1 POTENTIAL OUTPUT: A MARKET CONDITIONALITIES INTERPRETATION

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Abstract

The measurement of potential output has been addressed in economics from the supply- and demand-side perspectives. The purpose of this study was to deepen the latter interpretation, focusing on market conditionalities and providing a macro-model (EUMOD21) as a computational tool. This empirical research was conducted using the statistical databases of the European Union (EU) for the period 1996–2019. The potential output estimations obtained with the proposed methodology are compared with those computed by the EU-DGFIN using the production function method (close to the supply-side vision). Both sets of estimates are grounded in the same socio-economic background. However, they differ due to the inherent temporary misalignments between the supply-side and demand-side market impulses and to possible measurement discrepancies. None of these estimations appear to be optimal, and they may be looked at as Marshallian scissors. The true potential output seems to be linked to both perspectives and should be approximated by taking both of them into account. Quantitatively, this may be obtained by adopting different averaging algorithms.

Keywords: production function, market conditionalities, potential output

JEL Classification: C12, C13, C32, C52, E17

1. Introduction

The 2019 coronavirus disease (COVID-19) pandemic has subjected all countries to an extremely severe economic endurance test. The EU has ratified an ambitious agenda for "recovery and resilience" for its members to adopt and implement (see, for instance, *Darvas et al*., 2021). These conditions are likely to give rise to interest in the topic of potential output again.

1.1. A "potential output" signifies the output that:

a) may be obtained under the normal degree of capacity utilization, and

b) corresponds to a solvent demand, a sine-qua-non condition for the optimal objective function of producers to be compatible (and, therefore, in equilibrium) with consumers' preferences.

In principle, therefore, the potential output reflects the stable technological, demographic, institutional, and behavioral characteristics of socio-economic life in a certain period. This

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level is not immutable; it changes with modifications in the previously-mentioned constraints (a and b). For instance, such moves occur on the supply-side when the volume or quality of the available production factors change; meanwhile, on the demand side, consumers' preferences register structural shifts (for a large share of economic agents). Demographic mutations, investments, technical progress, human capital improvements, managerial innovations, changes in individual and collective values, and domestic and international specialization, among other factors, induce adjustments in the potential output. The a) and b) constraints are naturally characterized by a pronounced sluggishness, inducing gradual variations of the potential output.

1.2. As such, the potential output is not directly recorded. However, the extent to which the a) and b) conditions are concomitantly valid is reflected in the dimension of other statistical indicators (e.g., labor force participation rate, size of unemployment, intensity of exploitation of natural resources, demand pressure, prices and interest rates, external balance of payments, social acceptability of the existent income distribution system) or in the dynamic properties of corresponding data (e.g., stationarity of univariate time series, VAR processes obeying the stability condition, cyclical movements). This enumeration is far from exhaustive.

These socio-economic sensors of the potential output do not yet benefit from a largely accepted denomination. Regarding the natural unemployment rate (NRU), for example, the notion of "attractor" was adopted (see: Blanchard, 1995; Cross, 1995, 1996; Nymoen, 1995). There were also attempts to assign to the concept of attractor a wider significance in economics (Nowak, Vitting Andersen and Borkowski, 2015). The fact is that numerous VAR processes observing a stability condition (i.e., with no root outside the unit circle) behave computationally similar to the definition of an attractor emitted by Collet and Eckmann (1980), that is, "the set of points to which most points evolve under iterates..." (pg. 56). Some signs of attractors are really present in case of the potential output sensors. However, it remains unclear whether these signs are consistent with the concept of attractor from the causality point of view. Perhaps not coincidentally, with reference to NRU, the question was asked whether what we call an attractor is really an attractee (Cross, 1996). Such doubt may emerge regarding each of the previously mentioned potential output sensors. Consequently, for the moment we would prefer a somehow more neutral formulation - "potential output revealers."

In a general formalization, we have

$$Q=f(R_i) \tag{1}$$

where: **Q** is the potential output, and R_i – the potential output revealers admitted as relevant in a given application. The relative difference:

$$gap=(Q-\mathbf{Q})/\mathbf{Q} \tag{2}$$

represents the so-called output gap, which may be positive, negative, or null. As an elementary modeling specification of (1), the output statistical data was admitted as a potential output revealer, with the proper potential output approximated using a simple filtering operation. Although this algorithm is strongly dependent on the lengths of available series and on the computational properties of the chosen filter, it provides poor analytical information. Consequently, the theoretical and applied studies conducted in this field over the last few decades have concentrated on more complex **Q** determinations, focusing on a set of potential output revealers. Two mainstream strands of this research are important to spotlight.

1.3. Inspired by the supply-side approaches, one strand focuses on the potential output revealers engrafted on the components and valences of the macroeconomic production function. The resulted estimation was named the "production function potential output" (PFPO). There is a large body of existing literature on this topic. The following studies are representative of research into this topic across several different countries: St-Amant and van Norden (1997), de Brouwer (1998), Cerra and Saxena (2000), Congressional Budget Office (2001), Slevin (2001), Pina (2002), Yigal and Yakhin (2004), Benk, Jakab and Vadas (2005), Vrbanc (2006), Mishkin (2007), Bordoloi, Das and Jangili (2009), Altăr, Necula, and Bobeică (2010), Epstein and Macchiarelli (2010), Kemp (2011), Lienert and Gillmore (2015), Cuadrado and Moral-Benito (2016), Kloudova (2016), Kawamoto *et al*. (2017), Jysmä *et al*. (2019), Glocker and Kaniovski (2020), Radovan (2020). Additionally, significant methodological efforts to generalize the production function approach of the potential output were made by some international economic organizations; see, for example: De Masi (1997), Denis, Mc Morrow and Röger (2002), Cotis, Elmeskov and Mourougane (2005), Roeger (2006), Lemoine *et al*. (2008), D'Auria (2010), Havik *et al*. (2014), Chalaux and Guillemette (2019).

Despite the diversity of adopted computational solutions, the studies comprising the mainstream research into the PFPO gravitate around the following potential output revealers:

- the labor participation rate and the natural rate of unemployment as pillars of estimating employment;
- the rate of capital depreciation, which - together with the investment series and the perpetual inventory method - is used to approximate the capital stock;
- constant returns to scale and income-based share in gross value added as elasticities of labor and capital;
- filtered Solow residuals as trend efficiency.

The vast application of the PFPO in research is valuable and deserves careful attention. Among the models using different types of production functions, the methodology of the European Commission (D'Auria *et al*., 2010) has acquired large popularity.

However, the PFPO approach suffers from some limitations. Serious controversies have arisen surrounding most numerical evaluations of the working time, human capital, capital stock, and total factor productivity (TFP). The determination of the "normal degree of capacity utilization" remains largely disputed. In principle, it is understood as the utilization compatible with restrictions such as:

- the prescribed norms of maintenance and exploitation of machinery, land, equipment, and technology;
- the established limits for pollutant emissions;
- the labor legislation;
- the legal rules concerning any productive process.

Defining the output observing all these conditions seems feasible (although not simple) at the microeconomic level, but how to obtain reliable indicators at aggregate levels is an open question.

A limited interpretation of the second attribute of potential output (point 1.1, letter b) also raises serious concerns, since the real market equilibrium is realized in the final phase of the economic circuit (utilization of goods and services), based on the primary income distribution that arises from a large network of redistributive processes.

1.4. The second direction of the potential output modeling development is closer to the demand-side perspective.

1.4.1. Various theoretical and empirical studies have focused on the Phillips curve, NAIRU, and NAWRU - analytical products that link the potential output with the internal macroeconomic equilibrium (particularly concerning the labor market). The notable advantage of this type of model is that it uses macroeconomic data usually provided by the national accounts.

Some studies showed that, under contemporary exchange rates systems, the internal equilibrium (synthetically expressed by inflation) may coexist with serious imbalances in foreign trade (Dobrescu 2004, 2006; Anderton *et al*., 2014). Hence, the double conditioned potential output hypothesis has been advanced, which suggests an explicit connection of potential output to both the internal and external equilibria of the economy. The current study attempts to consolidate this approach.

1.4.2. The study's primary innovation lies in adopting a more extended interpretation of the demand-side perspective, considering not only the demand items but also other circumstances influencing the market equilibrium. To this end, we introduce the market conditionalities notion and, relatedly, define the potential output revealers.

- The components of aggregate demand (AD) are essential in the functioning of an economy. Domestic absorption *(*DA) gathers, as national account items, private and public consumption, the gross fixed capital formation, and inventory changes. The other significant portion of AD concerns the foreign market, namely, the export demand for goods and services produced by a given economy (X). The corresponding relative measures are derived by dividing AD, DA, and X by GDP; these ratios are named aggregate demand pressure (*adp*), domestic absorption pressure (*dap*), and export demand pressure (*xdp*).
- Another market conditionality is the pricing mechanism, an indispensable operational platform for calibrating the supply-demand disturbances. The multitude of partial price indices (for different market segments) is synthetized by the GDP deflator.
- The outcomes of any national economy are influenced by the international context. This external framework can be considered at different scales: the neighboring countries, a regional integrated space, or the global economy.
- After the Second World War, the Western governments increased the degree to which they interfered in the economic life. Since this intervention has been marked by the different interests of the parties that have come into power (usually through democratic processes), the presence of new market fluctuations has become gradually more evident. This phenomenon reflects the problems of political business cycles directly linked with shifts in the effective global output from its potential level.
- Temporary shocks (technological, demographic, sanitary, and natural, among others) may occur, and their impact is gradually reabsorbed by the entire economy at different intervals. Such circumstances also manifest as market conditionalities.

The current study attempts to identify the potential output revealers in a relationship with the previously described determinants. The accordingly estimated global output will be called the "market conditionalities potential output" (MCPO).

1.5. The quantitative estimation of the MCPO is conceived in two phases.

1.5.1. First, it is necessary to identify adequate statistical proxy indicators for the global output and market conditionalities admitted as relevant in the given application. Technically, these must be suitable for an iterative convergent formalization, which would allow an approximation of the corresponding potential output revealers. Therefore, the chosen statistical proxy indicators must be consistent from the economic viewpoint, and, at the same time, must reflect the essential characteristics of the examined interval as fairly as possible.

1.5.2. Second, this study considered computed i) the econometric estimators of relationships between global output and market conditionalities and ii) the corresponding revealers of the latter. Deduced from i) and ii), the output levels are considered as raw estimations of the potential output, which are subsequently transformed into final ones by a filtering procedure. This operation sought to apply a certain sluggishness to the final data of the MCPO (similar to real economic processes).

1.6. This study addresses the experience of the EU members before Brexit (which, for almost a quarter of a century, totaled 28 countries). The computational core of the MCPO estimation is a structural multivariate model, which assesses, for each EU country, the relationships between real GDP and the following determinants:

i) national domestic absorption, export demand, and prices as proxies of the macroeconomic equilibria;

ii) these three indicators are also taken into consideration at the EU level to observe interdependencies among the member countries;

iii) the fluctuations induced by the political business cycle are included in the model using trigonometric functions;

iv) using an asymptotically decreasing time factor, the diverse effects of institutional, technological, and other shocks are taken into account;

v) other influences are captured by the intercept (which also ensures that the residuals' sum is equalized to zero) and various dummy variables.

This model is named "EUMOD21."

1.7. Our results, which incorporate a market conditionalities interpretation of the potential output, are confronted with the official data provided by the European Commission, based on a production factors approach. The main conclusion of this study is that the true potential output should be measured by combining both estimations, a problem deserving further attention.

1.8. In the second chapter, this study describes the indicators representing the global output and market conditionalities, including a stationarity analysis of the corresponding time series. The third chapter describes the EUMOD21, structured into three blocks: i) functional relationships among market conditionalities and global output, ii) potential output revealers of indicators quantifying the market conditionalities, and iii) estimation of the potential output in a market conditionalities interpretation (MCPO). The results are compared with the official EU estimates based on a production factor paradigm (PFPO). The Supplementary Data detail the data and computational procedures. We conclude with a set of summative remarks and directions for further research.

2. Modeling Methodology

The proposed research hypotheses are tested using data from Eurostat. Supplementary Data S1 reports the statistical series (all EU countries, 1996–2019) used in the proposed modeling specification.

2.1. Global Output

The annual indexes of the gross domestic product at comparable prices (IGDPc) are used as a proxy for the global output. In the EU, this may be approached as a cumulated indicator of the entire EU area or each member country. The first variant seems simpler, but its performance is disputable. The EU still does not operate as a unitary entity, and many macroeconomic management tools (except for the monetary policy, but only for the Eurozone) remain prerogatives of the authorities of the sovereign states.

The economic evolution of the EU countries is characterized by significant peculiarities. Their economic growth is far from similar. Regarding the real GDP dynamics, five countries (Luxembourg, Poland, Lithuania, Estonia, and Ireland) register an (arithmetic) average yearly rate of 4-5.7% during the sample period, the highest among the EU members. At the opposite end of the spectrum, eight countries register rates of 0-2%: Italy, Greece, Germany, Portugal, France, Denmark, Austria, and Belgium. Most economies (the Netherlands, the United Kingdom, Spain, Finland, Croatia, Sweden, Bulgaria, Czechia, Hungary, Cyprus, Slovenia, Romania, Latvia, Slovakia, and Malta) experience a yearly rate of 2-4%.

Considering these circumstances, the second modeling option is adopted in this study. Thus, we elaborate distinct global output relationships for each EU country depending on their market conditionalities.

2.2. Internal Market Conditionalities

2.2.1. Regarding the demand pressure, we are faced with the question of using a single indicator, *adp* (=(DA+X)/GDP), or separate indicators, *dap* (=DA/GDP) and *xdp* (=X/GDP).

To address this issue, the real GDP indexes of each country are examined using two specifications: *IGDPc1=f(c, adp)* and *IGDPc2=f(c, dap, xdp).* Normally, the quality of such regressions is of secondary importance. The difference between the compared variants in terms of R^2 (or the standard error of the regressions) is the only element of interest, based on which the preferable variant is chosen. The results are presented in Table 1.

Table 1

R^2 of the preliminary regressions *IGDPc1* and *IGDPc2*

Country	IGDPc1= f(c, adp)	IGDPc2= f(c, dp, xdp)	Diference IGDPc2-Igdpc1	Country	IGDPc1= f(c, adp)	IGDPc2= f(c, dp, xdp)	Diference IGDPc2-Igdpc1
AT	0.005346	0.005798	0.000452	IE	0.056895	0.167767	0.110872
BE	0.029163	0.18402	0.154857	IT	0.0134	0.018025	0.004625
BG	0.229908	0.281182	0.051274	LT	0.013654	0.509332	0.495678
CY	0.236619	0.425304	0.188685	LV	0.027457	0.644152	0.616695
CZ	0.055613	0.389919	0.334306	LU	0.004061	0.06891	0.064849
DE	0.039757	0.109731	0.069974	MT	0.12957	0.439794	0.310224

Country	IGDPc1= f(c, adp)	IGDPc2= f(c, dp, xdp)	Diference IGDPc2-Igdpc1	Country	IGDPc1= f(c, adp)	IGDPc2= f(c, dp, xdp)	Diference IGDPc2-Igdpc1
DK	0.00004	0.037145	0.037105	NL	0.060615	0.271621	0.211006
EE	0.383272	0.403347	0.020075	PL	0.001592	0.218134	0.216542
EL	0.015403	0.171556	0.156153	PT	0.001843	0.043713	0.04187
ES	0.006045	0.072354	0.066309	RO	0.383748	0.454672	0.070924
FI	0.000895	0.387481	0.386586	SE	0.005559	0.059542	0.053983
FR	0.000581	0.451212	0.450631	SI	0.005451	0.054277	0.048826
HR	0.124333	0.404693	0.28036	SK	0.006696	0.39776	0.391064
HU	0.011379	0.370362	0.358983	UK	0.143242	0.322489	0.179247

The distinct representations of internal and external demand pressures provide better adjusting results.

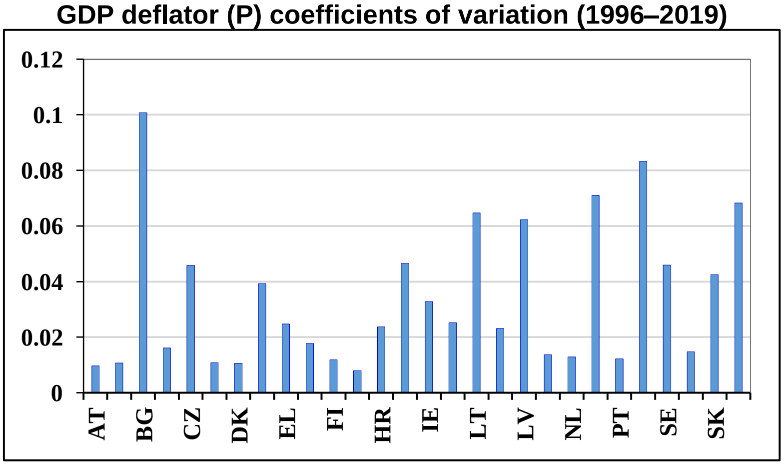
2.2.2. Since both the aggregate supply and AD address the totality of goods and services produced and circulated in the economy, the price level is approximated by the annual GDP deflator (*P*).

In terms of inflation, six countries (Germany, Sweden, France, Austria, Belgium, and Finland) experienced the lowest yearly rate, below 1.5%, during the sample period. Fourteen countries (Greece, the Netherlands, Denmark, Cyprus, Slovenia, the United Kingdom, Estonia, Malta, Portugal, Luxembourg, Italy, Ireland, Croatia, and Poland) registered a moderate annual deflator rate, 1.5-3%. The remaining countries (Hungary, Slovakia, Czechia, Bulgaria, Latvia, Estonia, Lithuania, and Romania) exceeded 3%, even approaching 6%. Generally, higher inflation characterizes the transitional economies.

Hence, inflation volatility is also differentiated by country (Figure 1).

Figure 1.

GDP deflator (P) coefficients of variation (1996–2019)



Disparities signaled in Figure 1 further justify the study's adoption of country specification for the relationship between output and demand-side conditionalities.

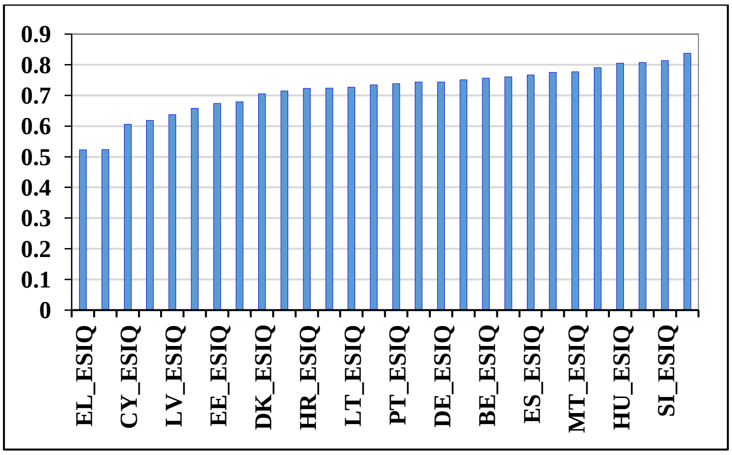
2.3. European Integration

Although it is produced under specific national conditions, the global output of each EU country bears a notable mark of the nation's participation in European integration in terms of decisions and actions.

2.3.1. Such intra-community influences reflect the expectational mechanisms of the EU space. Despite the controversies developed around its methodology, the Economic Sentiment Index (ESI) provided by the European Commission offers a conclusive image of the intra-EU interdependences. Using quarterly data estimated by Dobrescu (2020) for the 1995–2019 period, we calculated Galtung-Pearson correlations between the ESI of each EU country and the ESI of the other 27 EU countries. All correlations are positive. The average for each country is presented in Figure 2, which plots the data distribution in ascending order.

Figure 2.

Mean ESI correlations of each EU country with the other 27 EU countries (in ascending order)



In two cases, the mean is 52%; meanwhile, the mean exceeds 60% in all other cases; these findings indicate a strong interdependence among expectational economic processes within the EU.

2.3.2. The modeling specification of national IGDPc equations adds to the national demand conditionalities some similar explicative variables at the EU level (*EU-dap* and *EU_xdp*).

2.3.3. The EU pricing context is also included in the models, in some cases, through the GDP deflator at the EU level, or (preponderantly) using the weighted variance of the national GDP deflators (*EU_swp2*). The annual country shares in GDP of the entire EU are applied as weights at current market prices.

2.4. Cyclicity

2.4.1. The conditionalities imposed on the global output by the market equilibrium exigencies (DA and export demand pressure, prices, and intra-EU interdependencies) are embedded in the cyclical movements of the economy. Economic cycles may be predicted by considering both the internal structure of the free-market mechanism and the implications of the political power alternance characterizing the democratic systems.

2.4.1.1. The theory of cyclicity is built on solid qualitative foundations (see famous Schumpeter's synthesis, published in 1954) and has been adopted by detailed statistical and modeling investigations (Juglar, 1891; Kitchin, 1923; Kondratieff, 1935; Haberler, 1937; Schumpeter, 1939; Burns and Mitchell, 1946; Hansen, 1951; Mendelson, 1959,1964; Zarnowitz, 1985; Summers, 1986; Prescott, 1986a,1986b; Stock and Watson, 2003; McGrattan and Prescott, 2014). Regarding its causal factors, on the supply-side, the emphasis lies on the cyclical evolutions stemming from changes in the volume or efficiency of production factors: investment and new technologies, human capital improvements, inclusion in the economic circuit of new raw materials and energy sources, substantial demographic mutations, and sectoral and territorial productive capacities restructurings. Ample modifications in consumer preferences, monetary shocks, changes in wealth and current income of households, and international trade disturbances are potential causes of cyclical shifts on the demand side of the economy. As a result of the interaction between these and other technical and socio-economic circumstances, cycles of different duration have been identified in the literature (relevant systematizations may be found in Bormotov, 2009; Korotayev and Tsirel, 2010; Kwasnicki, 2011; Ganachari, 2016). Significant steps have been taken toward the operationalization of the cycle dating procedure (NBER, 2020a, 2020b; Romer and Romer, 2020; Anderson, 2021).

A five-type classification is primarily adopted: i) the Kitchin cycle of approximately four years, ii) the short-sized Juglar cycle of eight years, iii) the medium-sized Juglar cycle and short type Kuznets swing of ten years, iv) the medium-sized infrastructural Kuznets cycle of 18 years, and v) the long Kondratieff waves.

2.4.1.2. As the democratic systems have extended and consolidated, the Government, in the most comprehensive sense, has become an active and influential actor in the economy. The political cycle has been examined frequently in economics research, addressing the functioning of multi-party systems, the electoral campaigns and their management, the political programs and their influences on macroeconomic policies, and the technical organization of election processes, among others. Some overviews of the literature focus on this topic, especially the parliamentary cyclicity, such as Marsh (1998), Khemani (2000), Benoit (2004), Green (2007), Schofield (2007), Erkulwater (2012), Catt *et al*. (2014), Norpoth (2014), Weber and Franklin (2018), Strobl *et al*. (2019), Zandi (2019), and Müller and Louwerse (2020).

The current research assumes that the eminently economic roots of the global output cyclicity and its extra-economic origins (or amplifiers) act concomitantly and have an inherent interaction. In the notion of the political-business cycle, fluctuations are imputed to the market forces and (sometimes substantially) external political factors (Kalecki, 1943; Nordhaus, 1975, 1989; Rogoff and Sibert, 1988; Alesina and Roubini, 1992; Ohlsson and Vredin, 1996; Drazen, 2000; Hallerberg and de Souza, 2000; Jula, 2001; Shi and Svensson, 2002, 2006; Guitton, 2007; Martinez, 2009; Țigănaș and Peptine, 2012; Aidt *et al*., 2015; Dubois, 2016; Cottle, 2019; Müller, 2019). As the modern political systems are characterized by periodic changes in the power of forces promoting different objectives and macroeconomic management tools, such cycles are of short-medium length (approximately four years). Perhaps not accidentally (although without an explicit reference to the political cycles), Joseph Kitchin has concluded that economic fluctuations are "composed of: (a) Minor cycles averaging 3 1/3 years (40 months) in length; (b) major cycles, or so-called trade cycles, which are merely aggregates usually of two, and less seldom of three, minor cycles;

and…Fundamental movements or trends which are largely straight-line movements" (p. 10). The political-business cycles may be considered Kitchin's "minor cycles."

2.4.2. The inclusion of cyclicity in the present model specification requires previously establishing:

i) a macroeconomic indicator, based on which political-business cycles may be quantitatively identified;

ii) temporal limits (in years) within which political-business cycles take place in the EU countries;

iii) several trigonometric functions plausibly adjusting such cycles.

2.4.2.1. The political-business cycle externalizes various economic processes: the production with its numerous inter-sectoral flows, primary income distribution and the revenues redistributive channels, domestic and external market transactions, and the final utilization of goods and services. GDP is still the most statistically comprehensive aggregate indicator of the economy. In line with previous macroeconomic research, our application utilizes GDP as a primary indicator. The political-business cycle is, therefore, understood as fluctuations of the real GDP index imputable to the political power alternance. Real GDP fluctuations with a duration close to the usual length of the political cycle (according to the most relevant elections calendar) are considered expressions of political-business cycles.

2.4.2.2. To elucidate this question, we need to estimate the length of fluctuations recorded by the real GDP and the political cycles and approximate the intersection between these cycles.

a) We propose to identify the cyclicity of the economy adopting the first-order differences of the GDP yearly chain indexes as a benchmark (see Supplementary Data S2). A simple look at the data suggests that all EU members face a pronounced oscillatory evolution of output during the sample period. Whether this evolution may be represented as a succession of distinct cycles remains unclear.

Table 2a

Average length (in years) of the output cycles in the EU countries

Country / Output cycles		Country / Output cycles		Country / Output cycles		Country / Output cycles	
Austria	3.2857	Estonia	3.28571	Ireland	2.875	Poland	3.2857
Belgium	2.875	Greece	4.6	Italy	3.8333	Portugal	4.6
Bulgaria	3.2857	Spain	4.6	Lithuania	3.8333	Romania	3.2857
Cyprus	3.2857	Finland	3.8333	Luxembourg	3.2857	Sweden	3.2857
Czechia	3.8333	France	3.8333	Latvia	4.6	Slovenia	2.875
Germany	3.2857	Croatia	4.6	Malta	3	Slovakia	3.8333
Denmark	3.8333	Hungary	2.875	Netherlands	5.75	United Kingdom	3.2857

The key premise of our proposal is to identify the lowest points of possible fluctuations when the economy shifts from depression to recovery. These points are usually named "*through*." We observe years characterized by negative first-order difference of IGDPc, which precede a positive (or null) difference, thus implying the transition of the economy from decline to a stabilizing or recovering phase. The number of years separating two such successive *throughs* is admitted as the length of the respective cycle. Being deduced from the real GDP series, the obtained cycles are called "output cycles."

During the study period (24 years), in the EU, 179 national output cycles are observed. The duration of the output cycles in the EU countries ranges, on average, between three to five years, close enough to the Kitchin-type cycle.

b) To measure the political cycles, the agenda of the national parliamentary elections is employed, which has the most complex consequences on the institutional system and macroeconomic policies of the EU countries. The composition of the European Parliament itself reflects, at least until now, the political coloratura of the countries' legislatives. NSD (2020), Nordsieck (2020), and OSCE (2020) provide the necessary information, synthetically presented in Supplementary Data S3 (parliamentary elections in the EU countries).

Table 2b

Average length (in years) of the parliamentary cycles in the EU countries

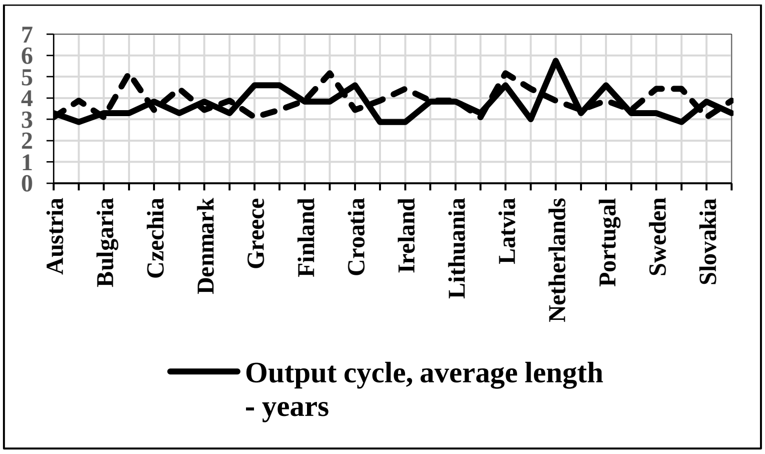
Country / Parlamentary cycles		Country / Parlamentary cycles		Country / Parlamentary cycles		Country / Parlamentary cycles	
Austria	3.1	Estonia	3.875	Ireland	4.4286	Poland	3.4444
Belgium	3.875	Greece	3.1	Italy	3.875	Portugal	3.875
Bulgaria	3.1	Spain	3.4444	Lithuania	3.875	Romania	3.4444
Cyprus	5.1667	Finland	3.875	Luxembourg	3.1	Sweden	4.4286
Czechia	3.4444	France	5.1667	Latvia	5.1667	Slovenia	4.4286
Germany	4.4286	Croatia	3.4444	Malta	4.4286	Slovakia	3.1
Denmark	3.4444	Hungary	3.875	Netherlands	3.875	United Kingdom	3.875

In terms of duration, the political cycles are comparable with the limits of the output cycles (Kitchin type). Most importantly, the proportion between the number of cycles and the sample size is 7.458 in the case of output cycles and 7.387 in the case of parliamentary cycles. This notable similarity suggests a correlation between the two types of cycles.

c) Such a connection results more clearly from the examination of the averages (in years) of both output and parliamentary cycles calculated for each EU country (Figure 3).

Figure 3.

Output and parliamentary cycles, length averages, by EU country



The deviations of the ratios of the parliamentary to the output cycles length averages oscillate around +/-1/3 in 24 countries; only four countries exceed these limits. Hence, the existence of a temporal juxtaposition between parliamentary elections and output cycles in the EU cannot be contested. Considering this evidence and using integers for measuring duration, we assume that in the EU countries, the political-business cycles last around three to five years.

2.4.2.3. The length of trigonometric functions (sin or cos) used to represent these cycles lies within the same range (as in Table 3).

Table 3

Trigonometric functions used to represent the political-business cycles

Country	Function	Country	Function	Country	Function	Country	Function
Austria	cos4	Estonia	sin5	Ireland	cos5	Poland	cos4
Belgium	cos4	Greece	cos5	Italy	sin5	Portugal	cos3
Bulgaria	cos4	Spain	cos4	Lithuania	sin5	Romania	cos3
Cyprus	cos4	Finland	sin5	Luxembourg	sin5	Sweden	cos4
Czechia	sin5	France	cos4	Latvia	cos4	Slovenia	cos4
Germany	sin5	Croatia	sin5	Malta	cos4	Slovakia	sin5
Denmark	sin5	Hungary	sin4	Netherlands	sin5	United Kingdom	sin5

The cyclicity impact is generally introduced in the model by a single variable, and in some cases, as a distributed effect attached to other regressors.

2.5. Other Factors

Relatively permanent influences exerted by other non-specified factors are captured by the intercept. Some shocks with impacts that are reabsorbed gradually are expressed as simple dependences on t, respectively, t/(t+1) or (t+1)/t, both tending asymptotically to unity.

In the cases of four countries (Sweden, Slovenia, Slovakia, and the United Kingdom), the replacement of such a time factor with the first lag of the real GDP index has proved more appropriate.

2.6. Stationarity

The stationarity of the global output and market conditionalities series are verified. A large battery of unit root tests is used: the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) and, with an auxiliary role, the DF-GLS (developed by Elliott-Rothenberg-Stock), Kwiatkowski-Phillips-Schmidt-Shin (KPSS), Elliott-Rothenberg-Stock point optimal (ERS), Ng-Perron (NgP) in four variants (MZa, MZt, MSB, MPT), and Breakpoint test.

The following testing strategy is adopted:

i) First, the series is tested in level using the ADF and PP tests. If at least one test indicates a null hypothesis probability below 5%, the series is used in level.

ii) When both the ADF and PP test results exceed this threshold, other tests are employed to determine whether the series should be used in level or differences.

2.6.1. Regarding the global output (IGDPc), both the ADF and PP tests indicate stationarity in level for 17 countries. Stationarity is confirmed by the ADF test for other four countries; together, these represent 75% of the cases. Seven series exceed 5% of the ADF or PP null hypothesis probability and are subsequently tested using other procedures (results in Table 4).

Table 4

Questionable stationarity of some IGDPc series

Test	Null hypothesis	CY_IGDPc	EL_IGDPc	ES_IGDPc	HR_IGDPc	NL_IGDPc	PT_IGDPc	UK_IGDPc
DF-GLS	Series has a unit root	1-5%	Over 10%	1-5%	1-5%	Under 1%	1-5%	Under 1%
ERS	Series has a unit root	5-10%	Over 10%	Over 10%	Over 10%	5-10%	5-10%	1-5%
NgP	Series has a unit root							
MZa		5-10%	Over 10%	Over 10%	5-10%	1-5%	5-10%	1-5%
MZt		5-10%	Over 10%	5-10%	5-10%	1-5%	5-10%	1-5%
MSB		Over 10%	Over 10%	Over 10%	5-10%	5-10%	5-10%	1-5%
MPT		5-10%	Over 10%	5-10%	5-10%	1-5%	5-10%	1-5%
KPSS	Series is stationary	Over 10%	Over 10%	Over 10%	Over 10%	Over 10%	Over 10%	5-10%
Breakpoint	Series has a unit root	0.0552	0.5306	0.0323	0.2628	0.2854	0.6377	Under 1%

As Table 4 shows, in some cases, we cannot reject unambiguously the stationarity in level of the discussed series. Besides, all these series generate autoregressive specifications with stability conditions (no root lies outside the unit circle, as per the EViews definition). Hence, their inclusion in level in the model specification is considered admissible. If other computational reasons require it, the first-order differences of IGDPc are also employed.

2.6.2. The national data for the DA pressure reveal a completely different picture: 24 series are characterized by non-stationarity in level as per the ADF and PP tests. We also test the first-order differences of the *dap* series, and only *IE_dap* is signaled as non-stationary by both the ADF and PP tests, and *SE_dap* by the ADF test only. Regarding *IE_dap*, all auxiliary tests, namely, DF-GLS, KPSS, ERS, NgP in four variants (MZa, MZt, MSB, and MPT), and the Breakpoint test confirm stationarity of the first-order differences. The KPSS and Breakpoint tests attest stationarity for *SE_dap*. Under these conditions, we model the national DA pressure series as first-order differences.

2.6.3. Similarly, 23 series of the country export demand pressure are non-stationary in level according to both the ADF and PP tests (24 series as per the PP test). Four series admitted by the ADF and PP tests as stationary in level (*AT_xdp, BE_xdp, HU_xdp*, and *UK_xdp*) are checked by supplementary tests. The DF-GLS, KPSS, ERS, NgP in all four variants, and the Breakpoint test reveal weak stationarity in level of *AT_xdp*, *BE_xdp*, and *HU_xdp*. The ERS and Breakpoint tests reach to the same conclusion for *UK_xdp*. Hence, the *xdp* series is retained for model specification as first-order differences.

2.6.4. The ADF and PP tests identify five annual GDP deflator series as non-stationary (*CY_P, DE_P, ES_P, NL_P,* and *PT_P*); the same conclusion is achieved for other series by the ADF (*fAT_P, DK_P, EE_P*), ERS and NgP (*BE_P, BG_P, EL_P, FI_P, IT_P, LT_P, MT_P*), KPSS (*CZ_P, EL_P, HU_P, IT_P, LT_P*), and Breakpoint test (*FR_P, IE_P, LT_P, SK_P).* As the above-mentioned two national output conditionalities, the first-order differences are retained for the modeling specification of the national GDP deflators.

2.6.5. The stationarity of EU conditionalities is reported in Table 5.

Table 5

Stationarity tests for EU conditionalities of the global output (series in level)

Test	Null hypothesis	EU_dap	EU_xdp	EU_swp2	EU_P
ADF	Series has a unit root	0.3924	0.5455	0.0149	0.0024
PP	Series has a unit root	0.3373	0.587	0.0198	0.0024
DF-GLS	Series has a unit root	5-10%	Over 10%	Under 1%	Under 1%
ERS	Series has a unit root	Over 10%\	Over 10%	5-10%	5-10%
NgP	Series has a unit root				
MZa		5-10%	5-10%	1-5%	1-5%
MZt		5-10%	5-10%	1-5%	1-5%
MSB		5-10%	5-10%	1-5%	1-5%
MPT		5-10%	5-10%	1-5%	1-5%
KPSS	Series is stationary	Over 10%	1-5%	Over 10%	5-10%
Breakpoint	Series has a unit root	0.8393	0.6571	0.0935	< 0.01

Two EU conditionalities of the global output have a unit root in level: nine tests (except for the KPSS) indicate such a characteristic for *EU_dap*, and all ten tests for *EU_xdp*. Normally, these are modeled as first differences.

In contrast, the stationarity in level of *swp2* is supported by eight testing procedures (the ERS and Breakpoint tests find the same result even though almost at the limit); in the case of *EU_P,* the number of favorable tests increases to nine (except for the ERS test).

3. Results and Discussion

The main result of our study is the introduction of the EUMOD21 model, structured into three blocks: i) functional relationships among market conditionalities and global output, ii) potential output revealers of indicators quantifying the market conditionalities, and iii) estimation of the MCPO.

3.1. Functional Relationships between Market Conditionalities and Global Output

3.1.1. The model specification gravitates around the global output (IGDPc) estimated for each EU country using the previously-analyzed determinants. These can be systematized into five groups:

i) Internal market conditionalities (*dap, xdp,* and *P* of each country);

ii) European integrated context (*EU-dap, EU-xdp, EU-swp2,* and *EU-P*);

iii) Cyclicity, expressed cumulatively (as a single coefficient) or in a distributive way (coefficients attached to the internal market conditionalities of output);

iv) Other factors captured by the intercept, time factor, *IGDPc(-1),* and various dummies (for years marked by significant breaks in output dynamics).

The limited sample length poses significant threats to empirical estimation. Two strategies exist to address this issue: eliminate some crucial output conditionalities from the model (seriously affecting the cognitive potential of the model) or maintain all relevant explaining variables (thus accepting a lower statistical consistency of estimators). Both solutions affect the model's robustness. The first approach seems more costly; hence, we are inclined, for the moment, toward the second approach.

3.1.2. The above-mentioned variables allow a multitude of modeling options, which, however, cannot omit the internal market conditionalities of the output (*dap, xdp,* and *P*) with their predominant influence on the utilization degree of the available production factors. The constant and dummy variables need to be added to the model. The remaining explanatory variables are included using diverse combinations, which considerably expand the puzzle of possible specifications.

3.1.3. As an illustration, we select four economically plausible (although not necessarily optimal) variants (V1, V2, V3, and V4); we describe their characteristics in Scheme I.

Scheme I. Preliminary modeling variants

Variables	V1	V2	V3	V4
Output	*IGDPc*	*IGDPc*	*IGDPc*	*d(IGDPc)*
Internal market conditionalities	*d(dap), d(xdp), d(P)*	*d(dap), d(xdp), d(P)*	*d(dap), d(xdp), d(P)*	*d(dap), d(xdp), d(P)*
EU economic context	*d(EU_dap), d(EU_xdp), EU_swp2*	*EU_swp2*	*d(EU_p)*	*d(EU_dap), d(EU_xdp), d(EU_p)*
Sluggishness	time factor	time factor	time factor	*IGDPc(-1)*
Cyclicity influence	cumulated	distributed	Distributed	Cumulated
Other factors	*c,* dummy	*c*, dummy	*c*, dummy	*c*, dummy

3.1.4. As a preliminary modeling approach, each variant of the specification presented in Scheme I is applied identically to all EU countries. Solved with weighted least squared, the obtained variants provide satisfactory R^2. However, they are characterized by a relatively low statistical significance of the estimators. The weight of the estimators with marginal significance (below 0.05) represents only 0.396 for the first variant, decreases to 0.35–0.34 for the following two, and to 0.254 for the fourth. This weakness is partially imputable to the quality of the data. Another, perhaps more explicative, circumstance is the presence of inter-equation error terms correlations. The four systems discussed here cannot be solved with a corrective econometric technique as the seemingly unrelated regression (SUR).

3.1.5. We review the model specification to avoid the near singular matrix when applying the SUR method. A comprehensive analysis of this problem exceeds the intentions of this study, which is limited to addressing an accessible modality for our application, consisting of the differentiation of the model specifications by countries. Remaining within the four proposed variants, the scheme comprises the V1 specification for 20 countries (AT, BE, BG, CY, CZ, DE, DK, EE, EL, ES, FI, FR, HR, HU, IT, LT, LU, LV, MT, NL), the V2 specification for three countries (IE, PL, PT), the V3 specification for one country (RO), and the V4 specification for the last four countries (SE, SI, SK, UK). The corresponding system of equations and their solutions obtained by SUR are reported in Supplementary Data S4.

3.1.6. The econometric consistency of EUMOD21 is verified by an extended residual analysis (Supplementary Data S5).

3.1.6.1. The normality of the residuals' distribution is checked with the Shapiro-Wilk and Shapiro-Francia procedures (Shapiro and Francia, 1965; Shapiro and Wilk, 1972; Sarkadi, 1975; *Royston, 1983*, 1992; Everitt and Skrondal, 2010*)* using the most powerful tests (Rahman and Govindarajulu, 1997; Yap and Sim, 2011; Patrício *et al*., 2017). To address potential heteroscedasticity, the White test is used. The Supplementary Data S5 contains the details.

The null hypothesis of normality cannot be rejected in the majority of cases. Only for two countries (Lithuania and Portugal), the *Shapiro-Francia test does not confirm the* normality *of the residuals' distribution.*

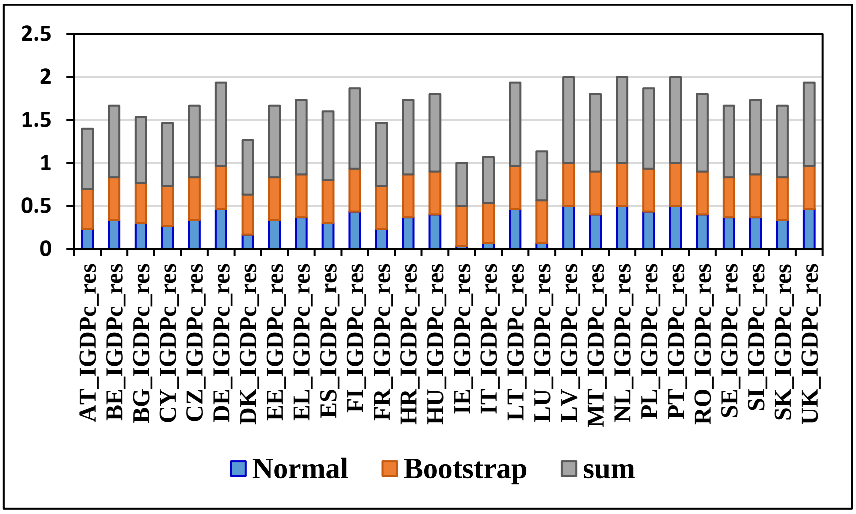
Except for two cases (Bulgaria and Germany), the residual series pass the heteroscedasticity test, confirming the properties of the SUR technique (Zellner, 1962; Creel and Farell, 1996; Moon and Perron, 2006; Afolayan and Adeleke, 2018).

3.1.6.2. The possible autocorrelation implications of the EUMOD21 residuals are examined using the BDS test (Broock, Scheinkman, Dechert and LeBaron, 1996) in EViews. BDS verifies, as the null hypothesis, whether the residuals are independent and identically distributed (iid), considering various deviations from independence (linear dependence, non-linear dependence, or chaos).

To obtain broad information, the test is calculated for five dimensions (2, 3, 4, 5, and 6) and three choices regarding the distance used for testing the proximity of the data points (fraction of pairs, standard deviations, and fraction of range). The null hypothesis probability is approximated for the sample data ("normal") and the bootstrapped series ("bootstrap"). For each country, we obtain 30 BDS-H0 estimations. The share of estimations for which the null hypothesis probability exceeds the critical threshold (0.05) in the total number of BDS tests (30 for each country) is plotted in Figure 4.

Figure 4.

Share of estimations with null hypothesis probability above the critical threshold of 0.05 in the total number of BDS tests



The share is between 50% and 60% only in three cases (Ireland, Italy, and Luxembourg). For the entire sample, this weight reaches 83%, clearly attesting that the EUMOD21 residuals do not raise concerns regarding the independence of the data.

3.1.6.3. The stationarity of residuals is also of interest. Insights from cointegration analysis (Apergis, 2003; Riveros, 2019) indicate that, at least in the case of a linear model, the stationarity of residuals suggest the lack of spurious regressions. Table 6 presents the results obtained by checking the EUMOD21 residuals with the ADF and PP procedures. These tests are calculated without and with a constant.

Table 6

Stationarity of the EUMOD21 residuals (in level)

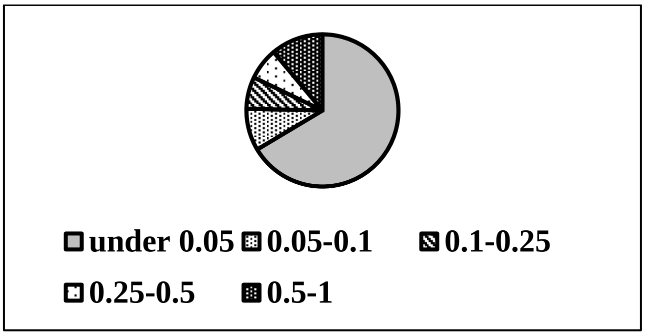
Residual	Augmented Dickey-Fuller		Phillips-Perron	
	none exogenous	constant	none exogenous	constant
AT_IGDPc_res	0.0012	0.0199	0.0011	0.0187
BE_IGDPc_res	0.0011	0.02	0	0.0004
BG_IGDPc_res	0.0639	0.3813	0.0002	0.0049
CY_IGDPc_res	0.0012	0.0198	0.0012	0.0198
CZ_IGDPc_res	0.0766	0.4159	0.0007	0.0123
DE_IGDPc_res	0.0003	0.0058	0.0003	0.0057
DK_IGDPc_res	0.0029	0.0407	0.0026	0.038
EE_IGDPc_res	0.0216	0.2008	0.0003	0.0056
EL_IGDPc_res	0.0004	0.0079	0.0004	0.0079
ES_IGDPc_res	0.001	0.0175	0.0013	0.0225
FI_IGDPc_res	0.0019	0.0259	0.0001	0.0021
FR_IGDPc_res	0.0004	0.0088	0.0004	0.0088
HR_IGDPc_res	0.0002	0.0051	0.0002	0.0046
HU_IGDPc_res	0.0016	0.0249	0.0015	0.0246
IE_IGDPc_res	0.0053	0.0661	0.0053	0.0661
IT_IGDPc_res	0.0001	0.0025	0.0001	0.0026
LT_IGDPc_res	0.0001	0.0016	0.0001	0.0016
LU_IGDPc_res	0.0001	0.0014	0	0
LV_IGDPc_res	0.002	0.031	0.0019	0.0294
MT_IGDPc_res	0.0001	0.0014	0	0.0012
NL_IGDPc_res	0.0001	0.0012	0.0002	0.0054
PL_IGDPc_res	0.0018	0.0277	0.0018	0.0277
PT_IGDPc_res	0.0014	0.0224	0.0013	0.0218
RO_IGDPc_res	0.0001	0.0024	0.0001	0.0022
SE_IGDPc_res	0.0001	0.003	0	0.0001
SI_IGDPc_res	0	0.0001	0	0
SK_IGDPc_res	0.0001	0.0025	0	0.0006
UK_IGDPc_res	0.0001	0.0022	0.0001	0.0014

The residuals of four cases (BG, CZ, EE, and IE) are questionable from the stationarity perspective. The KPSS test, however, provides opposite results for all these series. The stationarity is also supported for BG with the Breakpoint test, for EE with the DF-GLS and Breakpoint tests, for IE with the DF-GLS, ERS, and all variants Ng-P tests. Overall, the residuals of the EUMOD21 can be considered stationary, increasing the confidence in the correctness of the model specification.

3.1.6.4. This conclusion is enforced by the examination of the p-values (marginal significance level) of the econometric coefficients.

Figure 5.

Distribution of the marginal significance levels of the EUMOD21 econometric coefficients



Two-thirds of the model coefficients are characterized by a t-Statistic for the null hypothesis probability lower than the critical threshold of 0.05; together with the threshold of 0.05–0.1, this weight exceeds 75%.

3.1.6.5. The approximation of the basic samples provided by the model is also relevant.

Table 7

EUMOD21 – R^2 of *IGDPc* equations

Country	R-squared	Country	R-squared
AT_IGDPc	0.849115	IE_IGDPc	0.785624
BE_IGDPc	0.835071	IT_IGDPc	0.868206
BG_IGDPc	0.585041	LT_IGDPc	0.786148
CY_IGDPc	0.608038	LU_IGDPc	0.858584
CZ_IGDPc	0.575359	LV_IGDPc	0.778439
DE_IGDPc	0.848673	MT_IGDPc	0.688707
DK_IGDPc	0.744133	NL_IGDPc	0.798716
EE_IGDPc	0.847954	PL_IGDPc	0.607396
EL_IGDPc	0.753452	PT_IGDPc	0.808032
ES_IGDPc	0.821315	RO_IGDPc	0.634241
FI_IGDPc	0.888992	SE_IGDPc	0.686074
FR_IGDPc	0.90553	SI_IGDPc	0.793814
HR_IGDPc	0.763446	SK_IGDPc	0.82757
HU_IGDPc	0.778983	UK_IGDPc	0.670535

The R^2 in only two cases is slightly below 60% (Czechia, 0.575, and Bulgaria, 0.585); for six countries it lies between 60 and 70%, and for a majority of the countries it exceeds this threshold (nine in the range of 70–80% and 11 over 70%). It may be contended that these results depend on the relatively large number of independent variables. However, previous analysis of the marginal significance level of the econometric coefficients reveals that the selected estimators are generally not redundant. Overall, the functional relationships defined numerically in the EUMOD21 (see Supplementary Data S6) seem reliable for estimating the potential output in a market conditionalities interpretation.

3.2. Potential Output Revealers of Indicators Representing Market Conditionalities

3.2.1. As a guiding premise, this study admits that potential output correlates with the typical market conditionalities of the sample period. Since the essential characteristics of economic life tend to replicate in a given context, the series defining market conditionalities indicators should be characterized by convergence properties, verified by iterative operations.

According to the EUMOD21 specification, it is necessary to estimate the potential output revealers for the following categories of market conditionalities:

- internal provenances: the domestic absorption pressure (*dap*), the export demand pressure on the respective economy (*xdp*), and the national price environment expressed by the GDP deflator (*P*);
- the EU context as an integrated space, characterized by the same indicators at the EU level (*EU_dap, EU_xdp,* and *EU_P*), sometimes supplemented by the weighted cross-sectional variance of the national GDP deflators (*swp2*);
- the political-business cycle implications, with the corresponding trigonometric functions (sin or cos of different lengths);
- other indirectly-captured factors (by the constant, time factor, output lag, and dummy variables).

Technical methodologies for estimating the potential output revealers are presented below.

3.2.2. The first two groups of market conditionalities (national *dap, xdp,* and *P* on the one hand, and *EU_dap, EU_xdp, EU_P,* and *EU_swp2*, on the other hand) need a more extended discussion.

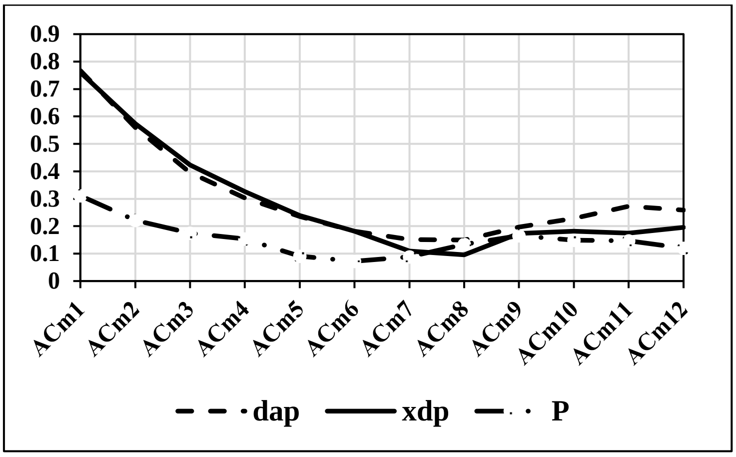
3.2.2.1. The statistical series of these indicators are characterized by a notable autocorrelation (AC). Since, in this case, the amplitude and not the algebraic sign of the AC coefficients is crucial, these are examined as modules.

Regarding the national *dap, xdp*, and *P*, for each lag-order (from 1 to 12), we compute the means of AC coefficients (in module) in level for all the 28 countries. The curves describing these means are plotted in Figure 6a.

Although somehow differentiated by these indicators (more intense for *dap* and *xdp*, and a little weaker for *P*), the AC generally appears significant. The allure of all curves is descending within lag-orders 2–6 and slightly re-enforcing afterward.

Figure 6a.

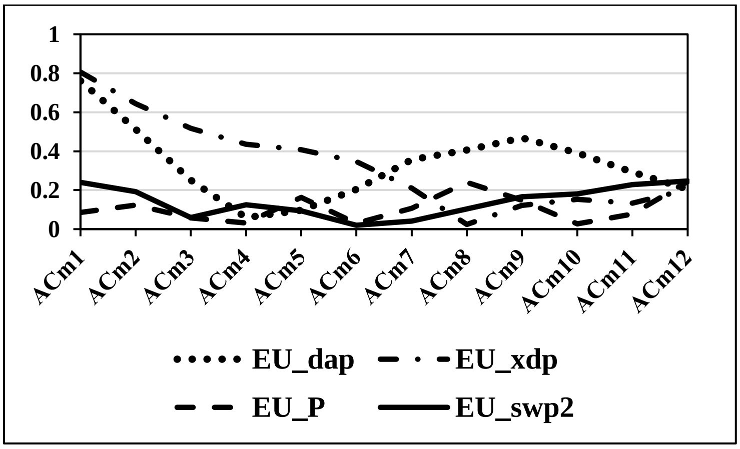
Means of AC coefficients at lag-order *i* (module) registered by all EU countries



AC is also present in series of indicators characterizing the EU context (Figure 6b).

Figure 6b.

AC coefficients at lag-order *i* (module) registered by the indicators of the EU context

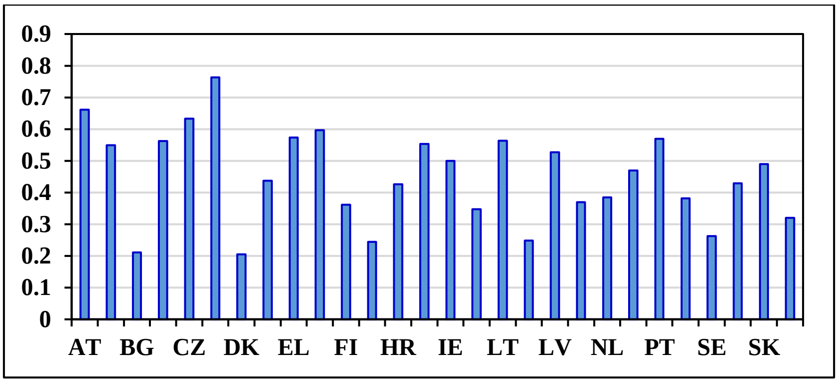


The presence of AC suggests the AR (autoregressive) processes as a possible modeling tool for approximating the revealers of indicators representing both analyzed groups of market conditionalities (national *dap, xdp,* and *P*, as well as *EU_dap, EU_xdp, EU_P,* and *EU_swp2*).

3.2.2.2. Cross-sectional correlations add useful information to this discussion. For each country, we compute the Galtung-Pearson correlations between *dap, xdp,* and *P;* the distinct bilateral coefficients (excluding the variances and repeated data) are aggregated into arithmetic means. The results are summarized in Figure 7.

Figure 7

Characteristics of simulations for the revealers of national *dap*



The means of 11 countries exceed 50% and for the other 11 lie between 35 and 40%; even the lowest group does not lie below 20%. Therefore, the interdependence among national market conditionalities is evident. In the case of EU-context indicators, such an interdependence is also observed, especially between *EU_xdp* and price parameters (*EU_P* and *EU_swp2*).

The existence of the cross-sectional correlations is an indication that AR processes may be employed not only individually, but also as a system.

3.2.3. In virtue of the mentioned two features of the statistical series (AC and cross-sectional correlation,) the VAR technique is used for estimating the revealers of the internal and EU-context market conditionalities indicators. It is applied in both forms, as a univariate model and as a system of equations.

3.2.3.1. Due to the convergence property of the revealers, the VAR stability condition is required (and double-checked). On the one hand, for each VAR estimation, we perform a lag structure test to verify that no root of the characteristic polynomial lies outside the unit circle. In many cases, even observing this criterion, the simulating iterations reveal non-stable estimations; hence, the stability condition is verified computationally by iteration until the relative successive differences of the results (y_t/y_{t-1}-1, in module) remain below 0.00001 at least one-hundred times. There were identified four types of simulating behaviors, named PO revealer-types: STL - stable level; CYC - cycle; IRR - irregular; OSC – oscillations.

3.2.3.2. The VAR specification for national *dap, xdp,* and *P* is used for each country in the following order:

i) we resort to the VAR system for all three indicators;

ii) if the stability condition cannot be obtained or the resulted equation generates economically implausible values, the two indicators are separated to be solved as a system, the other remaining as a univariate AR;

iii) when the compounded bivariate system also fails to provide consistent estimates, the involved variables are processed again as univariate AR;

iv) in principle, to involve in the econometric estimations as many observations as possible, we prefer the longest stable VAR (the VAR with a maximal number of lags observing the stability condition); in cases of stable VAR not inducing convergence in iterations, we use a VAR of shorter length.

3.2.4. The simulations aim to identify the equations for defining the revealers for 84 indicators of national market conditionalities and four for the EU context. Regarding the first category, we process VAR systems with three variables (national *dap, xdp*, and *P*) for the majority of EU members (20); in four cases, we can only gather two variables into the VAR systems, the third being solved separately; in the other four countries, only an individual VAR for each indicator is approachable.

3.2.4.1. The specification for national *dap* allows a good approximation of the sample data: for 14 countries, the R^2 exceeds 90%, and for 11 countries, it lies between 74% and 90%; in only one case it lies below 50% and in two at 54–58%. Other features of the simulations regarding national *dap* are presented in Table 8a.

Table 8a

Characteristics of simulations for the revealers of national *dap*

Indicator	PO revealer type	Pre-convergence iterative trajectory	Lags	Indicator	PO revealer type	Pre-convergence iterative trajectory	Lags
AT_DAP	STL	IRR	4	IE_DAP	STL	IRR	10
BE_DAP	STL	IRR	5	IT_DAP	CYC	IRR	8
BG_DAP	STL	IRR	4	LT_DAP	STL	IRR	5
CY_DAP	STL	IRR	3	LU_DAP	STL	IRR	10
CZ_DAP	CYC	IRR	5	LV_DAP	STL	IRR	4
DE_DAP	STL	IRR	3	MT_DAP	STL	IRR	3
DK_DAP	STL	OSC	5	NL_DAP	CYC	OSC	4
EE_DAP	CYC	OSC	6	PL_DAP	STL	IRR	4
EL_DAP	CYC	OSC	8	PT_DAP	STL	IRR	2
ES_DAP	STL	IRR	6	RO_DAP	CYC	IRR	4
FI_DAP	CYC	OSC	5	SE_DAP	STL	IRR	3
FR_DAP	STL	IRR	5	SI_DAP	STL	IRR	3
HR_dap	STL	IRR	6	SK_DAP	CYC	OSC	4
HU_DAP	STL	IRR	4	UK_DAP	CYC	OSC	5

Note: STL - stable level; CYC - cycle; IRR - irregular; OSC – oscillations.

3.2.4.2. The quality of fit for the national *xdp* is even better: the coefficient of determination exceeds 90% for 16 countries and lies between 75% and 90% for the other 10; the last two lie at 57% and 68%, respectively. Table 8b describes the simulations focused on market conditionality.

Table 8b

Characteristics of simulations for the revealers of national *xdp*

Indicator	PO revealer type	Pre-convergence iterative trajectory	Lags	Indicator	PO revealer type	Pre-convergence iterative trajectory	Lags
AT_XDP	STL	IRR	4	IE_XDP	STL	IRR	9
BE_XDP	STL	IRR	5	IT_XDP	STL	IRR	2
BG_XDP	STL	IRR	4	LT_XDP	STL	IRR	5

Indicator	PO revealer type	Pre-convergence iterative trajectory	Lags	Indicator	PO revealer type	Pre-convergence iterative trajectory	Lags
CY_XDP	STL	IRR	3	LU_XDP	CYC	IRR	8
CZ_XDP	CYC	IRR	5	LV_XDP	STL	IRR	4
DE_XDP	STL	IRR	3	MT_XDP	STL	IRR	3
DK_XDP	STL	IRR	5	NL_XDP	CYC	OSC	4
EE_XDP	CYC	OSC	6	PL_XDP	STL	IRR	4
EL_XDP	STL	OSC	6	PT_XDP	STL	IRR	2
ES_XDP	STL	IRR	6	RO_XDP	CYC	IRR	4
FI_XDP	CYC	OSC	5	SE_XDP	STL	IRR	3
FR_XDP	STL	IRR	5	SI_XDP	STL	IRR	3
HR_xdp	STL	IRR	6	SK_XDP	CYC	OSC	4
HU_XDP	STL	IRR	4	UK_XDP	CYC	OSC	5

Note: STL - stable level; CYC - cycle; IRR - irregular; OSC – oscillations.

3.2.4.3. Slightly weaker quality of fit is observed for the series of national *P*, with R^2 between 29% and 49% for five countries, between 55% and 65% for six countries, between 70% and 88% for 12 countries, and over 90% for only five countries. Additional information about the simulations of *P* is reported in Table 8c.

Table 8c

Characteristics of simulations for the revealers of national *P*

Indicator	PO revealer type	Pre-convergence iterative trajectory	Lags	Indicator	PO revealer type	Pre-convergence iterative trajectory	Lags
AT_P	STL	IRR	4	IE_P	STL	IRR	9
BE_P	STL	IRR	5	IT_P	STL	IRR	10
BG_P	STL	IRR	4	LT_P	STL	IRR	5
CY_P	STL	IRR	3	LU_P	CYC	IRR	8
CZ_P	CYC	IRR	5	LV_P	STL	IRR	4
DE_P	STL	IRR	3	MT_P	STL	IRR	3
DK_P	CYC	OSC	10	NL_P	CYC	OSC	4
EE_P	STL	OSC	6	PL_P	STL	IRR	4
EL_P	CYC	OSC	10	PT_P	STL	IRR	2
ES_P	STL	OSC	10	RO_P	CYC	IRR	4
FI_P	CYC	OSC	5	SE_P	STL	IRR	3
FR_P	STL	IRR	5	SI_P	STL	IRR	3
HR_P	STL	IRR	6	SK_P	CYC	OSC	4
HU_P	STL	IRR	4	UK_P	CYC	OSC	5

Note: STL - stable level; CYC - cycle; IRR - irregular; OSC – oscillations.

3.2.4.4. The attempts to apply a VAR system on all series for the EU context are unsuccessful. Only for the pair *EU_xdp* and *EU_swp2* the VAR is successfully employed; consequently, *EU_dap* and *EU_P* are treated as a univariate AR. The obtained coefficient of determination is satisfactory for *EU_dap* (71%) and *EU_xdp* (91%), but less so for price indicators (43% for *EU_P* and 36% for *EU_swp2*).

3.2.5. Regarding the other indirect explicative variables, as expected, when *t* increases, the revealers of the trigonometric functions remain almost identical, and factor-time *(t+1)/t* and its inverse *t/(t+1)* shift toward unit. The intercepts remain unaltered, and the dummy variables operate exclusively within the sample interval.

3.2.6. Supplementary Data S7 reports the set of equations used to estimate the potential output revealers of the market conditionalities indicators.

3.3. MCPO Estimation

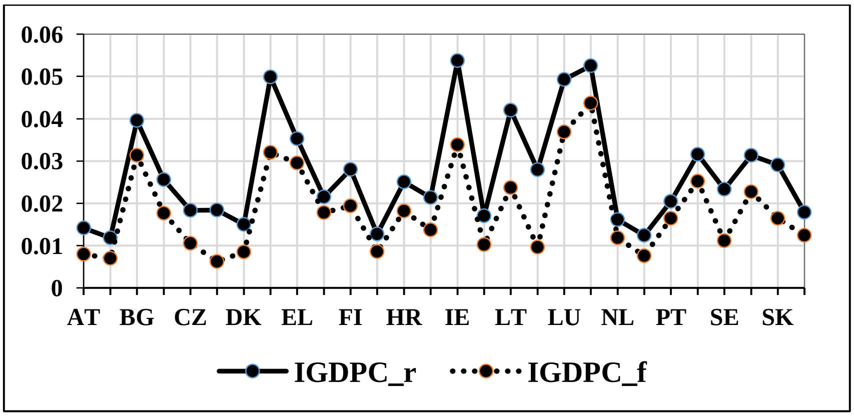
3.3.1. The EUMOD21 estimates the potential output in market conditionalities determination in two phases. In the first phase, the system (revealed in Supple2mentary Data S6) is solved using the revealers of the explicative variables (provided by the equations described in Supplementary Data S7). The results are named "raw estimations" and are denoted by letter *r*.

Since the variables involved in the EUMOD21 are highly aggregated in magnitudes with a smooth sluggishness, the raw data obtained in the first phase are subjected to a filtering operation using the Hodrick-Prescott procedure (Hodrick and Prescott, 1980, 1997). The key issue, in this case, is establishing the frequency response of the HP cyclical filter value (the well-known and controversial lambda). Concerning the annual data (with which our application operates), various coefficients were proposed: 100 (Backus and Kehoe, 1992; Giorno *et al*., 1995; Apel, Hansen and Lindberg, 1996; European Central Bank, 2000) , 400 (Dolado *et al*., 1993), 10 (Baxter and King, 1999), 6–14 under different computational hypotheses (Maravall and del Río, 2001); *6–25 (Ravn and Uhlig, 2002), and 30* (Ricardo and Almeida, 2006). We opt for the value of one to maintain the filtering operation as close as possible to the data yielded from the first computational phase. In Supplementary Data S8, these filtered estimations are denoted by letter *f*.

The filtering operations do not change the mean of the corresponding series: only their standard deviations diminish, as shown in Figure 8.

Figure 8.

Standard deviation of the raw *(r)* and filtered *(f)* estimations of the potential output (real GDP index)



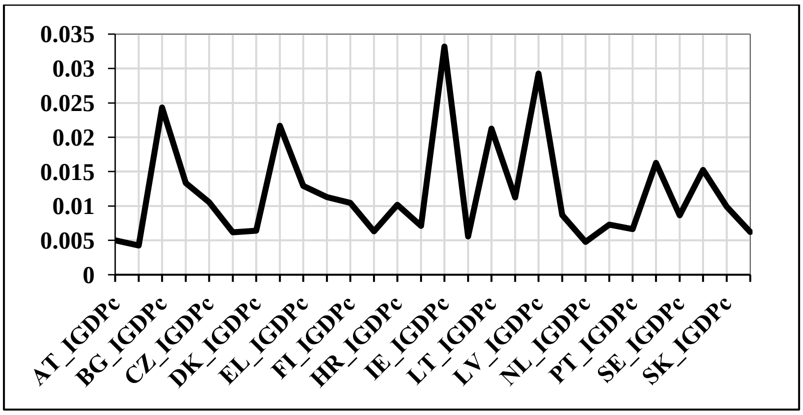
3.3.2. In principle, the market equilibrium imposes a continuously and reciprocally accommodating evolution of the supply- and demand-side approaches to economic activity.

As a logical consequence of such dynamics, the production factors (PFPO) and market conditionalities (MCPO) estimations of the potential output are also expected to be close in value. Empirically, this statement may be verified by comparing the EU potential output estimates (marked by capital *E*) and our filtered data (symbol *f*). Expressed as the annual real GDP index (these series are detailed for all EU countries in Supplementary Data S8). The first illustrates the PFPO (since the EU methodology is centered on production factor paradigm), while the second (*IGDPc_f*) is built on the MCPO interpretation.

The *IGDPc_E* and *IGDPc_f* series, although based on significantly different methodologies, provide close results. Figure 9 sketches the mean root of the squared relative difference between *f* and *E* [$MRSRD\_f\text{-}E=(\Sigma_i(IGDPc\_f_i/IGDPc\_E_i-1)^\wedge 2/n)^\wedge 0.5$], where *i* represents the country code, and *n* the number of years.

Figure 9.

Mean root of the squared relative difference between *f* and *E* potential output estimations (*MRSRD_f-E*)



For half of the countries, this coefficient does not exceed 1%, for nine countries it lies between 1% and 2%, and for five countries between 2 and 3.3%. These relative differences can result from two main sources. On the one hand, there are inherent temporal misalignments of supply and demand in a dynamic market equilibrium. On the other hand, measurement imprecisions may play a non-negligible role.

3.3.3. Therefore, we see PFPO and MCPO as two expressions of the same phenomenon, described from different perspectives. Quantitatively, it would be more appropriate to define the actual potential output by considering both PFPO and MCPO estimations. Many possible measures may be used: the simple arithmetic mean, representation by a band with limits, or diverse weighted averaging algorithms. Further research should investigate this issue.

4. Concluding Remarks

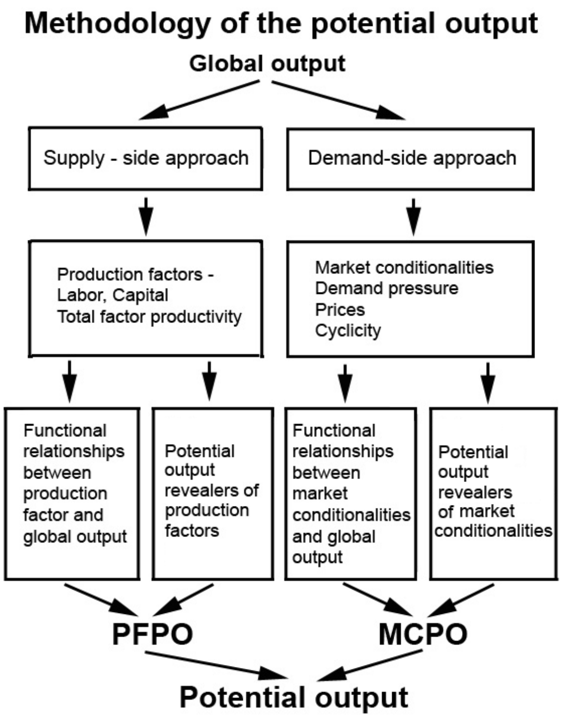
4.1. The measurement of potential output is dominated by two symmetrically positioned interpretations: one focusing on the supply-side determinants of the global output and the other on its market conditionalities. The core of the former is the macroeconomic production function, usually a Cobb-Douglas function (labor and capital, completed by TFP). The latter is centered on market conditionalities (demand pressure, prices, and cyclicity).

4.2. Both cases are addressed using analogous techniques. On the one hand, both imply some econometric estimators of the functional relationships between the global output and its various determinants (production factors and respective market conditionalities). These estimators are admitted to be concordant with the essential characteristics of the analyzed statistical series, and, hence, usable in post-sample extrapolations (especially on the short-medium term).

On the other hand, the twin approaches of potential output assume (at least implicitly) that for a given historical interval, the specified determinants are characterized by relatively stable levels, named in the present study as the potential output revealers. These are estimated for key factors as the labor participation rate, natural unemployment, alpha coefficient (labor share in gross value added) in the first output determination, and the main market conditionalities (domestic and export pressure, internal inflationary environment, the EU context, and cyclicity) in the second.

4.3. By solving the system of the functional relationships for the potential output revealers of the involved determinants, we obtain two estimates of the potential output: one corresponding to the supply-side approach (PFPO), and the other to the demand-side approach (MCPO), as shown in Scheme II.

Scheme II. Methodology for estimating the potential output



The production factor interpretation of the potential output is illustrated by the EU official indicators for member countries, while the results from the EUMOD21 developed in the present study correspond to the market conditionalities findings.

4.4. These two series of estimations reflect the same socio-economic framework and are not incompatible. Figure 9 and relative comments provide conclusive evidence in this regard. However, they remain different due to the inherent temporary misalignments between supply- and demand-side market impulses and possible measurement discordances. Regarding our application, in more than one-fifth of all calculated cases, the output gap shows opposing algebraical signs in compared estimates. The choice between PFPO and MCPO has, therefore, important consequences.

4.5. None of the estimations appear to be optimal, and they may be looked at as Marshallian scissors. The true potential output seems linked to both perspectives and should be approximated by taking both into account. Quantitatively, this may be obtained by adopting diverse averaging algorithms or some boundary bands; other solutions are also possible. Hence, the optimal measurement of potential output remains an open question.

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