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# Some Macroeconomic Effects of Income Inequality in a Simulation Approach

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**Abstract**

The paper focuses on inequality as an independently analysed phenomenon that has a real economic impact. The emergence and the increase of income inequalities are inevitable and sometimes useful elements inherent to the functioning of market economies. This paper analyses the macroeconomic effects of inequalities in a macroeconomic model applying heterogeneous agents and running a Monte-Carlo simulation. The simulations prepared by the model have revealed the macroeconomic impacts of inequality and rationality in terms of financial culture, within an overall context of economic growth and stability. The conclusions are as follows: (1) Growing inequality dampens the rate of GDP growth. (2) Losses in consumption and economic value added emanating from income inequalities are lower if the rate of GDP growth is permanently higher. (3) With diminishing income inequalities, volatility of consumption decreases, thereby the volatility and cyclicality of economic growth slackens as well. (4) The rationalisation of expectations (more precise expectations of households) as well as progress in the development of financial culture can contribute to sustainable growth patterns and moderate volatility of GDP growth. This report amends research results released in the relevant international literature in as much as it enriches the analysis of the macroeconomic effects of income inequality with a new approach and new aspects. This report discusses the mutual relationship between inequality, economic growth, and volatility (cycles).

**Keywords**

inequality, economic growth, modelling, sustainability

## 1 Introduction

Social inequalities in general and income inequalities in particular have long been the focus of interest in the social sciences. A vast literature reveals the trends and factors behind income inequality as well as their general and specific causes. Income inequality and its increase is widely held to be the necessary concomitant of a market economy, although it has been hypothesised that in modern economic development, income inequality first picks up and then decreases (Kuznets, 1955). This is the consequence of competition – very much the essence of capitalism (and the innovation it encourages) – which is one of the most important drivers of economic development and growth, and which has winners and losers.

However, this picture has been fine-tuned by a large number of empirical analyses which point out that extreme income disparities are not a consequence of a natural process. On the one hand, income inequalities can contribute to economic growth, although within certain limits, if individual performance and innovation are stimulated by them. On the other hand, significant income disparities can restrain economic growth in the long run by preventing certain social groups from competing on equal terms. As a result, social mobility may be slowed down or even halted, leaving considerable human potential untapped. Thus, several economic policy approaches – such as broad-based growth, shared growth, pro-poor growth, and inclusive growth that is perhaps best known and preferred by the OECD – have been proposed with some similarities and differences (Ianchovichina and Lundstrom, 2009).

The present paper aims to explore some of the macroeconomic effects, impacts, and mechanisms inducing income inequalities with the help of a simulation method under the consideration of different economic growth prospects. With the model, we sought to answer the question of what impact income inequality – whose level is defined by the concentration of income on the richest

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social strata – has on the growth rate, stability, and sustainability of GDP (including consumption) through the expectations of consumer groups.

The present report amends research results published in the relevant international literature as it enriches the analysis of macroeconomic effects of income inequality with a new approach and new points and conclusions. The use of modelling to reveal relationships has been hardly or rarely discussed by international literature until recently. This approach is considered a scientific novelty in the relevant field. Our model is suitable for the analysis of specific countries and/or groups of countries.

The first part of the paper includes a review of the relevant literature. The second part presents the model and the related assumptions. The third part describes the results of the modelling exercise, whereas the fourth part contains the summary and conclusions. The paper is also supplemented by a list of references.

## 2 Literature review

This synthesised overview focuses on the available relevant literature discussing the interrelationship and interaction between income inequality and various macroeconomic trends. We selected and discussed theoretical and empirical publications whose topics are closest to ours. It highlights the dynamics of the explanation of the subject in terms of the applied methodology, including models as well as various indicators.

To start with the basic issue, most of the literary sources measure income inequality with the Gini coefficient (Kapitány and Molnár, 2002; Tóth, 2003). By contrast, one of the most famous publications defined it as the share of the top one percent of the population in total incomes (Piketty et al, 2018). In this paper, we have used concentration ratios rather than the Gini index in defining income inequalities.

A great number of reports have explored the nature and the source of income inequality and its determinants, such as historical path, political-economic system, broader economic and institutional conditions, the economy's role in global value chains, etc. (Eichengreen et al, 2021; Piketty et al., 2018).

According to certain impact analyses, the evolution of income inequalities may generate *macroeconomic instability*. The short- and long-term relationship between the two factors was examined and quantified on the sample of 22 developing countries on panel data from 1992 to 2014 (Dita and Hayat, 2017). A principal component analysis was applied to construct a comprehensive macroeconomic instability index from a variety of macroeconomic indicators, including the rate of inflation, the real exchange rate, the external debt, and the general government deficit relative to GDP. Time-dimensional relationships were identified using panel cointegration and pool mean group estimation methods. The empirical results of the report suggest that *macroeconomic instability raises income inequality significantly*. The relationship between the two factors is stable and mutual in both the short and the long term. There is also a stable and long-term relationship between income inequality and personal remittances, public health expenditure, and foreign direct investments separately (Dita and Hayat, 2017). Another conclusion is that foreign direct investments and public health spending are effective tools for reducing income inequality. The results of the model can be useful for policymakers in developing strategies aiming to mitigate income inequality.

In a somewhat more specific approach, *the effect of growing income inequality on the evolution of a crisis* was discussed with the identification of the probability according to which increasing income inequality might trigger crises (Cardaci and Saraceno, 2015). An exchange rate-consistent macro model was used that included an agent-based household sector as well. The authors sought to answer the question of how economic crises arise due to different borrowing conditions and policy responses to growing income disparities. The results of the model simulation demonstrate that there is a twofold risk when inequality increases: on the one hand, low creditworthiness leads to a decline in aggregate demand and output, and, on the other hand, looser credit conditions and higher propensity to lend generates a higher degree of financial instability with debt-driven bubbles (recovery and then collapse). The key role of political interventions, too, was considered. A *structural reform* that remedies inequalities through a more progressive tax system would compensate for the widening of income disparities, thereby stabilising the economy. Such a reform is better than a stronger fiscal intervention, which would only extend the length of the recovery and the downturn cycle.

The central element of the recent approaches is the consideration of income, wealth, and wage differences in macroeconomic models. One of the reports (García-Peñalosa, 2018) reviewed and summarised the results of recently drawn-up models. *The effects of inequalities on long-term growth and macroeconomic volatility* are in line with the above trend. According to theoretical approaches

and empirical results, inequality in income and education leads to slower economic growth. This is because the mentioned inequalities limit access to education for a considerable part of the population. Inequality can also give rise to aggregate fluctuations if those at the bottom of redistribution are only able to meet their consumption needs temporarily by accumulating unsustainable debt.

Two aspects seem relevant concerning the impact of growth on inequality (García-Peñalosa, 2018). The first point relates to *human capital accumulation*. Education policies that enhance the number of educated people can bring about both equalisation and greater inequality. The overall effect on the distribution of income depends on various factors. If only the supply effect is considered, the wages of unskilled workers will mount whereas those of skilled ones drop due to a reduction in the labour force. Technological bias, however, reinforces income inequality if the structure of skilled and unskilled labour does not match the needs of technological development. The second point concerns unfolding *developments in the realm of the highest incomes*. In recent decades, the share of the highest wages/incomes in GDP has continuously increased simultaneously with economic growth. The development of international trade and intensified competition, as well as the access of highly skilled workers to the global labour market, must have played a role in this trend. Therefore, fostering economic growth through economic openness is likely to support people and households in the highest income category.

Similar conclusions can be depicted from some other papers (Eichengreen et al, 2021; Wood, 1997). According to the theory, income inequality would intensify in high-income countries whereas due to economic opening, it would moderate in low-income countries. Empirical evidence does not consistently support the theory as the overall impact depends on various economic and political fundamentals.

A new paradigm is gaining traction with integrating sticky prices, deficient markets, and the heterogeneity of households. This makes it possible to study how inequality shapes macroeconomic aggregates and how macroeconomic shocks and interventions affect inequality. The main limitation of most empirical studies on the redistributive effects of monetary policy is that they cannot identify simultaneously the transmission channels described in the theoretical literature (Colciago et al, 2018). Empirical analyses discussing the effects of conventional monetary policy on income and wealth inequalities have so far produced rather mixed results. However, there seems to be a consensus about the fact that higher inflation, at least above a certain threshold, increases inequality.

The limited number of publications about the impact of macroprudential policy on inequality have demonstrated the redistributive effects of this policy. Nevertheless, it would be premature to draw firm conclusions based on this. The empirical literature has recently begun to address the *redistributive effects of unconventional monetary policy*. Contrary to popular belief, the conclusions concerning the effects of these new types of monetary interventions on income inequality are ambiguous. On the one hand, unconventional instruments can reduce income inequality by stimulating economic activity, but on the other hand, inequalities may also increase as the prices of financial assets rise. The effects on wealth inequalities are also inconsistent: while higher financial asset prices induce higher inequalities, elevated real estate and apartment prices result in lower ones.

New research directions were also identified. Applying micro-data and analysing household income, wealth composition, and distribution may improve our understanding of how monetary and macroprudential policies affect inequalities. The redistributive effects of monetary policy cannot be separated from other policies, particularly from those that may have a stronger and more direct impact on inequality, such as fiscal policy (Colciago et al., 2018).

The relationships between inequalities and macroeconomic stability were explored by using, among others, *a simplified financial model and then a VAR model* (Hauner, 2017). The main objective of the first part of the paper was to examine the relationship between inequalities and the financial crisis in a theoretical framework where the financial economy is simplified to creditors and debtors. These economic actors are linked to each other through financial instruments. While several sources in the literature link the emergence of financial crises to debt in the field of income inequality, the analyses of the distribution of the asset side in the balance sheet shed light on the relationship between wealth inequality and crises (Hauner, 2017).

Significant statistical evidence was found for the Piketty hypothesis in the US (Hauner, 2017). In the 20$^{th}$ century, wealth inequality – in line with the high accumulation of aggregate financial wealth – contributed significantly in a positive sense to the instability of the financial system in the long run. There is also a long-term relationship between household debt and wealth inequality, to which rising interest rates also contribute. The higher the debt

ratio, the greater the differences would be. Cumulative stochastic shocks tend to result in financial instability and wealth inequality in the long run. Based on the results, the only corrective force is the rise in the probability of bank defaults. A further conclusion was that neither declining wealth inequalities nor adjustments in interest rates trigger a major financial crisis.

*The impact of economic growth policies on inequality* was analysed by using comprehensive multi-country databases (Lopez, 2004). Two types of shocks were distinguished in the empirical model describing external conditions. The first type displayed the range of shocks to foreign trade that affects countries individually (individual effect), whereas the second one concerned all countries in the sample (time effect). The conditions of trade shocks include international demand for the individual country's export goods and the cost of inputs for production and consumption. The time effect, on the other hand, depicts the global circumstances that appear in a given period, reflecting global recessions or booms.

Variables were used that appear as a standard growth element in other sources as a factor of inequality (Lopez, 2004). This allowed assessing the impact of growth-promoting decisions on poverty (through the expected interaction of growth and inequality). According to the results, economic growth does not affect inequalities; however, inequalities harm growth. As for policy interventions, substantial improvements in education and infrastructure, as well as lower inflation rates, support GDP growth and produce a more balanced distribution of wealth (Lopez, 2004). The development of financial infrastructure, increasing trade openness and reductions in the size of the government sector – all of which are factors that may give rise to faster growth – would induce mounting inequalities.

Although in the short run, intervention policies that rely on compromises diminish inequality and stimulate growth, they are insufficient to even out income disparities (Lopez, 2004). If these reforms are not accompanied by anti-poverty interventions financed by gains emanating from growth, inequality will intensify further. Nevertheless, in the long-run growth support will suppress wealth disparities if policymakers react to short-term imbalances.

In an *agent-based macroeconomic model* income distribution and wealth accumulation depend on the role of economic agents in production activities, i.e., whether they are capitalists or employees (Tóth, 2003). This paper focuses on the interactions between social structure development and macroeconomic dynamics. The aim was to show how endogenous economic cycles and crises may evolve due to decentralised interactions between economic actors who self-organise into social classes in the process of capitalist production (Tóth, 2003). As a result, over time, even perfectly equal societies may become unequal. The findings of the model simulations highlight that when unemployment benefits (referring to the bargaining position of employees) decrease, greater inequality develops due to the pickup in the profit rate of the capitalist class (streamlining). In a labour market, where the working class is weaker, a higher profit rate persists, inequality is greater, and the system is characterised by a greater degree of instability. Overall, an increase in unemployment benefits exerts a beneficial effect on the economy with lower inequality without reducing corporate profits.

One conclusion that can be drawn from the above literature review is that a rather rich set of papers has evolved in recent years on the analysis of the general interrelationship between inequality and economic growth. Second, their approaches were rather diverse, highlighting various aspects and/or fields of the topic such as the business cycle, macroeconomic stability and volatility, monetary and fiscal policies and interventions, economic policy and reforms, GDP growth, etc. Third, the methodology applied displayed various financial and economic models, including simulations and VAR with diverse geographical coverages.

This literature survey forms the theoretical, empirical, and methodological background of this paper since many elements of the identified and analysed factors related to the economic impact of inequality appear in it. The remaining chapters analyse the mutual interaction of inequality-growth-volatility (cycles) in a simulation approach. The novelty of the paper in the light of the relevant literature is its comprehensive approach on the one hand, and the applied methodology that models forward-looking economic actors, and the role of expectations also come under scrutiny. This type of simulation is missing from the relevant literature available so far. An additional novelty is the inclusion of differentiated consumer groups and the role of expectations in the discussion. Section 3 describes the model with its assumptions.

## 3 The applied model and the assumptions

Following the international financial and economic crisis of 2008-2009, agent-based models and microsimulations emerged as alternative model families in the methodology, as such methodological tools make it possible to model long-term imbalances in the economy.

For these types of models, heterogeneous economic actors are defined. The behaviour of different agents, the interactions between actors and markets, and their impacts are formalised mathematically. Economic actors and agents may also be able to learn in such models and this regard, emergent effects resulting from the interactions of heterogeneous economic actors are analysed.

The model includes heterogeneous actors whose behaviour is well distinguishable – and not necessarily directed towards utility or profit maximisation – and is mathematically defined (Macal and North, 2005). The agents are independent but interact with each other. However, the behaviour of the economic actors may change based on their experience.

These model types have also been severely criticised, with detractors emphasising that the results cannot be generalised, and that as such, the models still contain substantial simplifications and abstractions, and the results are highly dependent on the given assumptions and technical parameters (Kovács and Takács, 2003). In the following outline, we will present the assumptions and derivation of our model.

The issue of inequality was discussed in a macro model containing heterogeneous agents, which was run by a Monte-Carlo simulation, coded in the R software package. Assuming an open economy, the model distinguishes two types of products: one for domestic consumption and another for exports. Accordingly, two types of companies are defined. The first one produces the domestic product while the other one the export product to be shipped abroad.

Production is characterized by the Cobb-Douglas type production function with producers both for the domestic and the export markets, where $A$ is the level of technology (total factor productivity), $L$ is the number of human resources used (measured in working hours), $K$ is the amount of capital involved in the production, $\alpha$ is the parameter for the labour intensity of production, $\gamma$ is the minimum share of domestic production in total production, and $M$ depicts imports in both the domestic consumer product and the one meant for exports. Consequently, (1- $\gamma$) denotes the share of the maximum import content of the production. In the subscript, $d$ indicates production for the domestic market, $f$ production for foreign markets, and $t$ the period of time.

$$Y_{d,t} = \left(A_{d,t}L_{d,t}^{\alpha_{Yd}}K_{d,t}^{1-\alpha_{Yd}}\right)\gamma_{Yd} + \min\left(M_{d,t};\left(\left(A_{d,t}L_{d,t}^{\alpha_{Yd}}K_{d,t}^{1-\alpha_{Yd}}\right)\left(1-\gamma_{Yd}\right)\right)\right)$$

$$Y_{f,t} = \left(A_{f,t}L_{f,t}^{\alpha_{Yf}}K_{f,t}^{1-\alpha_{Yf}}\right)\gamma_{Yf} + \min\left(M_{f,t};\left(\left(A_{f,t}L_{f,t}^{\alpha_{Yf}}K_{f,t}^{1-\alpha_{Yf}}\right)\left(1-\gamma_{Yf}\right)\right)\right)$$

The level of production is thus determined by the technological parameter, the labour force, and the capital. Technology (productivity) is a gradually increasing technical parameter, the annual improvement of which (in percent year-on-year) is determined by the $\lambda$ parameter.

$$A_{d,t} = \left(1+\lambda_{Ad}\right)A_{d,t-1}$$

$$A_{f,t} = \left(1+\lambda_{Af}\right)A_{f,t-1}$$

In the production process, we do not differentiate the labor force, i.e. we do not assume any differences based on productivity, education, skills, and work experience in the labour market. The amount of labour force, which has no supply constraint, is determined by labor demand. The latter is defined by short-term demand expectations for the product manufactured. Although the labor force stock involved in the production is not restrained by supply, temporary changes (simultaneous hiring and firing that may be a realistic assumption due to labour market flexibility, the activity of trade unions, etc.) from one period of time to another certainly are possible. Labour demand is shaped by short-term expectations of demand for goods produced. Long-term demand expectations determine capital demand, that is, investments. Thus, the expectation channel is of great importance in this model.

$$L_{d,t} = \left(\frac{\gamma_{Yd}D_{d,t}}{\gamma_{Yd}\left(A_{d,t-1}K_{d,t}^{1-\alpha_{Yd}}\left(1+\lambda_{Ad}\right)\right)}\right)^{\frac{1}{\alpha_{Yd}}}$$

If $0 < \Delta L_{d,01}$ then $L_{d,t} = \min\left(L_{d,t-1}+\Delta L_{d,01}; L_{d,t-1}\left(1+\lambda_{LMAXd}\right)\right)$
and if $0 > \Delta L_{d,01}$ then $L_{d,t} = \max\left(L_{d,t-1}+\Delta L_{d,01}; L_{d,t-1}\left(1+\lambda_{LMINd}\right)\right)$
otherwise $L_{d,t} = L_{d,t-1}$

$$L_{f,t} = \left(\frac{\gamma_{Yf}D_{f,t}}{\gamma_{Yf}\left(A_{f,t-1}K_{f,t}^{1-\alpha_{Yf}}\left(1+\lambda_{AF}\right)\right)}\right)^{\frac{1}{\alpha_{Yf}}}$$

If $0 < \Delta L_{f,01}$ then $L_{f,t} = \min\left(L_{f,t-1}+\Delta L_{f,01}; L_{f,t-1}\left(1+\lambda_{LMAXf}\right)\right)$
and if $0 > L_{f,01}$ then $L_{f,t} = \max\left(L_{f,t-1}+\Delta L_{f,01}; L_{f,t-1}\left(1+\lambda_{LMINf}\right)\right)$
otherwise $L_{f,t} = L_{f,t-1}$

Besides the parameters already presented, $D_{d,t}$ stands for the demand for the domestic product in period $t$. Similarly,

$D_{f,t}$ indicates demand for the export product in period $t$. In the model, $\lambda_{LMAXd}$ and $\lambda_{LMINd}$ represent labor market flexibility and supply-demand constraint, respectively. The reason for this is that the company is unable to recruit or lay off an unlimited number of workers immediately if short-term demand so requires it. The maximum number of the additional labour force that can be recruited is determined by the upper limit, while the maximum number that can be laid off, triggering a decrease similar to the previous period, is determined by the lower limit.

The capital accessible during production is determined by the capital stock available after depreciation in the previous period and investments capitalised during the period is the following instead of as follows:

$$I_{d,t} = \left( \frac{\gamma_{Yd} \begin{pmatrix} \theta_{Id,1} ED_{d,t,t+1} \\ +\theta_{Id,2} ED_{d,t,t+2} \\ +\theta_{Id,3} ED_{d,t,t+3} \end{pmatrix}}{\begin{pmatrix} \theta_{Id,1} \gamma_{Yd} A_{d,t-1} L_{d,t-1}{}^{\alpha_{Yd}} \\ +\theta_{Id,2} \gamma_{Yd} \left( \left( \lambda_{Ad} \right) A_{d,t-1} \right) L_{d,t-1}{}^{\alpha_{Yd}} \\ +\theta_{Id,3} \gamma_{Yd} \left( \left( \lambda_{Ad} \right)^2 A_{d,t-1} \right) L_{d,t-1}{}^{\alpha_{Yd}} \end{pmatrix}} \right)^{\frac{1}{1-\alpha_{Yd}}} - K_{d,t-1},$$

$$K_{d,t} = K_{d,t-1}\left(1-\delta_d\right) + I_{d,t},$$

$$I_{f,t} = \left( \frac{\gamma_{Yf} \begin{pmatrix} \theta_{If,1} ED_{f,t,t+1} \\ +\theta_{If,2} ED_{f,t,t+2} \\ +\theta_{If,3} ED_{f,t,t+3} \end{pmatrix}}{\begin{pmatrix} \theta_{If,1} \gamma_{Yf} A_{f,t-1} L_{f,t-1}{}^{\alpha_{Yf}} \\ +\theta_{If,2} \gamma_{Yf} \left( \left( \lambda_{Af} \right) A_{f,t-1} \right) L_{f,t-1}{}^{\alpha_{Yf}} \\ +\theta_{If,3} \gamma_{Yf} \left( \left( \lambda_{Af} \right)^2 A_{f,t-1} \right) L_{f,t-1}{}^{\alpha_{Yf}} \end{pmatrix}} \right)^{\frac{1}{1-\alpha_{Yf}}} - K_{f,t-1},$$

$$K_{f,t} = K_{f,t-1}\left(1-\delta_f\right) + I_{f,t},$$

where $ED_{d,t,t+1}$, $ED_{d,t,t+2}$, $ED_{d,t,t+3}$ in the $t^{\text{th}}$ period represent the demand for the domestic product expected for the $t + 1$, $t + 2$ and $t + 3$, etc. periods, and $\theta_{Id,1}$, $\theta_{Id,2}$, $\theta_{Id,3}$ the weight of each period in the case of decisions made in the $t^{\text{th}}$ period. The similarly interpreted $ED_{f,t,t+1}$, $ED_{f,t,t+2}$, $ED_{f,t,t+3}$ stand for the expected demand only for products intended for export. Demand expectations are shaped by the stochastic growth rate projected by economic agents for demand in period $t$:

$$ED_{d,t,t+1} = D_{d,t} * \left[1 + N_d\left(Gr; Std\right)\right],$$

$$ED_{d,t,t+2} = D_{d,t} * \left[1 + N_d\left(Gr; Std\right)\right]^2,$$

$$ED_{d,t,t+3} = D_{d,t} * \left[1 + N_d\left(Gr; Std\right)\right]^3,$$

where $N_d(Gr; Std)$ is a random number with a $Gr$ average (expected growth rate) and an $Std$ deviation (growth volatility) according to normal distribution.

In contrast, actual demand expands linearly at a stable growth rate.

$$D_{d,t} = D_{d,t-1} * \left(1 + HPD_{d,act}\right)$$

$$D_{f,t} = D_{f,t-1} * \left(1 + HPD_{f,act}\right)$$

Here $D_{d,t}$ denotes demand for the domestic product, and $D_{f,t}$ that for the export product in the $t^{\text{th}}$ period. It is determined by the demand of the previous period, and the growth rate of demand, which is $HPD_{d,act}$ for the domestic product and $HPD_{f,act}$ for the export product.

The production also requires imported goods. The import content required to produce a domestic product is typically less than that of products manufactured for export. The production sector–sectors producing for the domestic and the foreign markets taken together–imports goods for the upcoming period depending on the expected demand of that upcoming period, i.e. of orders that are placed one period earlier. Thus, imports are determined as follows:

$$M_{d,t-1} = ED_{d11}\left(1-\gamma_{Yd}\right),$$

$$M_{f,t-1} = ED_{f11}\left(1-\gamma_{Yf}\right),$$

where $\gamma_{Yd}$ and $\gamma_{Yf}$ are the share of domestic factors of production in total production, while $1-\gamma_{Yd}$ and $1-\gamma_{Yf}$ define the import content of production in each production sector. Thus, total imports can be determined from the import and production functions as follows:

$$IMP_t = \min\left(M_{d,t-1}; \left(A_{d,t} L_{d,t}{}^{\alpha_{Yd}} K_{d,t}{}^{1-\alpha_{Yd}}\right)\gamma_{Yd}\right) + \min\left(M_{f,t-1}; \left(A_{f,t} L_{f,t}{}^{\alpha_{Yf}} K_{f,t}{}^{1-\alpha_{Yf}}\right)\gamma_{Yf}\right).$$

When examining income inequalities, we assumed and used heterogeneous households in the model. We distinguished three groups of households, which differ mainly in the size of their income, but their consumption habits and expectations may also be different. As we did not differentiate among households in the labor market in terms of their education, productivity, experience (everyone does the same job, with the same efficiency), individual groups earn their extra income from the assets they

own. Thus, wealth differences also appear explicitly in the model. These three income groups are denoted by the letters 'a', 'b', and 'c', respectively. In our model, $\mu$ shows the income concentration, which is the flow of all income generated to each group in period t. Thus, it follows that $\mu_a + \mu_b + \mu_c = 1$.

The consumption of individual households is described by the following equations:

$$C_{a,t} = \hat{c}_a \mu_a \left( \begin{array}{l} \left( \beta_a \dfrac{\left( \begin{array}{l} \mathrm{GDP}_{t-1} \\ +\alpha_{c,a1}\mathrm{GDP}_{t-2} \\ +\alpha_{ca,2}\mathrm{GDP}_{t-3} \end{array} \right)}{\left(1+\alpha_{c,a1}+\alpha_{c,a2}\right)} \right) \\ + \left( \left(1-\beta_a\right) \dfrac{\left( \begin{array}{l} \mathrm{EGDP}a_{t,t+1} \\ +\gamma_{c,a1}\mathrm{EGDP}a_{t,t+2} \\ +\gamma_{c,a2}\mathrm{EGDP}a_{t,t+3} \end{array} \right)}{\left(1+\gamma_{c,a1}+\gamma_{c,a2}\right)} \right) \end{array} \right),$$

where GDP growth expectations in the second set of the consumption function are described by the following equations:

$$\mathrm{EGDP}a_{t,t+1} = \mathrm{GDP}_t * \left[1 + \mathrm{HPGDP}a_{\exp}\right],$$

$$EGDPa_{t,t+2} = \mathrm{GDP}_t * \left[1 + \mathrm{HPGDP}a_{\exp}\right]^2,$$

$$\mathrm{EGDP}a_{t,t+3} = \mathrm{GDP}_t * \left[1 + \mathrm{HPGDP}a_{exp}\right]^3,$$

and where $\mathrm{HPGDP}a_{exp}$ is the expected GDP growth rate by group 'a'.

$$C_{b,t} = \hat{c}_b \mu_b \left( \begin{array}{l} \left( \beta_b \dfrac{\left( \begin{array}{l} \mathrm{GDP}_{t-1} \\ +\alpha_{c,b1}\mathrm{GDP}_{t-2} \\ +\alpha_{c,b2}\mathrm{GDP}_{t-3} \end{array} \right)}{\left(1+\alpha_{c,b1}+\alpha_{c,b2}\right)} \right) \\ + \left( \left(1-\beta_b\right) \dfrac{\left( \begin{array}{l} \mathrm{EGDP}b_{t,t+1} \\ +\gamma_{c,b1}\mathrm{EGDP}b_{t,t+2} \\ +\gamma_{c,b2}\mathrm{EGDP}b_{t,t+3} \end{array} \right)}{\left(1+\gamma_{c,b1}+\gamma_{c,b2}\right)} \right) \end{array} \right),$$

where GDP growth expectations in the second set of the consumption function are described by the following equations:

$$\mathrm{EGDP}b_{t,t+1} = \mathrm{GDP}_t * \left[1 + N\left(\mathrm{HPGDP}b_{\exp}; \mathrm{Std}\right)\right],$$

$$\mathrm{EGDP}b_{t,t+2} = \mathrm{GDP}_t * \left[1 + N\left(\mathrm{HPGDP}b_{\exp}; \mathrm{Std}\right)\right]^2,$$

$$\mathrm{EGDP}b_{t,t+3} = \mathrm{GDP}_t * \left[1 + N\left(\mathrm{HPGDP}b_{exp}; \mathrm{Std}\right)\right]^3,$$

and where $\mathrm{HPGDP}b_{exp}$ is the expected GDP growth rate by group 'b' and Std the expectation error. The growth expectations of group 'b' are not deterministic but appear in a stochastic way.

$$C_{c,t} = \hat{c}_c \mu_c \left( \frac{\left( \mathrm{GDP}_{t-1} + \alpha_{c,c1}\mathrm{GDP}_{t-2} + \alpha_{c,c2}\mathrm{GDP}_{t-3} \right)}{\left(1+\alpha_{c,c1}+\alpha_{c,c2}\right)} \right),$$

where $C_{a,t}$ is the consumption of household group $a$ in period $t$, and based on this $C_{b,t}$ and $C_{c,t}$ denote the consumption of groups $b$ and $c$ in period $t$. $\hat{c}_a$, $\hat{c}_b$, $\hat{c}_c$ are the marginal propensities to consume, based on this $0 < \hat{c} \leq 1$.

In the simulated economy, GDP and thus the disposable income of households (assuming that households own companies in the productive sector) are defined as follows.

$$\mathrm{GDP}_t = C_t + I_{d,t} + I_{f,t} + Exp\left(Y_{f,t}\right) - IMP_t$$

We can set periods and successive steps in the operation of the model, which covers 5 years with an annual frequency. It includes the identification of the following factors for each period:

1. Consumption expectations of households.
2. Consumption decisions of the household groups.
3. Actual future demand and that expected by producers.
4. Investment decisions, which in turn define the capital stock of the period.
5. Imports based on expected demand.
6. The labor force is based on demand in the given period.
7. Production.
8. GDP.

The results of the model are presented in Section 4.

## 4 Results and findings

The model presented in Section 3 allows us to simulate the effects of several factors individually or jointly on the economy described by us. In our simulations, we analyse an economy that devotes a quarter of its capital stock and available labour force to the production of an export product. Domestic economic demand is growing at an average rate of 3.5 percent annually, with a 1 percent standard deviation over the five years. The three consumer groups (social strata) presented earlier receive an equal share of the income each year.

The difference among the consumer cohorts is as follows. The first group can assess accurately the growth trajectory of the economy and its marginal propensity to consume is lower (0.7) than that of the other two groups. This is the *wealthy group*. The marginal propensity to consume (0.85) of the second group of consumers is higher than that of the first one. This group can identify the growth potential of the economy adequately, albeit with a small degree of error (1 percent). This group constitutes the *middle class*. The third group is formed by the poorer stratum, which has no savings, its members have no future expectations. It is important to emphasize that there are significant differences among the individual groups in terms of their wealth (and therefore their marginal propensity to consume). Although each worker is equally efficient in the labour market, the income generated by the economy in a year is divided unequally among the social groups.

We simulated the effects of inequality in our model. Although the indicated parameters were not determined empirically, they are not far from actual empirical data. E.g., according to the figures of the Hungarian Central Statistical Office, in Hungary in 2018 the marginal propensity to consume of the poorest households (lower two deciles) was 1.04. Considering those belonging to the lower three deciles to be the poorest, we get a parameter of 0.98. The marginal propensity to consume of the middle class was 0.89 (0.9 in the case of a completely even distribution of deciles), whereas 0.79 in the highest income deciles.

Income inequality refers to the increase in the income concentration of the richest social group. Thus, income inequality is measured by concentration ratios rather than the Gini coefficient. According to the results of the model, if the income concentration of the richest social stratum is lifted (and simulated these 1000 times because of dynamic variables and stochastic parameters), the average consumption of the five simulated years in the 1000 simulations is presented in Fig. 1.

Macro-level consumption is highest when there is no income inequality. The model endogenously does not take into consideration savings, and by extension, the allocation of resources. Investments are determined namely solely by expectations for future demand. Consequently, according to the model, investments in such a society will be higher, therefore GDP will necessarily be higher as well[1].

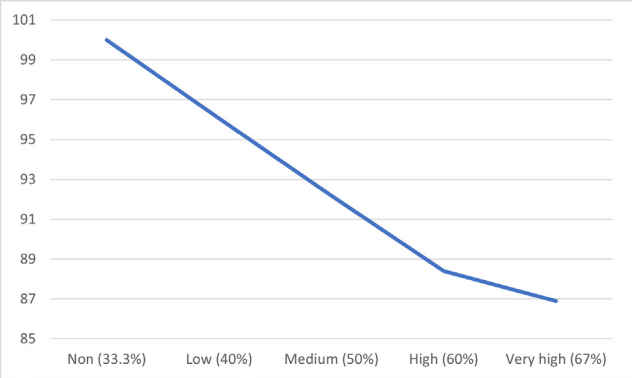


**Fig. 1** The average level of consumption over the period with different levels of inequality (simulated level of consumption without income inequalities is 100 percent). Source: the authors' calculation.

According to Fig. 1, significant loss can be measured in an economy due to social inequality. The graph depicts economies with the same fundamentals but different levels of income inequality (with the same quality and quantity of labour force in every cohort). They are likely to face shrinking consumption and GDP. Furthermore, in the case of extreme income disparities, macro-level consumption is 13 percent lower in the economy we simulated.

Regarding the impact of income disparities with different growth prospects, the conclusion can be drawn that the higher the rate of economic growth, the smaller the relative loss of consumption to society.

This is mainly due to the wait-and-see effect related to the expectation channel, because economic agents are aware of the distribution of demand growth, albeit with some degree of uncertainty, depending on their social group. Thus, their expected disposable income is higher, which weakens the reserve motivation of households. This is indicated in Fig. 2, where the horizontal axis shows the different growth rates for the five years surveyed, and the vertical axis the consumption losses associated with different growth rates.

As far as expectations for different growth rate levels and the standard deviation of the estimates are concerned, we found that the more uncertain the consumer's expectation, i.e., the greater the estimation error over future economic performance, the more volatile consumption will be, which causes economic cycles to shorten and fluctuate more (Fig. 3). Thus, one of the most important factors for sustainability is to have more precise expectations.

**1** Similarly to other models used in the literature, behaviours here are considered constant until the end of the period. The same is true for consumption patterns, which is an unrealistic assumption. As incomes rise, the consumption habits of all groups (particularly those of the poor households) are likely to change over time. This may anticipate an inverted U shape curve depending on the economic structure. Resolving the condition with dynamic conditional behavior may be another research topic.

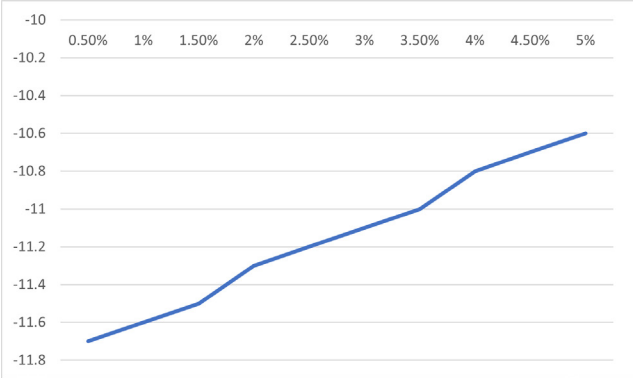


**Fig. 2** Consumption deviation (vertical axis) at different growth rates (horizontal axis) in case of inequality. Source: the authors' calculation.

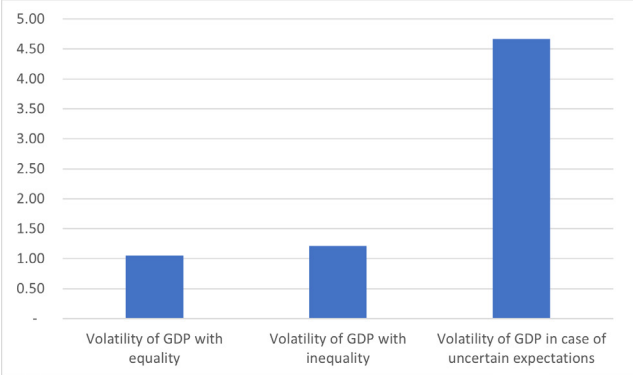


**Fig. 3** Average of the variance of consumption at the different growth rate and rationality levels (in basis point relative to consumption). Source: the authors' calculation.

Assuming that the distribution of annual growth rates is normal, and economic agents know the parameters characterising the distribution of growth (average and standard deviation of the growth rate) for the given period, the variance of consumption decreases to almost zero, thus minimising economic fluctuations, and helping the economy to function sustainably at its potential level. Growing inequality, too, significantly augments the volatility of macro-level consumption at all growth rate levels, but the impact on volatility is much smaller than in the case of expectations.

Concerning the variance of consumption under conditions of inequality, we found that in an unequal society, inaccurate expectations amplify the deviation of consumption, triggering fluctuation with a larger amplitude (Fig. 4). In reality, this may be due to the fact that households with less wealth and less income possess less information and may therefore be willing to become indebted even to an unrealistic extent. They hope that economic growth will be more sustained and much more significant, or they will cut their spending sharply in the middle of the recovery to a greater extent than would be rational to generate

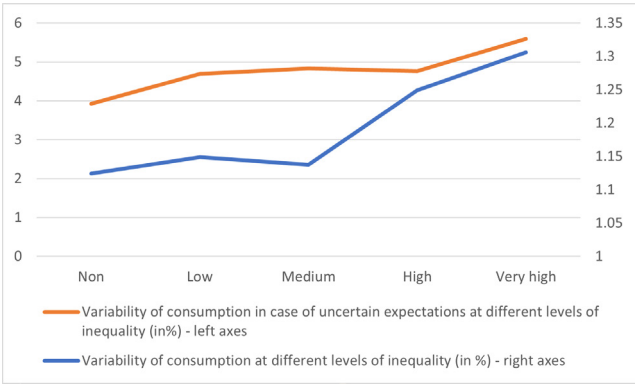


**Fig. 4** The variance of consumption at different levels of inequality (basis points relative to consumption). Source: the authors' calculation.

reserves as they anticipate a crisis with liquidity problems and price decreases. Both behaviours bear significant real economic costs. When expectations are accurate but income inequality among different groups in society increases, variance in consumption intensifies, albeit slightly. In summary, inequality and uncertain expectations both raise the variance of consumption but to different degrees. The role of expectations is more pronounced, the impact of which is amplified strongly by inequality. Inequality alone involves higher costs in terms of sunken consumption. Nevertheless, in reality, levels of education (and thus, financial literacy), proper expectations, and differences in incomes are interlinked factors.

Thus, irrational expectations amplify economic cycles by significantly raising the volatility of household consumption. For this reason, managing amplified cycles (shorter ones with larger amplitudes) requires more costly economic policy interventions. For that reason, maintaining the credibility of institutions and managing expectations can be a crucial implication for economic policy. Rationalising expectations (putting them on a fundamental footing) can help mitigate it, and its tool may primarily be education.

The results of the model were validated for all simulated results at confidence intervals. The confidence interval is the lower and upper limits of the variable at a given significance level, calculated from the mean (upper $X$) standard deviation ($\sigma$) of the simulated results, the number of simulations ($n$) as a set of observations, and the 95 percent confidence level of the Student's t-distribution ($t_{N,\alpha}$) as follows:

$$\left[\bar{X} - t_{N,\alpha}\frac{\sigma}{\sqrt{n}}, \bar{X} + t_{N,\alpha}\frac{\sigma}{\sqrt{n}}\right].$$

Based on the intervals obtained for the simulation data, the results are stable and significant. The conclusions drawn from them are presented in Section 5.

## 5 Summary and conclusions

The paper focused on inequality as an independently analysed phenomenon that has real economic impacts. The underlying assumption was that through its positive incentives, innovation bolsters long-term economic growth, one of the side-effects of which is increasing income inequality. Consequently, inequality is the essence of capitalism. However, extended inequality can involve significant economic costs. Our objective was to analyse the direct and indirect economic impact of inequality rather than the process of how inequality has been generated that could accelerate economic development.

This paper complements the research results achieved so far in the relevant international literature with a new approach. It analyses the interaction between inequality, growth, and volatility (organized in cycles as well) while taking the rationality of economic actors into account. The simulations created by the model demonstrate the macroeconomic effects of income inequality and rationality (i.e., more accurate expectations) in terms of GDP growth, stability, and sustainability. Our results are in line with the relevant literature such as Ditsa and Hayat (2017) and Cardaci and Saraceno (2015). Nevertheless, our model is more comprehensive than previous ones since it contains more variables. The inclusion of expectations in the model is entirely new.

Our original results also show that the loss of consumption (and the economic value added in general) resulting from inequality is lower when the rate of economic growth is persistently higher. According to the model, the stimulation of economic growth can be achieved by diminishing income inequalities, which can thus reduce "lost consumption" in two ways: first, through extended growth alone, second, through decreased loss on consumption, i.e. by increasing the welfare of the population.

Reducing income disparities can mitigate fluctuations in consumption and thus alleviate the volatility and cyclicality of the economy. Rationalising expectations and improving financial culture is essential to achieve sustainable potential economic output levels. The result of the simulation points out that inequality and uncertain expectations, too, raise the variance of consumption, albeit in varying degrees. Our original conclusion is that the role of expectations is more pronounced, the impact of which is significantly amplified by inequality. The results help to understand the empirical phenomenon that shows why some unequal economies seem to be more volatile and exposed to external shocks.

Fiscal policy can contribute to slackening inequality and strengthening the middle classes through income transfers. Since monetary policy is most effective for the middle classes as they are actors in the saving and credit market as well, fiscal interventions may also be more effective for them. Monetary policy and central banks, in general, can play a crucial role in managing expectations, thereby minimising the uncertainty of an economic outlook that may endogenously support economic stability.

Based on the results in general and on the analysis of the role of expectations, we concluded that the rationalisation of expectations can contribute significantly to the maintenance of sustainable growth patterns and the moderation of the volatility of growth. Therefore, the conclusion can be drawn that the most effective tool for creating economic growth and stability is the improvement of education. Education intensifies and promotes competition, enhances skills, therefore income disparities may be eased, and social mobility bolstered in a way that the two main drivers of capitalism – competition and innovation – are not weakened. Improving education may be a crucial element of reforms as mentioned by Cardaci and Saraceno (2015), and Lopez (2004), although without specifying education.

Another very important outcome of improving education is that rationality is elevated through the improvement of financial culture. Consequently, consumer expectations are also becoming more valid, which can endogenously reduce the amplitudes of economic booms and busts and their reactions to the external environment, thereby supporting the economy in reaching long-term sustainability. In our paper, we applied heterogeneous households in terms of their consumption but not in terms of their productivity. We also assumed fixed consumption habits for all groups over time. To scrutinise the impact of education further, those restrictions need to be suspended.

Furthermore, the rationalisation of expectations is enhanced by forward guidance and ongoing and regular communication on economic prospects and risks (including potential impacts as well). Our results underline the importance of the credibility of economic policy actions and institutions. The economic policy aims to promote growth and maintain the stability of the economy to approximate the actual level of economic activity to the potential one. Consequently, the social segment with savings and thus expectations may be able to make more rational economic and financial decisions.

New research directions and topics may include analysis of the distribution effects of monetary policy actions,

the inclusion of demographic factors (ageing, migration, heterogeneous production, and the labour market) and the interest rate channel in the model as well as the simulation of social trends and processes unfolding in specific countries and groups of countries in terms of their economic growth prospects and sustainability.

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