Check for updates

Folia Oeconomica
Acta Universitatis Lodziensis
ISSN 0208-6018 e-ISSN 2353-7663

https://www.czasopisma.uni.lodz.pl/foe/
2(367) 2024
DOI: https://doi.org/10.18778/0208-6018.367.02

Jan Marek Sztaudynger https://orcid.org/0000-0002-6402-7654

University of Lodz, Faculty of Economics and Sociology, Lodz, Poland, jan.szt@wp.pl
MA, former (graduate) doctoral student

Non-Cyclical Fluctuations in *GDP* Growth in Poland

Abstract: The aim of the study presented in the paper is to verify the hypothesis of non-cyclical economic fluctuations; in particular, the hypothesis concerning the irregularity of causes and the hypothesis concerning the regularity of rebalancing the economy. Slow past *GDP* growth is taken as a symptom of disequilibrium, that is, the occurrence of either fixed asset bottlenecks or demand shortages. These two causes of disequilibrium arise irregularly in the economy. The hypothesis tested states that the slower the economic growth that occurred in the past, the stronger the compensatory *GDP* growth that will occur in the future. This is the regularity of rebalancing.

The method of least squares was used to estimate a modified Solow model for Poland's *GDP* in the years 1994–2019. The most important modification consisted in replacing the dynamics of net physical capital, which is not available in Polish statistics, with the investment rate. The second reason for this modification is the inaccuracy of statistical data on gross physical capital, which cannot be avoided. Another modification was the introduction of lagged *GDP* growth into the model as an indicator of disequilibrium.

The hypothesis that the intensified occurrence of bottlenecks results in greater investment efficiency after 3–5 years has been confirmed. On the other hand, a slowdown in *GDP* growth results after 1–2 years in the accumulation of unused capacity, which enables a compensatory acceleration of economic growth. Thus, the hypothesis of the occurrence of non-cyclical economic fluctuations in the Polish economy has been confirmed.

Keywords: economic growth, Solow model, physical capital investment, bottlenecks, capacity utilisation, economic fluctuations

JEL: E13, E22, E32, O40

1. Introduction

The market can be in one of the three states: equilibrium of demand and supply, disequilibrium with excess demand or disequilibrium with excess supply. Each type of disequilibrium slows the growth of a partial market and the corresponding segment of the economy.

States of undersupply or shortages of fixed assets will be equated with the occurrence of bottlenecks, while unused capacity will be equated with shortages of demand. An attempt will be made to build an economic growth model to describe the mechanism of restoring equilibrium by eliminating bottlenecks or reducing unused capacity. The greater the imbalance, the greater the growth effect should be produced by the return to equilibrium, which requires investment. In other words, there occurs the phenomenon of hysteresis, that is, the dependence of current economic growth on past growth.

In short, the elimination of disequilibrium can occur either based on investment or in a non-investment manner. In both situations, there occurs an economic slowdown, and then a corresponding acceleration. It can be assumed that the greater the disequilibrium, the greater the slowdown, and the stronger the effects of compensatory measures. Thus, it seems that economic fluctuations are not characterised by a regular course over time, since the occurrence of disequilibrium in the economy is irregular in nature. On the other hand, regularity can be observed in the recovery from irregularly occurring shortages of fixed assets (shortages of supply) or shortages of demand.

The purpose of the presented research is to answer the question of whether Poland's economy experiences non-cyclical, i.e. irregular, economic fluctuations. The analysis covers the years 1994–2019. A modified Solow economic growth model with a Cobb–Douglas production function, which describes the mechanism of restoring equilibrium by eliminating bottlenecks or stimulating demand to activate unused production capacity, will be applied.

Economic growth (*GDP* dynamics) will depend on the investment rate, the employment rate and the lagged *GDP* growth. The model will use annual data from Statistics Poland (the Central Statistical Office of Poland). Data on *GDP* and investment come from the CSO's macroeconomic data bank (https://bdm.stat.gov.pl/). Data on employment (employed), in addition to the above, will also come from the CSO's Statistical Yearbooks and the author's own calculations.

Earlier studies confirmed hypothesis $\mathbf{H}_1$ that the greater the slowdown in economic growth, that is, the greater the severity of fixed asset bottlenecks, the greater the efficiency of investment after two, three and even six years (Sztaudynger, Sztaudynger, 2022). This sort of acceleration and growth was called the investment type. In this paper, after refining the model, the hypothesis will be tested again.

In the current study, the following modifications have been made compared to the previous model (Sztaudynger, Sztaudynger, 2022):

1) the elimination of disequilibrium occurs not only through investment but also through adjustments to fluctuations in demand;
2) employment (employed)[1] growth rate was introduced and the lags in its impact on *GDP* growth were determined;
3) one of the assumptions of the Solow model was transformed to replace the dynamics of physical capital with the rate of investment.

The economic growth achieved by increasing the utilisation of existing production capacity will be called the non-investment economic growth. Such growth is the subject of the following new hypothesis:

H_2: the slower the *GDP* growth that occurred one and two years ago, the faster the compensatory non-investment growth that will occur in the current year in addition to the growth resulting from capital expenditures.

Verifying hypotheses H_1 and H_2 is the primary objective of the paper. These hypotheses address the key issue of economic growth, namely the mechanism of economic fluctuations, in particular whether they are regular or not. This important question still remains unanswered. Are the economic fluctuations occurring in the Polish economy cyclical or not?

The growth modelling literature does not differentiate the effects of investment based on the presence of bottlenecks preceding the investment (e.g.: Cobb, Douglas, 1928; Romer, 1994; Baranowski, 2008; Tokarski, 2009). According to hypothesis H_1, such differentiation does occur. Similarly, economic growth does not depend on the magnitude of previous demand shortages. According to hypothesis H_2, such dependence occurs.

If hypotheses H_1 and H_2 are confirmed, that is, if the causes of economic fluctuations turn out to be, among others, bottlenecks in fixed assets and unused production capacity, which appear in the economy in an irregular or random way (structural changes, transformations, armed conflicts, or pandemics), this will lead to the conclusion that economic fluctuations do not have a regular cyclical pattern over time.

Another, less significant, hypothesis is that:

H_3: Employment growth impacts *GDP* growth not only in the same year but also with lags.

The structure of the paper is as follows: Section 2 presents the classical Cobb-Douglas production function from the Solow growth model with references to the literature. Then, one of the assumptions of the Solow model is transformed, which allows us to replace the dynamics of net physical capital[2] with the rate of investment. In Section 3, the model presented in Section 2 is modified taking into account the impact of demand shortages. Section 4 presents the results

1 In Polish statistics, the category that best describes the volume of people's involvement in production processes is the number of persons employed in the national economy (according to Statistics Poland, this group comprises employed workers, employers and the self-employed). Growth models use the term 'employment.' In this paper, these terms will be used interchangeably to avoid the ambiguous term 'employment dynamics.'

2 Net physical capital dynamics is not reported in Polish statistics.

of estimating this model, which will be used to verify hypotheses H_1 and H_2 concerning non-cyclical economic fluctuations and hypothesis H_3 regarding the lagged effect of employment on *GDP* growth. Sections 5 and 6 include a discussion of the results obtained and conclusions.

2. The Cobb–Douglas production function in the literature and a proposal for its modification[3]

The starting point for the study is the classical Solow model with the Cobb–Douglas production function (Cobb, Douglas, 1928; Solow, 1956; 1988; Douglas, 1976; Jones, 2000; Aghion, Howitt, 2009, pp. 21–29; Sasaki, 2017; Dykas, Tokarski, Wisła, 2022, pp. 16–24)[4] in its dynamic form:

$$G\dot{D}P_t = \propto_0 + \propto_1 \dot{L}_t + \propto_2 \dot{K}_t, \qquad (1)$$

where:
GDP – the volume of production (*GDP*) at constant prices,
$G\dot{D}P_t$ – *GDP* growth at constant prices,
$\dot{L}_t$ – employment dynamics–working people in the national economy (%) as of the end of the year compared to the beginning of the year,
$\propto_0$ – the rate of technical and organisational progress,
$\propto_1$ and $\propto_2$ – the elasticity of *GDP* with respect to *L* and *K*,
$\propto_1 + \propto_2 = 1$ – is therefore a homogeneous function of degree one,
$\dot{K}_t$ – physical capital (fixed assets) dynamics, net value at constant prices.[5]

3 This point was taken from the author's publication (Sztaudynger, 2022).
4 This is a supply-oriented model which does not explain physical capital dynamics and investments. Kalecki's model makes GDP dynamics dependent on consumption and capitalist investment, which means it is demand-oriented (see Kalecki, 1958). The Solow model with the Cobb–Douglas production function is the subject of various modifications, including the use of Kalman filters to make the parameters of this Cobb–Douglas model time-varying (Munguía, Davalos, Urzua, 2019).
5 However, the CSO publishes the gross (initial) value of fixed assets at constant prices (more information on the dynamics of this value can be found in an email of Ewa Śliwka from the Department of Capital Expenditures and Fixed Assets, 1.12.2022). The CSO does not calculate or publish the dynamics of net capital at constant prices, and such a variable is present in the Solow model. The problem of calculating the value of physical capital was already recognised by Cobb and Douglas (1928, p. 142). They state that La Verne Beals, who was responsible for business statistics in the census, claimed that entrepreneurs reported the value of capital based on initial value rather than net value: 'original cost rather than cost of reproduction.' Cobb and Douglas' way of measuring capital was criticised as early as 1927 by S. Slichter. Firstly, the Aldrich Committee found the fixed asset investment data for the years 1880–1889 in the US unreliable. Secondly, Douglas' method of calculating investment prices is inaccurate as it assumed a constant share of wages in construction, while it was, in his view, declining (Slichter, Black, 1928, p. 166; cf. Biddle, 2012, p. 231). One rationale for calculating K depreciation is the fact that the productivity of fixed assets tends to decline with age. Therefore, the net value of fixed assets should better express the contribution of physical capital to production value creation.

It is a very difficult statistical problem to separate the increase in the value of fixed assets into a part related to their improvement/modernisation and a purely inflationary part, and to express in constant prices fixed assets with very different degrees of wear and tear. Therefore, the dynamics of physical capital at constant prices $\dot{K}_t$ will be replaced by the investment output (production) ratio $\frac{I_t}{GDP_t}$ (the numerator and denominator expressed in current prices).

In the neoclassical Solow model, this substitution can be derived from the net capital growth equation:[6]

$$\Delta K_t = s_t GDP_t - \delta K_t,$$

where:
ΔK_t – net capital growth at constant prices,
s_t – the savings rate is equal by assumption in the Solow model to the investment rate I_t / GDP_t (both numerator and denominator expressed in current prices),
δ – capital depreciation rate.

Dividing both sides of the above equation by K_t, we obtain:

$$\dot{K}_t = \frac{\Delta K_t}{K_t} = \frac{s_t GDP_t}{K_t} - \delta,$$

where:
GDP_t / K_t – capital productivity.

Under the assumption that in the long term the productivity of capital is constant $GDP_t / K_t = PR\_c$, we obtain:

$$\dot{K}_t = \frac{\Delta K_t}{K_t} = PR\_c (I / GDP)_t - \delta.$$

And after substitution into (1):

$$G\dot{D}P_t = \propto_0 + \propto_1 \dot{L}_t + \propto_2 \left[PR\_c \ (I / GDP)_t - \delta \right]$$

and ordering:

$$G\dot{D}P_t = \propto_0 - \propto_2 \delta + \propto_1 \dot{L}_t + \propto_2 PR\_c \ (I / GDP)_t.$$

6 When seeking an answer to the question whether the model should include capital dynamics (net, at constant prices) or the investment rate, it is worth noting that the problem is the availability of data. Data on net capital dynamics are not available from CSO statistics. This is probably due to the necessarily conventional calculation of depreciation rates. These considerations do not seem to imply a need to change the CSO's calculation procedures. The rationale for replacing physical capital dynamics was proposed by Baranowski (18.11.2022).

If we additionally assume that the absolute value term can change over time, we obtain the following:

$$G\dot{D}P_t = \dot{A}_t + \beta_1 \dot{L}_t + \beta_2 (I / GDP)_t ,$$

where:

$\dot{A}_t$ – the equivalent of Total Factor Productivity (*TFP*) – not only the level of technology, in the Solow model, it is either an exogenous variable or a constant,[7]

β_1 – the elasticity of *GDP* with respect to the employment,

β_2 – the elasticity of *GDP* with respect to the investment rate.

As it can be seen, the equivalent is reduced by the rate of capital depreciation in the product of the elasticity of production with respect to capital.

In earlier studies (Sztaudynger, Sztaudynger, 2019; 2022), a model was verified in which the TFP equivalent was constant $\dot{A}_t = \beta_0$ and the parameter β_2 was time-varying $\beta_2 = \beta_2^{'} - \beta_2^{''} G\dot{D}P_{t-i}$:

$$G\dot{D}P_t = \beta_0 + \beta_1 \dot{L}_t + \left(\beta_2^{'} - \beta_2^{''} G\dot{D}P_{t-i}\right)(I / GDP)_t . \qquad (2)$$

This provided a confirmation of hypothesis H_1 stating that if there was a slowdown in *GDP* growth in earlier years, then this year's (current) investment efficiency expressed by the time-varying parameter $\beta_2 = \beta_2^{'} - \beta_2^{''} G\dot{D}P_{t-i}$ will be higher. This is a way of describing the mechanism of economic fluctuations by compensating for the past slowdown in *GDP* with higher current investment efficiency. This result can be viewed as a description of non-cyclical, irregular economic fluctuations.

3. The proposed modification of the *GDP* growth model

Model (2) does not describe the situation of falling demand. At that time, fixed assets are fully utilised. After demand increases and *GDP* grows in the next period, no bottlenecks will appear (see W. Zatoń cited after: Sztaudynger, Sztaudynger, 2019). Acceleration is then not related to the elimination of bottlenecks, but it will be based on meeting the restored level of demand,

7 The problems of measuring *TFP* were analysed, among others, by Sztaudynger (2005, pp. 17–18), Baranowski (2008, pp. 33–35) and Tokarski (2009, pp. 27–37). The sources of *TFP* growth were sought in self-improvement of the employed through learning by doing, spillovers of knowledge, technology, and skills (Arrow, 1962; Romer, 1986), innovation, education, as well as in the growing skills of group interaction in economic and social networks. The absolute value term should not be interpreted as *TFP* dynamics since on the right side we do not have only production factor dynamics, as in the production function, but also lags and products of those with past dynamics. If we find that <<Eqn069.wmf>> changes over time, then the time-varying absolute value term will no longer be equivalent to *TFP*, as the change in investment efficiency should be 'within' *TFP*, and not be related to investment.

based on unused production capacity, i.e. in a way that does not require investment. The decline in demand and its reconstruction generally requires less time than eliminating a bottleneck in fixed assets.

The rationale will be similar: if there was a slowdown in *GDP* growth a year or two ago, caused by a decline in demand (e.g.: due to a banking crisis or epidemic), and if in the current year it is possible to rebuild this demand (eliminate these imbalances) without investment in fixed assets, there will also be an increase in *GDP* that will not require investment, which I propose to see as the equivalent of *TFP*, i.e., total factor productivity $\dot{A}_t$. Hence, the following formula of the analysed model is obtained:

$$G\dot{D}P_t = \underbrace{\beta_0^{'} - \beta_0^{''} G\dot{D}P_{t-i}}_{H_2} + \underbrace{\beta_1 \dot{L}_{t-i}}_{H_3} + \underbrace{\left(\beta_2^{'} - \beta_2^{''} G\dot{D}P_{t-i}\right)}_{H_1}(I / GDP)_t, \tag{3}$$

H_2, H_3, H_1 – are given under the parameters expressing the hypotheses.

On the formal side, in equation (3), the absolute value term is time-varying $\beta_0^{'} - \beta_0^{''} G\dot{D}P_{t-i}$. The slower the *GDP* growth occurred in the past, the greater the time-varying absolute value term. Thus, the non-investment equalisation of growth dynamics, the balancing of capacity utilisation rate, is modelled.

This is an unusual autoregressive model. Most often in autoregressive models with lagged endogenous variables there are positive parameters. In this case, these models describe the inertia of the dependent variable. In model (3), parameters at $G\dot{D}P_{t-i}$ are negative. This is a peculiar hysteresis – high lagged economic growth values slow down current *GDP* growth, while slow past *GDP* growth accelerates current *GDP* growth. Good past growth slows current growth, and vice versa.[8] This phenomenon can be called negative inertia. The role of this variable is to equalise economic fluctuations. In model (3), the rebalancing takes place in the following order:

1) through the non-investment elimination of demand constraints (new and restored markets, increased customer demand – e.g.: after the COVID pandemic);
2) through investment in fixed assets to eliminate bottlenecks.

The component $\beta_0^{'} - \beta_0^{''} G\dot{D}P_{t-i}$ expresses the impact of demand adjustments which are expected to occur relatively quickly, over 1–2 years. Widening bottlenecks through investments is manifested in changes in the parameter $\beta_2^{'} - \beta_2^{''} G\dot{D}P_{t-i}$, which requires more time – lags of 3–5 years.

The question arises whether the role of this variable is not too large: that with a lag of 1–2 years it should map the underutilisation of production capacity – demand shortages, and then with a lag of 3–5 years it should reflect supply constraints – fixed asset bottlenecks. Seek-ing argument in favour of this approach, it should be noted that the grand aggregate

8 The adoption of the assumption concerning the occurrence of regular fluctuations in the economy also makes the current value, such as *GDP*, dependent on past values in accordance with the adopted formula of cyclical fluctuations.

of GDP encompasses both underutilised capacity (insufficient demand) and insufficient supply. These imbalances are resolved with different lags depending on what type of goods or services we are dealing with.

The stages of adjustment are listed below, showing why a period of 3–5 years is needed to respond to a bottleneck through investments:

1) determining the occurrence of a bottleneck;
2) investment project preparation;
3) fulfilment of formal requirements;
4) gathering the necessary financial and material resources;
5) commissioning (technical, organisational aspects) and execution of the investment;
6) achieving the target level of production or services and organisational activities associated with it (reaching customers, gaining market share).[9]

According to the estimated linear weights 4, 3, 2 (main variant, Table 1): *GDP* growth after three years (t – 3) dominates in the 'response' to the bottleneck of the parameter at the investment rate, then the response to *GDP* growth declines linearly to end after five years; it is then 50% weaker than after three years. The time that elapses from the determination that there is a bottleneck to the completion of the investment and the 'harvesting' of the full effects of this investment is up to five years.[10]

On the other hand, the stages of a non-investment response to a demand shortfall are as follows:

1) determining the occurrence of demand shortfall;
2) taking steps to increase market share;
3) drafting a non-investment production restructuring project;
4) gathering the necessary financial and material resources to launch a promotional campaign;
5) achieving the target level of production or range of services.

9 Some similarity can be drawn here to Kydland and Prescott's (1982) RBC Real Business Cycle with time-to-build. The time required to respond to a supply shock and to build an investment, and the accompanying lag, is the cause of business (cyclical) fluctuations in this model (Krawiec, Szydłowski, 2017). In model (3), the cause of economic fluctuations is a lag of up to five years in response to supply bottlenecks, of which past *GDP* dynamics is an indicator. The response consists in fluctuations in current investment efficiency. Thus, we assume here that a supply bottleneck causes a lagged response of investments (put into operation) resulting in *GDP* growth after several years (from three to five years). The difference also lies in the fact that in the real business cycle model there are lagged investments (the investment-based elimination of supply shocks takes more than one period, time-to-build). In the model (Sztaudynger, Sztaudynger, 2019), the effect of current investment depends on the severity of lagged supply shocks.

10 Comparable results were obtained for lags of up to six years: $G\dot{D}P_{t-i}$ 3–6 years.

4. Results of estimating the proposed *GDP* growth model

Model (3) describes non-cyclical economic fluctuations that occur due to irregular bottlenecks, resulting in changing investment efficiency described by the parameter $\beta_2 = \beta_2^{'} - \beta_2^{''} G\dot{D}P_{t-i}$ (according to H_1).

Another source of non-cyclical economic fluctuations can be found in irregular declines in demand and accompanying changes in the rate of capacity utilisation described by the changing equivalent of the absolute value term $\beta_0 = \beta_0^{'} - \beta_0^{''} G\dot{D}P_{t-i}$ (according to H_2).

4.1. The main variant of the *GDP* growth model

The table below shows the results of estimating, with the use of the least squares method, of the parameters of model (3), testing hypotheses H_1 and H_2 that show balancing, non-cyclical acceleration or deceleration of economic growth with lags of one to five years, and verifies hypothesis H_3 on the lagged effects of employment dynamics on *GDP* dynamics.

Table 1. *GDP* growth model (1994–2019). Main variant

Variable	Parameter	Hypothesis	Parameter estimate	t-statistic	*ADF*
Endogenous $G\dot{D}P_t$ growth rate	–		–		– 2.9*
	$\beta_0^{'}$		– 4.9	2.5	
Average *GDP* growth rate $t-1,\ t-2$	$\beta_0^{''}$	H_2	– 0.69	3.8	– 4.8***
Employment rate t	β_1	H_3	0.31	6.0	– 3.0**
Employment rate $t-1$	β_1	H_3	0.21	AA	AA
Employment rate $t-2$	β_1	H_3	0.10	AA	AA
Investment/*GDP* $\left(\frac{I}{GDP}\right)_t$	$\beta_2^{'}$		0.68	5.2	– 4.1***
$G\dot{D}P_{t-3} \times \left(\frac{I}{GDP}\right)_t$	$\beta_2^{''}$	H_1	– 0.0025*4	5.7	– 5.8***
$G\dot{D}P_{t-4} \times \left(\frac{I}{GDP}\right)_t$	$\beta_2^{''}$	H_1	– 0.0025*3	AA.	AA

Variable	Parameter	Hypothesis	Parameter estimate	t-statistic	*ADF*
$G\dot{D}P_{t-5} \times \left(\frac{I}{GDP}\right)_t$	$\beta_2^{''}$	H_1	– 0.0025*2	AA	AA
Dummy 2012–2016[a]			– 2.9	6.6	–

[a] From 2012 to 2016, *GDP* was at a lower level than estimated by the model. This can be explained as follows: after Poland's accession to the EU, the VAT rate averaged 7.8% of *GDP* between 2005 and 2019, except for 2012–2016, when it was lower by about 0.8 percentage points. The corresponding figures for the total tax rate are 16.1% and 1.4 percentage points, respectively. Both tax reductions: VAT and total taxes, are statistically significant $P < 0.001$ (Student's t-statistic values above 4). This was a significant reduction in budget revenues, which reduced the spending of the state and local budgets, decreased demand, and thus slowed economic growth. Several variants of variables 0.1, related to Poland's accession to the EU, were also analysed. No significant estimates were obtained.
Adjusted $R^2 = 0.799$, $Se = 0.74$, $JB = 0.84$, $DW = 1.89$, *ADF* (residuals) = –4.79***.
ADF test significant at the level of: *** 0.001, ** 0.05 or * 0.1.
The parameters β_1 and $\beta_2^{''}$ were estimated from the Almon polynomial distributed lag model; a polynomial of degree one (linear). Alternative estimation results are provided in the Appendix.

Source: own calculations based on CSO data.

From 1994 to 2019, the average growth rate of $G\dot{D}P_{t-i}$ was 4.3%. A peculiar feature of this model is the occurrence of a series of lags of up to five years. Based on the above schedules, lags were indicated, which were then verified using F-statistics, Student's t-statistic and the adjusted R^2 coefficient.

Since the issue of lags may be questionable, let us note the explanations in the paper Sztaudynger and Sztaudynger (2022). Stigum (2003: 388) says that: "Economic theory rarely provides a basis for specifying the lag lengths in empirical macro-models" (as well as Nerlove, 1972 and Holden, 2005: 467). In addition, there is another argument: Hendry stresses that the theory lacks precision in determining the length of the lag (Hendry, 2009: 29). With the aid of the model, we will attempt to determine the length of these lags in a way that enables statistical verification.

Since the above-presented model includes variables that are only *GDP* growth and investment dynamics, the model is short-run in nature. In such a model, non-stationarity appears sporadically (Majsterek, 2008). Since there are three-year averages in the model, the model seems to take on a medium-term character.

In contrast, the *ADF* test shows that the variables in the main variant are stationary, as are the residuals: the *GDP* growth rate is stationary with a probability of 94%. The remaining variables with a probability above 95%. Thus, stationarity and the *JB* test allow for the use of Student's t-test.

Due to the use of linear lag distributions, only six parameters were estimated. Attempts to employ a parabolic lag distribution did not improve the results, allowing the simplest linear distribution to be used.

The model shown in Table 1 can be regarded as a special – non-cyclical – representation of economic fluctuations. *GDP* dynamics lagged by 3–5 years (four years on average) is in the opposite position to the state in the year *t*. Therefore, a certain similarity of specific eight-year 'cyclical' fluctuations can be found here. GDP_t is negatively correlated with $GDPt_{-4}$, which is lagged on average by four years. This result to some extent confirms the occurrence of fluctuations similar to the Juglar cycle.[11] Bottlenecks, however, appear irregularly. The model shows a specific kind of regularity – it is regularity in eliminating bottlenecks and reducing imbalances.[12] However, this is not a cyclical regularity, involving accelerations and decelerations in growth that are regular over time.

Figure 1 shows the parameter β_2 with *GDP* dynamics (over three years, from t – 3 to t – 5) interacting with the investment rate (it is significant at the 0.999 level). Therefore, if *GDP* growth was slow (1%) in the previous three years, then investment efficiency, as measured by the parameter β_2, was 0.65. In the case of rapid *GDP* growth (5%), the estimate of β_2 was 0.55.

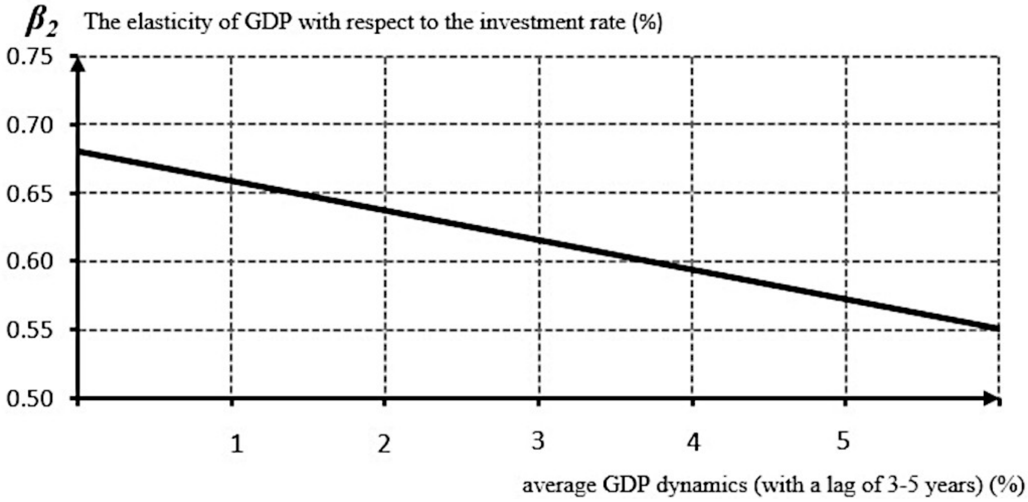

Figure 1. The elasticity of $\beta 2$ with respect to average lagged *GDP* dynamics (with a lag of 3–5 years)

Source: own calculations based on the main variant.

11 This interpretation is similar to (Sztaudynger, Sztaudynger, 2022, p. 133). The length of Juglar's investment cycle is 7–11 years. Assumption that "[…] by simple elimination of the excesses, the crisis will bring the system back to a state of stable […] equilibrium" is adopted (Besomi, 2005, p. 32).

12 This result seems to support the view that the economy does not experience regular cyclical fluctuations: "Since no two cycles are the same in detail, some economists question the existence of cycles and use the word 'fluctuations'" (Nagakawa, 2008, p. 1). According to Romer (2008) "[…] in reality, there is no regularity in the timing of the cycles" (the views quoted above are cited after Sztaudynger, Sztaudynger, 2022, p. 34). More than seventy years ago, Burns and Mitchell, concluding a monograph on economic growth, argued that the dispute over whether business fluctuations are or are not cyclical is ongoing. In their opinion, difficulties in establishing cyclicality stemmed, among others, from the differences of individual economic activities (Burns, Mitchell, 1946, p. 506). As written in (Sztaudynger, Sztaudynger, 2022, p. 118), the proposed approach is similar to the 'plucking model' proposed by Friedman in 1964. Friedman (1993, p. 171) stated that the magnitude of an expansion is "[…] related systematically to the magnitude of the succeeding contraction." He "suggested a model of business fluctuations that stresses occasional events producing contractions and subsequent revivals rather than a self-generating cyclical process."

According to the estimation results, in response to investment, economic growth follows a specific pattern related to the previous imbalance. For example, in the main variant (Tab. 1), as a result of slowing GDP growth in the year t by 1 pp, we obtain: an increase in the parameter β_2 in the years $t + 3$ $t + 4$ and $t + 5$ equal to 0.02, and acceleration of *GDP* growth of 0.4 pp in these three years combined (assuming an investment rate of 20%).

As it seems, this result confirms hypothesis H_1, stating that the effects of investment depend not only on the investment rate – the investment/*GDP* ratio – but also on the extent to which the investment was preceded by a bottleneck characterised by the average *GDP* dynamics of three years (t – 5, t – 4, t – 3). The result is described by the following formula:

$$\hat{\beta}_2 = 0.68 - 0.0025 \times \left(\sum_{i=3}^{i=5} w_i G\dot{D}P_{t-i} \right)$$

$$w_3 = 4,\ w_4 = 3,\ w_5 = 2,$$

where: parameter estimates were taken from the main variant – Table 1.

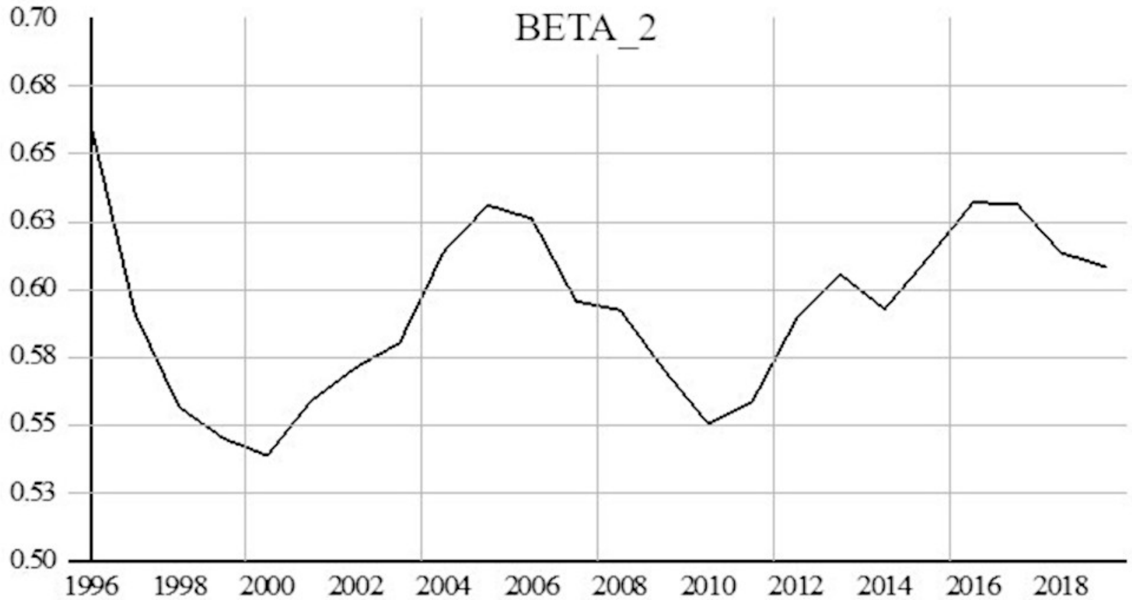

Figure 2. Investment efficiency: parameter $\hat{\beta}_2$, 1996–2019

Source: own calculations based on the main variant.

The parameter $\hat{\beta}_2$ (beta_2) took values in the range of 0.54–0.66. In the years 1998–2001, which were not preceded by bottlenecks, the parameter values were the lowest – in the 0.54–0.56 range. In contrast, the years 2004–2005 and 2015–2017 were preceded by slower *GDP* growth (and intensified bottlenecks) in 2000–2001 and 2011–2013, respectively. Therefore, in the years 2004–2005 and 2015–2017, the efficiency of investments measured by the parameter $\hat{\beta}_2$ was relatively high ($\hat{\beta}_2$ above 0.62).

Summing up the impact of past investment and non-investment imbalances on *GDP* growth (approximated by past *GDP* dynamics), the greatest slowdown can be observed in the years 1998–1999 and the greatest acceleration was recorded in the years 2003–2004 and 2014–2017. The differences between the years of slowdowns and accelerations are at the level of 4 pp. Given the average *GDP* growth of 4.3% during the period under review, this impact can be considered very large.

4.2. The impact of employment dynamics on *GDP* growth

According to hypothesis H_3: employment growth affects *GDP* growth not only in the same year but also with lags. The possibility of lags is indicated by the staggered response of *GDP* to employment growth:

1) when employment grows (as of the end of the year), part of the growth effect is observed in the current year and part in the following year;
2) due to the time needed to onboard new employees and improve coordination within teams of co-workers, this period lengthens, and the effects of productivity growth fade. As can be seen from the linear distribution of lags, the effect in the year t is three times greater than after two consecutive years.

There are indirect, gradually fading multiplier effects. An increase in employment (and the accompanying increase in the income of the population) entails an increase in demand, and this results in an increase in *GDP*. These relationships are called the employment multiplier.[13]

Hypothesis H_3, therefore, raises the question whether it is advisable to introduce lags in employment growth into the analysed model. This hypothesis was tested by comparing the main variant, in which employment dynamics occur for t, $t - 1$ and $t - 2$, with the variant in which this dynamics is not lagged. In both cases, the studied variable is significant, but much better results were obtained for the variant with lags (R^2 0.80 and 0.75 respectively and also Student's t-statistics). This confirms hypothesis H_3. The estimation of the elasticity of *GDP* with

13 Richard F. Kahn is considered to be the originator of the multiplier concept. In 1931, he published the article entitled *The Relation of Home Investment to Unemployment* (reprinted in *Selected essays on Employment and Growth*, 1972). "The multiplier is a relation between the increase in exogenous aggregate expenditure and the increase in net national product thereby generated (and thus also in employment…)" (Pasinetti, 2008, p. 7196). An increase of expenditure equivalent to 1 extra job will finally generate $1/(1 - c)$ extra jobs, where c is the fraction of any increase in income that consumers tend to spend (Kahn, 1931, p. 183; Pasinetti, 2008, p. 7196). This is Kahn's employment multiplier. Kahn claims that "[…] if there is ever any justification for expenditure on "public works" as a means of reducing unemployment, the justification is greatest when depression is most severe" (Kahn, 1972, p. 182). Kahn's concept was further developed by Keynes, who collaborated with him.

respect to labour was 0.62[14] (including for t, t – 1 and t – 2: 0.31, 0.21 and 0.10 respectively) using Almon's linear distributed lag. Below we compare this result with results obtained in other studies.

5. Discussion

In macro studies, output-employment elasticities in the range of 0.60–0.66 are considered typical (Tab. 2). In studies on 19 developed countries, this range is wider: 0.55–0.77.

For Poland, studies of the elasticity of production with respect to labour and physical capital have been conducted for several years. Based on micro-data from 82,000 enterprises (576,000 observations) in the years 2002–2016, Gradzewicz, Mućk (2019) estimated β_1 at the level of 0.83. The authors point out that this elasticity is well above the 0.66 that is commonly assumed in macro studies. They draw attention to the fact that, in macro approaches, the elasticity with respect to labour is usually calibrated according to the long-run characteristics of the labour factor's share of output. They refer to somewhat earlier studies of their own covering several long-run measures of the labour share of *GDP* in the United States at the level of 0.61–0.67 (Gradzewicz, Mućk, 2019, footnote, pp. 14–15).

In a similar Polish study on micro data, Górajski and Błażej (2020: 307) obtained β_1 = 0.76 (the years 2005–2016, 585,000 observations).

Measures of the elasticity of *GDP* with respect to employment are higher on a micro-data basis (0.76 to 0.83) than those calculated on a macro-data basis (0.61 to 0.67). Determining the reasons for this difference is problematic. One possible explanation is the usually short time series of micro data.

Table 2. Comparison of production elasticity in respect to employment in various models

Authors	Macro/Micro data	Period	$\hat{a}_1$
Usually acc. Gradzewicz, Mućk (2019)	Macro	–	0.66
Gradzewicz, Mućk (2019)	Micro, Poland	2002–2016	0.83*
Mućk, McAdam, Growiec (2018)	Macro, USA	Different periods	0.61–0.67

14 If we omit the variable dummy 2012–2016 from the main variant of the model, the elasticity with respect to the number of employed falls to an evidently too low level of 0.38. This is yet another argument in favour of the fact that these were distorted years, in such a way that *GDP* responded very inelastically to changes in the employed.

Authors	Macro/Micro data	Period	$\hat{a}_1$
Górajski, Błażej (2020)	Micro, Poland	2005–2016	0.76
Autor, Salomons (2018: 5)	Macro, 19 developed countries	1970–2007	0.55–0.77
Easterly, Levine (2001: 183)	Macro, 6 OECD	1960–1990	0.58–0.62
Stylised Easterly, Levine (2001: 182)	Macro	–	0.60*
Xu et al. (2022: 796)	31 eastern China provinces	1993–2015	0.36–0.52 Average 0.38 **
The proposed model in Table 1	Macro, Poland	1994–2019	0.62

* Share of employment in GDP.
** GWR geographically weighted regression.

Source: own elaboration.

The results obtained for 31 provinces differ significantly from the elasticities described above (Xu et al., 2022, p. 793 and pp. 796–797). First, the elasticities with respect to employment are significantly lower, averaging 0.38. Moreover, they are lower than the elasticities with respect to capital. The World Bank, on the other hand, estimated the analysed elasticities at around 0.6, which Xu explains by WB's assumption that these elasticities are constant over time. Meanwhile, that elasticity recorded a declining trend in the surveyed years 1993–2015.

An explanation for the different elasticities of GDP with respect to changes in employment, both over time and between countries, may be the different levels of employment infrastructure, education and wage levels. Workers who are less productive (less skilled or having access to inferior technology) or relatively low-paid (income is only enough to meet basic needs) are less of a stimulus to *GDP* growth than in the opposite situation.

The sum of the elasticities with respect to labour for t, $t-1$ and $t-2$ in my model is 0.62 and falls within the above-mentioned ranges for macro data of developed countries. This can be considered as an argument in favour of the model proposed in the paper. None of the measures of elasticity reported in the literature considers lags in the response of *GDP* to changes in employment.

6. Conclusions

Based on the improved model, hypothesis H_1, concerning the varied impact of the investment rate on economic growth, has been confirmed yet again. The greater the slowdown in economic growth, the more intense the severity of fixed asset bottlenecks, the greater the investment efficiency after several years. The period of increased investment efficiency was previously estimated with lags of two to six years (Sztaudynger, Sztaudynger, 2022). This also applies to the reverse situation, where acceleration of lagged economic growth results in a reduction in current investment efficiency. After the model verification presented in the paper, we find that lags of three to five years result in increased investment efficiency. The validity of hypothesis H_1, stating that the effects of investment depend not only on the investment rate – the investment/*GDP* ratio – but also on the extent to which the investment was preceded by a bottleneck characterised by the three-year average *GDP* growth rate (t – 5, t – 4, t – 3), has been therefore confirmed.

By formulating hypothesis H_2, an attempt was made to examine non-investment growth: the slower the *GDP* growth occurring one and two years ago, the faster the growth that will occur in the current year, regardless of investment. Hypothesis H_2 has also been confirmed: *GDP* growth lagging one and two years directly – not through investment – and negatively affects economic growth.

We interpret the confirmation of hypotheses H_1 and H_2 as a confirmation that the causes of economic fluctuations are bottlenecks in fixed assets and unused production capacity. Since they occur randomly or irregularly in the economy (transitions, armed conflicts, or the COVID epidemic), economic fluctuations are not characterised by regular cyclicality over time.

It is worth adding that H_1 and H_2 describe a kind of regularity in the way equilibrium is pursued. However, this is not a sufficient argument for the cyclicality of sinusoidal economic growth, with regular fluctuations over time. In other words, irregular bottlenecks that occur and irregular excess capacity (demand deficits) do not generate *GDP* cycles that are regular over time.

Hypothesis H_3 has also been confirmed. Employment (labour) growth impacts *GDP* growth not only in the same year, but also with lags of one and two years. The current impact is three times stronger than with a lag of, for example, two years.

The research presented in this paper attempts to describe non-cyclical economic fluctuations. Two sources of cyclical fluctuations were distinguished: bottlenecks of fixed assets and insufficient demand with unused production capacity. To distinguish between demand shortages and supply bottlenecks, the analysis can be expanded to include the inflation rate. In a free-competitive economy, when prices rise relatively quickly, we experience a bottleneck or supply shortage. When prices rise relatively slowly and economic growth slows, we are dealing with unused production capacity. In further research, we will attempt to introduce inflation and transportation infrastructure investment into the model and replace the Cobb–Douglas production function with the CES function (Dykas, Tokarski, Wisła, 2022, pp. 31–32).[15]

The model of non-cyclical economic fluctuations presented in the paper can be applied to other countries, but only for the period up to 2019, as it is doubtful whether it will be possible to describe the deep COVID slowdowns of 2020 and 2021. *GDP* lags for other countries may differ from the results obtained for Poland. Shorter ones will indicate a faster response of the economy to emerging bottlenecks or demand shortfalls. On the other hand, due to the lack of sufficiently long time series, it is impossible to conduct such a study by voivodeships.

I would like to thank Janina Witkowska, Paweł Baranowski, Michał Majsterek, Wojciech Zatoń, and my father Jan Jacek for their valuable advice and significant remarks.

15 If the elasticity of substitution between labour and capital is less than one and there is a decline in population, then, based on the CES function, the long-term growth rate of *GDP per capita* is determined by the exogenous rate of technical progress. In contrast, if the elasticity of substitution rate is one, then the production function takes the Cobb–Douglas form, and the long-term growth rate of *GDP per capita* is positive, even without technical progress and with a negative population growth rate (Sasaki, 2017, pp. 8–9). It is worth noting that a negative population growth rate identically reduces the denominator of the growth rate of *GDP per capita*. Thus, it enlarges the *GDP per capita*.

Appendix

Table 3. The main model (3) and alternative estimation results of the Cobb–Douglas function in which capital dynamics is replaced by the investment rate

	Simple		**Almon distribution of the employed**		**Almon distribution of the employed – bottlenecks**		**The employed with no lags – bottlenecks**		**Main**	
	1		**2**		**3**		**4**		**5**	
	Coefficient	**t-statistic**	**Coefficient**	**t-statistic**	**Coefficient**	**t-statistic**	**Coefficient**	**t-statistic**	**Coefficient**	**t-statistic**
C	1.1	0.6	3.9	1.8	– 1.1	– 0.5	– 2.6	1.3	– 4.9	2.5
$GDPt_{-1, t-2}$ growth rate									– 0.34	3.8
Growth rate of the employed	0.56	4.8					0.45	4.4		
Growth rate of the employed Almon distributed lag	–		0.57	3.8	0.47	3.8			0.62	6.0
I/GDP ratio	0.15	1.6	0.02	0.2					–	–
I/GDP Almon distributed lag	–	–	–	–	0.22–0.31	2.7 and 3.6	0.30–0.38	3.5 and 3.1	0.54–0.66	5.2 and 5.7
U2012_2016	– 2.3	– 4.3	– 2.4	3.9	– 2.1	4.2	– 2.1	4.5	– 2.9	– 6.6
Adjusted R^2	0.59		0.49		0.67		0.71		0.80	

Source: own calculations with the use of the method of least squares.

As we can see, replacing the simple variant 1 (investment rate, employed growth rate) with models with supply bottlenecks and demand shortfalls (variants 3, 4, 5) significantly increases the model fit.

Variants 4 and 5 (the main one) can be considered the best. The advantages of both variants are significant estimations of structural parameters (except for the absolute value term in variant 4).

Advantages of variant 4: a simpler design, one less variable, the employed growth rate without lags, and more typical values of the investment rate parameter.

Advantages of main variant 5: more typical parameter with the growth rate of the employed, a higher R^2 coefficient, allows for the verification of H_2. Based on the above-presented comparison, I have decided to choose variant 5 (main) of the model.

References

Aghion P., Howitt P. (2009), *The Economics of Growth*, The MIT Press, Cambridge–London, http://digamo.free.fr/aghionh9.pdf [accessed: 20.01.2023].

Arrow K.J. (1962), *The Economic Implications of Learning by Doing*, "Review of Economic Studies", vol. 29, no. 3, pp. 155–173.

Autor D., Salomons A. (2018), *Is Automation Labor Share–Displacing? Productivity Growth, Employment, and the Labor Share*, "Brookings Papers on Economic Activity", pp. 1–63, http://www.jstor.org/stable/26506212 [accessed: 20.01.2023].

Baranowski P. (2008), *Problem optymalnej stopy inflacji w modelowaniu wzrostu gospodarczego*, Wydawnictwo Biblioteka, Łódź, https://dspace.uni.lodz.pl/xmlui/bitstream/handle/11089/1866/Problem_optymalnej_stopy_inflacji.pdf?sequence=4&isAllowed=y [accessed: 20.01.2023].

Besomi D. (2005), *Clément Juglar and the transition from crises theory to business cycle theories*, [in:] *Conference on the occasion of the centenary of the death of Clément Juglar*, Paris, https://www.unil.ch/files/live/sites/cwp/files/users/neyguesi/public/D._Besomi [accessed: 11.01.2023].

Biddle J. (2012), *Retrospectives: The Introduction of the Cobb–Douglas Regression*, "The Journal of Economic Perspectives", vol. 26, no. 2, pp. 223–236, http://www.jstor.org/stable/41495312 [accessed: 20.01.2023].

Burns A.F., Mitchell W.C. (1946), *Stable and Irregular Features of Cyclical Behavior*, [in:] A.F. Burns, W.C. Mitchell (eds.), *Measuring Business Cycles*, National Bureau of Economic Research, New York, pp. 466–508.

Cobb C.W., Douglas P.H. (1928), *A Theory of Production*, "American Economic Review", vol. 18, pp. 139–165, http://digamo.free.fr/cobbdoug28.pdf [accessed: 22.05.2024].

Douglas P.H. (1976), *The Cobb–Douglas Production Function Once Again: Its History, Its Testing, and Some New Empirical Values*, "Journal of Political Economy", vol. 84, no. 5, pp. 903–915, https://doi.org/10.1086/260489

Dykas P., Tokarski T., Wisła R. (2022), *The Solow Model*, [in:] P. Dykas, T. Tokarski, R. Wisła, *The Solow Model of Economic Growth. Application to Contemporary Macroeconomic Issues*, Routledge, London–New York, pp. 16–40, https://doi.org/10.4324/9781003323792-3

Easterly W., Levine R. (2001), *It's Not Factor Accumulation: Stylized Facts and Growth Models*, "The World Bank Economic Review", vol. 15, no. 2, pp. 177–219, http://www.jstor.org/stable/3990260 [accessed: 20.01.2023].

Friedman M. (1993), *The Plucking Model of Business Fluctuations Revisited*, “Economic Inquiry”, vol. 31, no. 2, pp. 171–177.

Górajski M., Błażej M. (2020), *A control function approach to measuring the total factor productivity of enterprises in Poland*, “Bank i Kredyt”, vol. 51, no. 3, pp. 293–316.

Gradzewicz M., Mućk J. (2019), *Globalization and the fall of markups*, “NBP Working Paper”, no. 304, http://www..researchgate.net/publication/331559276_Globalization_and_the_fall_of_markups [accessed: 11.01.2023].

Hendry D.F. (2009), *The Methodology of Empirical Econometric Modeling: Applied Econometrics Through the Looking Glass*, [in:] T.C. Mills, K. Patterson (eds.), *Palgrave Handbook of Econometrics*, Palgrave Macmillan, London, pp. 3–67, https://doi.org/10.1057/9780230244405_1

Holden K. (2005), *Macroeconomic Forecasting*, [in:] D. Greenaway, M. Bleaney, I. Steward (eds.), *A Guide to Modern Economics*, Taylor & Francis e-Library, London, pp. 163–181.

Jones Ch.I. (2000), *A Note on the Closed-Form Solution of the Solow Model*, http://www-leland.stanford .edu/~chadj/closedform.pdf [accessed: 9.03.2022].

Kahn R.F. (1972), *The Relation of Home Investment to Unemployment*, [in:] R.F. Kahn (ed.), *Selected Essays on Employment and Growth*, Cambridge University Press, New York, pp. 1–27.

Kalecki M. (1958), *Teoria dynamiki gospodarczej*, Państwowe Wydawnictwo Naukowe, Warszawa.

Krawiec A., Szydłowski M. (2017), *Economic growth cycles driven by investment delay*, “Economic Modelling”, vol. 67, pp. 175–183, https://doi.org/10.1016/j.econmod.2016.11.014

Kydland F.E., Prescott E.C. (1982), *Time to Build and Aggregate Fluctuations*, “Econometrica”, vol. 50, no. 6, pp. 1345–1370, http://www.finnkydland.com/papers/Time%20to%20Build%20and%20Aggregate%20Fluctuations.pdf [accessed:1.02.2023].

Majsterek M. (2008), *Wielowymiarowa analiza kointegracyjna w ekonomii*, Wydawnictwo Uniwersytetu Łódzkiego, Łódź.

Mućk J., McAdam P., Growiec J. (2018), *Will the “True” Labor Share Stand Up? An Applied Survey on Labor Share Measures*, “Journal of Economic Surveys”, vol. 32(4), pp. 961–984.

Munguía R., Davalos J., Urzua S. (2019), *Estimation of the Solow-Cobb–Douglas economic growth model with a Kalman filter: An observability-based approach*, “Heliyon”, vol. 5(6), https://doi.org/10.1016/j.heliyon.2019.e01959

Nagakawa T. (2008), *Business Fluctuation and Cycles*, Nova Science Publisher, New York.

Nerlove M. (1972), *Lags in Economic Behavior*, “Econometrica”, vol. 40, no. 2, pp. 221–251, https://www.jstor.org/stable/1909403 [accessed: 23.05.2020].

Pasinetti L.L. (2008), *Kahn, Richard Ferdinand (1905–1989)*, [in:] M. Vernengo, E. Perez Caldentey, B.J. Rosser Jr. (eds.), *The New Palgrave Dictionary of Economics*, Palgrave Macmillan, London, pp. 7195–7198, https://doi.org/10.1057/978-1-349-95121-5_1088-2

Romer C.D. (2008), *Business Cycles*, http://www.econlib.org/library/Enc/BusinessCycles.html [accessed: 20.01.2023].

Romer P.M. (1986), *Increasing Returns and Long Run Growth*, “Journal of Political Economy”, vol. 94, no. 5, pp. 1002–1037, https://www.parisschoolofeconomics.eu/docs/darcillon-thibault/paul-romer-increasing-returns-and-long-run-growth.pdf [accessed: 17.01.2019].

Romer P.M. (1994), *The Origins of Endogenous Growth*, “Journal of Economic Perspectives”, vol. 8, no. 1, pp. 3–22, https://pubs.aeaweb.org/doi/pdf/10.1257/jep.8.1.3

Sasaki H., (2017), *A Note on the Solow Growth Model with a CES Production Function and Declining Population*, “Munich Personal RePec Archive”, no. 80062, https://mpra.ub.uni-muenchen.de/80062/1/MPRA_paper_80062.pdf [accessed: 20.01.2023].

Slichter S.H., Black J.D. (1928), *Economic and Social Aspects of Increased Productive Efficiency – Discussion*, "The American Economic Review", vol. 18, no. 1, pp. 166–172, http://www.jstor.org/stable/1811557 [accessed: 20.01.2023].

Solow R.M. (1956), *A Contribution to the Theory of Economic Growth*, "Quarterly Journal of Economics", vol. 70, pp. 65–94.

Solow R.M. (1988), *Growth theory and after*, "The American Economic Review", vol. 78 (3), pp. 307–317.

Stigum B.P. (2003), *Econometrics and the Philosophy of Economics: Theory-Data Confrontations in Economics*, Princeton University Press, Princeton–Oxford, https://doi.org/10.1515/9781400873234

Sztaudynger J.J. (2005), *Wzrost gospodarczy a kapitał społeczny, prywatyzacja i inflacja*, Wydawnictwo Naukowe PWN, Warszawa.

Sztaudynger J.M. (2022), *The Dynamics of Physical Capital Substitution for Investment Output Ratio in the Solow Model*, [in:] J.J. Sztaudynger (ed.), *Economic Growth. Social Capital, Family, Inequality of Income, Quality of Life, Bottlenecks. Selected papers from 2018 to 2022*, Wydawnictwo Uniwersytetu Łódzkiego, Łódź, pp. 141–143, https://doi.org/10.18778/8331-030-5

Sztaudynger J.M., Sztaudynger J.J. (2019), *Wzrost gospodarczy a inwestycje – znaczenie wąskich gardeł*, "Ekonomista", no. 6, pp. 680–700, http://www.pte.pl/pliki/1/8905/E2019-6_31-51.pdf [accessed: 20.01.2023].

Sztaudynger J.M., Sztaudynger J.J. (2022), *The Impact of Supply Bottlenecks on Investment Efficiency*, "Ekonomista", no. 1, pp. 23–40, http://www.pte.pl/pliki/1/8905/Ekonomista_1-22_2.pdf [accessed: 20.01.2023].

Tokarski T. (2009), *The Supply Side Determinants of Economic Growth*, [in:] W. Welfe (ed.), *Knowledge Based Economies. Models and Methods*, Peter Lang, Frankfurt am Main–Berlin–Bern–Bruxelles–New York–Oxford–Wien, pp. 25–48.

Xu Z., Li X., Zhang C., Zhu J., Zhang S., Lu K. (2022), *Estimation and Dynamic Evolution of Provincial Factor – Output Elasticity in China*, "Journal of Advanced Computational Intelligence and Intelligent Informatics", vol. 26, no. 5, pp. 792–800, https://doi.org/10.20965/jaciii.2022.p0792

Niecykliczne wahania wzrostu PKB w Polsce

Streszczenie: Celem artykułu jest weryfikacja hipotezy o niecyklicznych wahaniach koniunkturalnych, w szczególności o nieregularności przyczyn oraz o regularności przywracania równowagi w gospodarce. Powolny przeszły wzrost PKB jest traktowany jako symptom nierównowagi, czyli występowania wąskich gardeł w środkach trwałych albo niedoborów popytu. Te dwie przyczyny nierównowagi pojawiają się w gospodarce nieregularnie. Weryfikowano hipotezę, że im wolniejszy wzrost gospodarczy występował w przeszłości, tym silniejszy, kompensujący będzie wzrost PKB. Jest to regularność przywracania równowagi.

Metodą najmniejszych kwadratów oszacowano zmodyfikowany model Solowa dla PKB Polski w latach 1994–2019. Najważniejszą modyfikacją było zastąpienie dynamiki kapitału fizycznego netto, niedostępnej w polskiej statystyce, stopą inwestycji. Drugim powodem tej modyfikacji była niedokładność danych statystycznych o kapitale fizycznym brutto, której nie można uniknąć. Kolejną modyfikacją było wprowadzenie do modelu opóźnionej dynamiki PKB jako indykatora nierównowagi.

Potwierdzono hipotezę, że nasilone występowanie wąskich gardeł, powoduje, że po 3–5 latach efektywność inwestycji jest większa. Natomiast spowolnienie wzrostu PKB po 1–2 latach powoduje kumulację niewykorzystanego potencjału, co umożliwia wyrównujące przyspieszenie wzrostu gospodarczego. Potwierdzono zatem hipotezę o występowaniu w polskiej gospodarce niecyklicznych wahań koniunkturalnych.

Słowa kluczowe: wzrost ekonomiczny, model Solowa, inwestycje w kapitał fizyczny, wąskie gardła, wykorzystanie mocy produkcyjnych, wahania koniunkturalne

JEL: E13, E22, E32, O40

OPEN ACCESS

© by the author, licensee University of Lodz – Lodz University Press, Lodz, Poland.
This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution license CC-BY (https://creativecommons.org/licenses/by/4.0/)

Received: 2023-05-17; revised: 2023-11-20. Accepted: 2024-07-16

COPE Member since 2018 JM13703

This journal adheres to the COPE's Core Practices https://publicationethics.org/core-practices