deviations from the steady state values so that the equilibrium change in the model corresponds to the observed changes in the corresponding time series during the outbreak of the COVID-19 pandemic. Therefore, we need to identify the changes in the corresponding time series in the corresponding period. We are interested in time series expressing GDP and its components, labor, the average product of labor, and labor income. Labor can also be expressed as total employment (N), but also as total hours worked (N_h). We will focus on the performance of the largest economies - the USA and the EU.

4.1. Data sources

An overview of the data used is in Table 1. Quarterly (Q) U.S. data on GDP and its components (excluding imports and exports) at constant prices ranging from the first quarter of 1947 to the first quarter of 2021 come from the U.S. Bureau of Economic Analysis [25], along with monthly employee compensation and consumer price index (CPI) data. Monthly data on employment and average weekly hours worked per worker come from the U.S. Bureau of Labor Statistics [26]. The time series of the total number of hours worked is obtained by multiplying employment and the average number of hours worked. The range of monthly data varies (see Table 1). The FRED portal of the Federal Reserve Bank of St. Louis was used to obtain the data [15].

Time series	Den.	USA Source	USA Fr.	USA Range	EU Source	EU Fr.	EU Range
GDP	Y	BEA	Q	1947Q1–2021Q1	Eurostat	Q	1995Q1–2021Q1
Consumption	C	BEA	Q	1947Q1–2021Q1	Eurostat	Q	1995Q1–2020Q4
Investment	I	BEA	Q	1947Q1–2021Q1	Eurostat	Q	1995Q1–2020Q4
Government p.	G	BEA	Q	1947Q1–2021Q1	Eurostat	Q	1995Q1–2020Q4
Employment	N	BLS	M	1948M1–2021M5	Eurostat	Q	2000Q1–2020Q4
Labor, hours	N_h	BLS	M	2006M3–2021M5	Eurostat	Q	2006Q1–2020Q4
Compensations	—	BEA	M	1959M1–2021M5	—	–	—
CPI	—	BEA	M	1947M1–2021M4	—	–	—

Table 1: *Review of data sources and ranges*

We obtained all European data corresponding to the 27 EU countries, excluding the United Kingdom, from the Eurostat database [13]. The time series of GDP and its components range from the first quarter of 1995 to the fourth quarter of 2020 (1st quarter of 2021 for the GDP time series). The range of labor time series varies (Table 1). The European time series of hours worked corresponds to all workers. All considered data are seasonally adjusted.

Note that the understanding of investment and government consumption differs in the US and European national accounts. From American databases, we have a time series of employee compensation, which we consider nominal income from work. Such simplification can be problematic [19]. We are not mistaken in assuming that the immediate relative response of employee compensation to pandemic shocks corresponds to the relative response of total labor income. From the nominal labor income, we obtain the real income w by dividing it by the CPI time series. Monthly data are aggregated into quarterly averaging. The average labor product APN is obtained by dividing the output time series Y by labor N. The following applies:

$$APN = \frac{Y}{N}, \tag{29}$$

$$APN\_h = \frac{Y}{N\_h}, \tag{30}$$

where suffix $\_h$ denotes the total hours.

The COVID-19 pandemic had a significant economic impact in the second quarter of 2020. There was a significant drop in GDP and its components, labor, and income from labor. This very short-term downturn is not matched by any other downturn associated with historical global economic crises in the entire period under review. In contrast to the USA, government consumption also collapsed in the EU. In the EU, we observe a relatively small drop in employment but a relatively high drop in hours worked. This phenomenon can be explained by the different labor legislation of the USA and the EU, as well as by the fact that in 2020 the governments in the EU tried more to eliminate the outbreak of unemployment with subsidies.

For this reason, the total number of hours worked is a better labor indicator. As a result of the EU policy, the average labor product expressed by employment in Europe decreased, but paradoxically, expressed by the number of hours worked, increased. We also observe an increase in the US economy's average product of labor in the second quarter of 2020. It follows from this fact – due to the procyclical characteristic of the average labor product in real-business cycle models that assume productivity shocks – that the shock of total factor productivity is not the only primary source of the economic downturn. We are also observing a slight drop in real labor income.

4.2. Trend and cyclical components

In order to compare the observed deviations from the steady state with the theoretical ones, we need to measure them. For this purpose, the time series are trend-fitted and cyclical characteristics can be detected from deviations from the trend. According to [27], smoothing the data with a log-quadratic trend is sufficient to compare the volatility, variability, and persistence of the investigated time series cyclical components. Cyclical components obtained by deviations from the log-quadratic trend in the USA and the EU confirm the stated conclusions. Interestingly, the relative drop in investments is less significant than in previous crises from the second half of the 20th century. Table 2 shows the deviations of the investigated variables from the log-quadratic trend in the second quarter of 2020. It shows that the immediate economic response to the COVID-19 pandemic was approximately the same in the US and the EU. Real GDP fell by more than 10% against the log-squared trend. Consumption fell even more. Due to the tendency of households to "smooth" their consumption over several periods, consumption is usually less volatile than GDP [27]. Since consumption fell relatively deeper than GDP immediately after the pandemic outbreak, it can be estimated that the shocks associated with the COVID-19 pandemic are considered more permanent by the private sector, and the level of uncertainty has increased. On the other hand, if consumption falls relatively more and the private sector expects a long-term shock, a minor fall in investment can be expected. This expectation was fulfilled. We stated that the collapse of investments is not more significant than in other historical crises. Moreover, investment fell against the log-squared trend in the EU only by about 9%. However, investigating the movement of the cyclical component of investments indicates that the log-quadratic trend may not accurately estimate this decline. Just before the pandemic outbreak, the cyclical component was well above trend for about two years, falling from +8.5% (+12.5% in 2019Q3) to –8.5% during the pandemic outbreak. The estimation error may result from an incorrect choice of the trend model or an insufficient number of periods in estimating the trend. The point that public investments are also included in investments (gross capital formation) in the EU is also significant. Government responses to the pandemic outbreak were less significant than private ones. If we measure labor by the number of hours worked, labor has fallen by more than 10% in both the US and the EU, and the average product of labor has increased in the US.

	Y	C	I	N_h	w	APN_h
USA	–12.1	–14.3	–21.2	–12.2	–1.5	2.2
EU	–11.5	–12.7	–8.8	–14.1	—	–1.2

Table 2: *Percentage deviations of variables from their long-term trend in Q2 2020*

4.3. Calibration of the theoretical model

When calibrating the coefficients and exogenous variables of the theoretical model from government consumption and GDP data, we note that the long-term share of government consumption in GDP is approximately 20%. Long-term average values of the capital depreciation rate and the share of capital resulting from the database Penn World Tables [16] are $\delta = 0.035$ and $\pi_0 = 0.38$. We assume that the elasticity of substitution is 0.4 [5], the coefficient of consumer risk aversion is 1 [17], and Frisch's value of the elasticity of labor supply is 0.4 [28]. The real interest rate corresponds to relation (23), and the discount factor corresponds to (24). Calibrated values are in Table 3.

Coefficient	G_{ss}	δ	π_0	σ_y	σ_c	ς	β
Value	0.2	0.035	0.38	0.4	1	2.5	0.743

Table 3: *Calibration of model coefficients*

5. Methodology and results

We obtain the competitive equilibrium in the theoretical model by solving equations (2)–(5), (11), and (13)–(16). For exogenous variables and parameters, we substitute values from Table 3. The values of the total productivity of factors A, the scaling parameter for labor supply shifts ν, and the parameter for labor demand shifts ϵ in both periods remain. By substituting the values (21) and (25), we obtain the steady state (17)–(20), (22)–(24). Our task is to find such deviations of the coefficients from (21), (25), with the persistence (26)–(28) so that the theoretical economic deviation from the steady state corresponds to the economic deviation from the trend observed in the second quarter of 2020 (Table 2).

By reducing total factor productivity A, GDP and its components will be reduced. The income effect of the decrease in A will increase the labor supply, and the substitution effect will decrease it. A decrease in A will decrease the marginal product of labor and the demand for labor. The wage rate, the average product of labor, must fall, but there is little or no fall in labor. The result does not correspond to the facts in Table 2 because in the second quarter of 2020, the average product of labor and the wage rate mainly stayed the same, and labor decreased significantly.

If by reducing ϵ, we shift only the demand for labor to the left, not only labor but also the wage rate will decrease. The decline in labor is insufficient. Since economic decline is caused only by labor reduction, the average product of labor will increase. This result is similarly contrary to reality. Decreasing only the labor supply (increasing ν) leads to an increase in the wage rate, contrary to Table 2.

We conclude that the global economic reaction in the second quarter of 2020 could not be linked to a single shock but to a combination of several changes. Based on the current research and the assumption that the SIR model can explain pandemic waves, we conclude that a decrease in labor supply manifested in the outbreak of COVID-19.

A simultaneous decrease in labor supply and demand is economically meaningful. This change corresponds to a sectoral shock, in which the efficiency of successful matches between workers and firms is reduced or in which supply-customer chains are broken. However, the simultaneous decrease of ϵ and increase of ν in the theoretical model will increase the average product of labor, contrary to reality. Assuming a simultaneous decrease in total factor productivity and labor supply, the wage rate will increase. The result in Table 3 can be replicated only by reducing all three: total factor productivity, labor demand, and labor supply.

Finally, we adjust the ratio of changes in consumption and investment by the persistence rate ρ. The more permanent the shocks, the more significant the change in consumption as opposed to investment. We stated that the pandemic crisis is historically characterized by an unusually high decline in consumption and a low decline in investment. It corresponds to a relatively high persistence rate.

A possible shock combination explaining the observed economic response in the second quarter of 2020 is in Table 4. Supposing a decrease in A by 4%, an increase in ν by 60%, and a decrease in ϵ by 9% with a persistence rate of 1.48, we obtain a theoretical economic response approximately corresponding to the response of the global economy after the outbreak of the pandemic.

	A	ν	ϵ	ρ	Y	C	I	N	w	APN
USA	—	—	—	—	–12.1	–14.3	–21.2	–12.2	–1.5	2.2
EU	—	—	—	—	–11.5	–12.7	–8.8	–14.1	x	–1.2
Model	-4	60	–9	1.48	–11.8	–14.5	–20.4	–12.4	–1.7	0.6

Table 4: *Comparisons of observed deviations from log-squared trend in Q2 2020 with theoretical deviations from steady-state values in %*

In common practice, one can interpret a serial correlation ρ lower than 1. In the two-period model, this can be explained by pessimistic expectations. Economic agents expect an even more significant worsening of the crisis in the future. Such an explanation is justified given the unpredictable situation during the pandemic outbreak in the second quarter of 2020. At Frisch's value of the elasticity of labor supply 0.4, a 60% increase in coefficient ν corresponds to a 24% decrease in labor supply. At a value of elasticity of input substitution of 0.4, a 9% decrease in the ϵ coefficient corresponds to a 3.6% decrease in labor demand.

Replicating the global economy reaction in the second quarter of 2020 by the theoretical two-period model, the total productivity factor decreased by 4%, labor supply by 3.6%, and labor demand by 24%.

6. Discussion and conclusion

Our analysis used a simple macroeconomic model with microeconomic foundations with rationally behaving agents. According to current scientific recommendations, we used the production function form with an elasticity of substitution lower than 1. According to our proposal, the model can replicate the response of the global economy to shocks associated with the outbreak of the COVID-19 pandemic by simultaneously reducing total factor productivity, labor demand and supply. According to our model modification, shifts in labor supply correspond to changes in the scaling parameter in the consumer's utility function and shifts in labor demand to changes in a specially created parameter. With this combination, we obtained a model result corresponding to the observed response of the global economy, which includes the observed changes in output, consumption, investment, labor, average labor product and labor income in the given period.

Compared to several studies dealing with the economic impact of the outbreak of the COVID-19 pandemic, this paper focused on explaining the change in the global economy in one period - the second quarter of 2020. According to observations resulting from American and European statistics, during this period, GDP fell by 11–12%, consumption by 13–14%, investments by 9% in Europe, respectively by 21% in the USA, labor by 12–14% and wages in the USA by 1.5%. In the next period, the mentioned indicators increased again, although in most cases they did not reach their original level.

We used the two-periods real-business cycle model to explain the observed global economic movements in the second quarter of 2020. The observed recession can be achieved in the model simultaneously by reducing the supply and demand of labor and total factor productivity and increasing the level of uncertainty that corresponds to the expected future, even more a pronounced slump of these values. The economic decline cannot be attributed solely to productivity or labor market shocks. It is assumed that the total factor productivity decreased by 4%, labor demand by 3.6%, and labor supply by 24%.

Unlike other macroeconomic phenomena, a single type of shock cannot capture a pandemic outbreak. A simultaneous persistent change of several parameters can only capture the observed economic reaction. The decomposition of the response to individual shocks does not yield different results from the perspective of the complexity of the investigated issue than those known from non-pandemic standard models. The impulse response (Table 4) is the simultaneous combination of the given shocks and the response is the model reaction.

The two-period model is also simple because, unlike many other studies [1, 11, 12, 3, 14] does not assume sticky prices or wages. Nevertheless, it explained the immediate response of output, consumption, investment, labor, the average product of labor, and the wage rate.

Compared to previous crises from the second half of the 20th century, a relatively high level of uncertainty in global markets was confirmed. This result corresponds to the research of Chudik et al. [7] based on a vector autoregressive model extended by identifying volatility thresholds. The authors state that "the COVID-19 shock and policies implemented to contain it have brought about simultaneous disruptions to demand and supply in a totally new economic environment, where consumers and firms are faced with additional uncertainties about the disease itself." The high shock persistence rate corresponds to a relatively more significant drop in consumption compared to investment. Pessimistic expectations are manifested in a tendency to consume less and save more. Eichenbaum et al. [11] observed that in the COVID-19 pandemic, the decline from peak to trough was about the same for consumption, investment and output and explained this phenomenon with a New Keynesian model.

Assuming that the pandemic displays itself in a sharp one-time drop in the economy's performance in one quarter, the economic policy cannot react in time. In addition, according to the results of this research, the decline in the second quarter of 2020 was caused by shocks on the economy's supply side. We do not expect the traditional monetary and fiscal policy supporting aggregate demand can effectively eliminate the crisis under the assumption of sticky prices. Of the various recommendations for economic policy during the pandemic, we lean toward the research result of Brzoza-Brzezina et al. [3]. According to the authors, political authorities should not approach the decline in economic activity associated with the pandemic as a standard recession. An expansionary monetary policy should only react to the government's social pandemic restrictions (lockdown).

Immediately after the outbreak of the pandemic, the government's task is to aim to reduce the level of economic uncertainty, which in the future could be embodied by a decrease in aggregate demand and economic performance as a result of pessimistic sentiments, excessive investor caution, an increase in the interest gap in financial markets, and disruption of supply-customer chains. The government should strive to improve social feelings by promoting good news and supporting programs developing effective drugs and treatments (vaccines).

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