PLOVDIV UNIVERSITY PAISII HILENDARSKI
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ABSTRACT FOR A DISSERTATION PAPER ON THE TOPIC:
FINANCIAL AND ECONOMIC EFFECTS OF STIMULATING CLIMATE NEUTRAL GROWTH

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I. General characteristics of the dissertation work

Structure of the dissertation

Chapter 1 - Introduction

Chapter 2 Theoretical basis of the study

Translogarithmic production function

Linear Programming and Simplex Method

Markov processes and chains

Fixed Income Credit Instruments

A model for assessing the effects of climate-neutral growth

Chapter 3 Assessing the effects of climate-neutral growth

Climate-neutral growth and added value

Influence of the released greenhouse gas emissions on the added value - by industry

Impact of financial incentives and the tax system on added value by industry

Optimal industry structure under conditions of climate-neutral growth

Modeling the behavior of residuals from inferred dependencies

Fixed income financial instruments supporting climate-neutral growth

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Chapter 1 Introduction

Issues concerning sustainable management using less, or at least through less wasting, of natural resources in the sectors of a given national economy are widely discussed problems that are touched upon daily, not only in scientific research, but also in non-specialized public discussions. Currently, there are ambitious political commitments made through the Green Deal project - the European Green Pact at the European Union level and the Global Sustainable Development Goals (SDGs) with a global scale. In the context of the political commitments made, there is an increased interest and intensity of multidisciplinary scientific research affecting sustainable development topics.

The 1972 Stockholm Agreement, the 1992 Rio Earth Summit, the 1997 Kyoto Protocol, the 2015 UN Sustainable Development Goals, the 2016 Paris Agreement, and the 2019 European Green Deal are just a few of the global signed documents that record the deficits and make political commitments to addressing environmental issues. This demonstrates a high level of public interest, which can be directly translated into market influence through consumer purchasing power or political influence through voting rights.

Economic and financial indicators in a given national economy are sensitive to both technological changes and regulatory requirements. The effects caused by these influences are considered economic and financial effects of exogenous changes to the national economy. This paper examines the quantitative sensitivity of economic and financial indicators to certain exogenous factors applied to a given national economy.

Object of the study

The object of the study is the overall national economy of Bulgaria, described by key quantitative and qualitative indicators presented as dynamic statistical series or statistical cross-sections. These are static and dynamic indicators that reflect the achieved levels and structure of the national economy at a given time, reflecting the influence of internal and external factors. The composite structure of the object of the study is divided into three main types - macroeconomic indicators, financial indicators and indicators of separate negative impact on the environment. The group of macroeconomic indicators is the measured results of added value produced in total for the national economy or in a selected sector of the economy. The group of financial indicators includes data in dynamic statistical series and statistical cross-sections of financial indicators for the private sector of the national economy and such from the public finance sector. The group of indicators of environmental effects contains data presented in dynamic statistical series and as statistical cross-sections, describing the produced quantities of negative impact on the environment by selected sectors and in total for the economy of Bulgaria. All individual observed quantities are considered both as individual variables describing quantitative characteristics of the individual indicator, and as an integrated system of indicators simultaneously describing the state of the object of study - the national economy of Bulgaria for the period under consideration.

Subject of the study

The subject of research interest includes the following several groups of dependencies:

1. Quantitative relationships between the total value added for the national economy and the added values in each of the selected industries.

2. Quantitative relationships between the added value for each of the selected industries and the negative environmental effects produced as a result of production in the given industry.

3. Quantitative relationships between the produced added value in given selected industries of the economy and a selected set of financial indicators, divided into a group of financial indicators affecting corporate and public financial indicators.

4. Mathematical dependencies and their application in solving a linear optimization problem when introducing regulatory restrictions on the produced negative environmental effect as a result of the production of added value in the aggregate economy.

5. Dependencies of financial mathematics in calibrating a financial instrument, after introducing regulatory restrictions on the produced negative environmental effect as a result of the production of added value in the aggregate economy

Main problem solved in the research

This study examines the possibility of short-term economic growth and, accordingly, positive financial effects in the transition to a climate-neutral economy. Defining a climate-neutral economy or the net zero economy is a multidisciplinary problem that has been presented in a large body of work. This study does not aim to derive or summarize the available statements for defining or regulating this concept, but a working definition was published in the work "The meaning of net zero and how to get it right" (FANKHAUSER, Sam, et al. The meaning of net zero and how to get it right. Nature Climate Change, 2022, 12.1: 15-21). In the process of pursuing and achieving the above-described goals, some restructuring of the economy is required, which also requires changes in the sphere of public and corporate finance, which must be addressed. Among these are:

- High investment costs for restructuring the economy, for the repayment of which it is necessary to provide financial resources.

- Loss of revenue resulting from the contraction of production in certain sectors, relying on carbon-intensive production. This is expressed in a contraction of production revenues, a decrease in the corresponding value added produced and a decrease in tax revenues from these productions.

- Increase in the unemployment rate resulting from the restructuring of certain sectors.

- Creation of a lack of financing in restructuring projects.

- Presence of increased transaction and administrative costs.

The main objective of this work is to derive quantitatively described changes in financial flows in the national economy after setting regulatory limits for greenhouse gas emissions when creating added value in the national economy in the short term.

Goals and objectives

To solve the main problem and objective of the study, the following tasks have been set:

1. Derivation of statistically significant relationships between the added value for the national economy and the added values in the selected industries.

2. Analysis of the relationships between the added value in the industries and the negative effects on the environment.

3. Establishment of quantitative relationships between the added value and various financial indicators, divided into business and public.

4. Derivation of a stationary distribution of stochastic elements from these relationships.

5. Determination of linearly achievable mathematical relationships and their application for optimization in view of regulatory restrictions.

6. Calculation of the quantitative effects of regulatory restrictions on negative environmental effects.

7. Calibration of financial instruments for resource redistribution after the introduction of restrictions.

8. Calibration of methods for mathematical modeling and automation (data mining) for deriving significant algebraic and geometric relationships.

9. Systematizing the conclusions obtained and explaining the probability of their predictive power, as well as developing a structure and methodology for applying the models in economic and financial policy.

Thesis and Hypotheses

The main thesis is that, given the direction of the national economy, a quantitative algorithm must be derived to assess the financial dimensions of the commitments made for emissions, in order to prepare an adequate financial and economic policy. The main hypotheses are the following:

1. Through the quantitative dependencies related to economic growth and added value, the effects of regulatory restrictions on negative impacts by sector can be measured.

2. There are statistically significant linear or nonlinear relationships between the added value for the national economy and the selected sectors.

3. There are linear relationships between the added value in a sector and the negative environmental effects of the production process.

4. There are linear relationships between the added value for a sector and financial indicators that are statistically significant.

5. Through econometric analysis and modeling, an integrated group of models can be found describing the relationships between economic, financial and environmental variables.

6. A stationary distribution of random fluctuations in the estimates can be established.

7. It is possible to solve an optimization problem useful for the formulation of economic policy.

8. Interventions on the boundaries of variables can lead to positive effects on economic growth and financial performance.

Limitations in the scope of the study

The study is limited to the available, registered historical data for the national economy of Bulgaria. In order to limit the scope of the study, it is limited to the inclusion of only a certain number of selected sectors of the national economy of Bulgaria, as well as a certain limited number of indicators of the environmental impact produced as a result of economic activity. The study is also applied to a limited chronological period for which there are sufficiently complete registered observations available for all of the variables studied.

Methodology. Approach, methods and means of the research

The general approach of the study is aimed at using quantitative analysis and mathematical modeling to apply theoretical functional models of economic growth and production functions in the economy through statistical hypothesis testing, regression analysis, Monte Carlo simulations, k-fold simulations and methods for dividing populations into test and predictive subsets. The input data are registered observations presented in time series and statistical cross-sections. The study covers a sufficiently long (longer than one business cycle) chronological range of the observed quantities in order to overcome the shift of the results due to seasonality or cyclicity of the data. The study also takes into account the variation of the calculated variables. The variation of the variables is assumed to be variables following random fluctuations of Markov chains. The stationary distributions of these processes are derived using the Monte Carlo simulation method. The practical part of the study is divided into several sub-stages.

Theoretical functional models for economic growth and production functions in the economy are selected and applied to observed data and the corresponding statistically significant coefficients for the participating variables are derived. The functions thus derived are also vertically detailed into the effects of economic growth through the system of national accounts and the dependencies between the elements of growth and the financial effects on specific sectors of the economy are studied. This is achieved by measuring quantitative effects on a set of certain financial indicators. A yield curve for risk-free instruments and a yield curve for a one-year Credit Default Swap instrument are calculated using financial mathematics methods. Based on the derived curves using financial mathematics methods and the application of derived theoretical approaches for assessing credit risk instruments, a Synthetic Collateralized Credit Default Swap instrument is calibrated and the required equilibrium yield for the three most important risk tranches is found. The study goes through the following stages:

- Study of dependencies between value added indicators.

- Study of dependencies between value added indicators and greenhouse gas emissions.

- Study of dependencies between value added indicators and financial indicators.

- Introduction of regulatory restrictions and solving a problem for mathematical optimization of the industry structure.

- Study of the behavior of the residual values from the studied dependencies.

- Calibration of a risk instrument for redistribution of financial resources between industries in the national economy.

II. Applicability of research findings

The welfare obtained from reduced negative impact on the environment should not lead to a decrease in economic growth, at least not in the long term, because this would cause a long-term decrease in welfare. Scientific discoveries stimulate developed societies to switch to national economies leaving a smaller footprint on the environment (at least within their geographical borders). On the other hand, societies must also ensure the efficiency of the transitional national economy, i.e. preservation or increase of their welfare. This study explores the possibilities of searching for new mechanisms on which to build economic and financial policy in order to ensure the necessary level of welfare under the existing imposed changes and restrictions on permissible environmental impact and reduced resource use.

It is recognized that it is not unusual for modern economies to make decisions dictated by public or political pressure. Restructuring of the economy should aim at preserving economic growth and stable financial and budgetary systems. The present work aims to give a quantitative form to the dependencies that, under specific conditions, would produce certain results as a result of the changes that have occurred in economic life.

III. Main content of the dissertation work

Chapter 2 Theoretical basis of the study

Translogarithmic production function

A sufficiently large number of developed production models are known. The main objectives of a production model are:

a) Divisibility means that the model can be applied to subsets of variables.

b) Aggregation requires that the results of macroeconomic data do not contradict the microeconomic ones.

c) Homotheticity means that the aggregated data represent a monotonically increasing transformation of a linearly homogeneous function connecting the micro- and macroeconomic data.

Translogarithmic production frontiers were first presented by Christensen, Jorgenson, and Lau in 1971 (Christensen, Laurits R., Dale W. Jorgenson, and Lawrence J. Lau. "Transcendental logarithmic production frontiers." The review of economics and statistics (1973): 28-45). Independently, Griliches and Ringstad in 1971 (DREW, M. W. Economies of scale and the form of the production function: Griliches, Z. and Ringstad, V. (1971). Amsterdam: North-Holland.) and Sargan in 1971 (Sargan J.D. “Production functions” Part V of Layard, R., Sargan, J., Ager, M., & Jones, D. (1971). Qualified manpower and economic performance: an inter-plant study in the electrical engineering industry. Allen Lane (Firm)) proposed a special case of a production frontier, called the translogarithmic production function, which has only one product of production.

Transcendent logarithmic limits

Christensen, Jorgensen, and Lau (1973) present a variant of the production possibilities frontier that is neither additivity nor homogeneity. They call it the transitional logarithmic production possibilities frontier, expressed as a logarithmic function of the quantities of input factors. In short, it is known as the "translogarithmic frontier".

Advantages and disadvantages of the translog function

Translogarithmic functions arose in the context of research on new flexible forms of production functions and approximations with constant elasticity. The first such function was proposed by J. Kmenta (Kmenta, Jan. “On estimation of the CES production function.” International Economic Review 8.2 (1967): 180-189) in 1967 to approximate a production function with constant elasticity of the second order. It has an elasticity of substitution close to unity, similar to the Cobb-Douglas production function – it has the form (1):

$$\ln g(X) = \alpha_0 + \sum \alpha_1 \ln X_i + \frac{1}{2}\sum_i \sum_j \beta_{ij} \ln X_i \ln X_j , \quad (1)$$

whereas $\alpha_0 = f(0), \alpha_i = f_i(0),$ и $\beta_{ij} = f_{ji}(0)$.

The main advantages of the translog production possibilities frontier are that it does not require assumptions of smooth factor substitution or perfect competition, and it allows for a nonlinear relationship between output and factors without limiting the degrees of freedom. In 1979, Ferguson (Ferguson C.E. (1979), The Neo-Classical Theory of Production and Distribution, Cambridge, New York, Melbourne, Cambridge University Press) demonstrated that marginal product is equal to the elasticity of scale.

A disadvantage of the translog production function is the complexity of the calculations due to the many parameters. In addition, there is a risk of multicollinearity between the independent variables, which leads to variation in the results. An alternative to Ridge regression is to limit the number of production factors. A practical approach is to calculate functions with a single factor and, if there is a significant dependence, to include them in more complex functions.

Characteristics of a translogarithmic production function with a single factor of production

A translogarithmic production function with a single factor has the form (2) - by Florin Pavalescu (Pavelescu, Florin-Marius. "Some aspects of the translog production function estimation." Romanian Journal of Economics 32.1 (2011): 41):

$$\ln Y = \ln A_2 + \alpha_{2X} \cdot \ln X + \left(\frac{1}{2}\right) \cdot \beta_{2X} \cdot \ln^2 X \quad (2),$$

whereas the calculated parameters could be presented as :

$$\ln A_2 = (\ln Y)_{\text{med}} - \alpha_k \cdot (\ln X)_{\text{med}} - \left(\frac{1}{2}\right) \cdot \beta_k \cdot (\ln^2 X)_{\text{med}}$$
$$\alpha_{2k} = \alpha_{1k} \cdot T_{\ln X}$$
$$\beta_{2X} = \beta_{1X} \cdot T_{\ln^2 X}$$

Whereas:

$(\text{InY})_{\text{med}}$ = Arithmetic average of the natural logarithms of the indices of the output.

$(\ln X)_{\text{med}}$ = Arithmetic average of the natural logarithms of the indices of the production factors.

$(\text{In}^2\text{X})_{\text{med}}$ = Arithmetic average of the squared natural logarithms of the indices of the production factors.

Simplex method

Basic elements. Target variables. Objective function

Variables are a set of quantities that must be determined to solve the optimization problem by finding the best quantities for each variable. The goal of linear programming is to find the minimum or maximum of a specified numerical value. The objective function shows how each variable contributes to the value to be optimized when solving the problem. It can have the following general form (3):

$$\textit{To minimize } Z = \sum_{i=1}^{n} c_i X_i \quad (3),$$

Whereas c_i *= coefficient of the objective function respective to the* i^{th} *variable and* $X_i = i^{th}$ *target variable.*

The coefficients of the objective function indicate the contribution to the total value of a unit quantity of the corresponding variable.

Restrictive Terms

The constraint conditions define the sets of admissible values that the variables can take and have the following general form (4):

$$\textit{when fulfilled } \sum_{i=1}^{n} a_{jj} X_i \leq b_j j = 1,2,\ldots,m, \qquad (4),$$

whereas $X_i = i^{th}$ *target variable,*
$a_{j,i}$ *= coefficient of* X_i *in the constant j, and*
b_j *= right side coefficient of the constant j.*

The constraints must be transformed into non-negative form before solving the corresponding linear programming optimization problem. A general form of the linear programming problem has the form (5):

$$\text{To Minimize } Z = \sum_{i=1}^{n} c_i X_i \qquad (5)$$

$$\textit{When fulfilled : } \sum_{i=1}^{n} a_{j,} X_i \leq b_j, j = 1,2,\ldots,m$$

$$\text{and } X_i \cdot 0 \text{ i} = 1,2,\ldots,n$$

whereas $X_i = i^{th}$ *target variable,*

Features of the Simplex method

The simplex algorithm is the most popular method for solving linear programming problems. By Lewis, Catherine. "Linear programming: theory and applications." Whitman College Mathematics Department (2008) – definition: given a system Ax=b and x≥0, where A is a mxn matrix, and b is a column vector with m elements. It is assumed that rank(A, b) = rank(A) = m. After rearranging the columns of A, let A = [B,N], where B is an mxn invertible matrix and N is an mx(n-m) matrix. The solution $x = \begin{bmatrix} \mathbf{x}_B \\ \mathbf{x}_N \end{bmatrix}$ of the equations Ax =b , where $\mathbf{x}_B = \mathbf{B}^{-1}\mathbf{b}$ and $\mathbf{x}_N = 0$, is called the base solution of the system. If $\mathbf{x}_B \geq 0$, then x is called a basic feasible solution of the system. Let **B** be called a basis matrix and N be called a non-basis matrix. The components of x_B are called the basis variables and the components of x_N are called the non-basis variables. If $\mathrm{x}_B > \mathbf{0}$, then x is a non-negative basis solution, and if even one component of x_B is zero, then x is a degenerate basis solution.

Rule selection

There are various rules for solving an optimization problem described in detail in the study. This makes most methods more interesting as a theoretical set than as practical tools.

Effectiveness of the Simplex Method

In practice, the simplex method gives very satisfactory results even for large linear problems. Empirical checks show that for linear programs in the form of equations with m equations, an optimal solution is usually reached after about 2m to 3m steps $(2^n - 1)!$. Klee and Minty (KLEE, Victor; MINTY, George J. How good is the simplex algorithm. Inequalities, 1972, 3.3: 159-175) developed a linear program with n non-negative variables and n inequalities, for which the Simplex method with the rule for a Danzig rotation needs exponentially many rotation steps.

Markov processes and chains

Stochastic matrix - definition

A stochastic matrix is a square matrix that satisfies (6):

$$P_{ij} \geq 0 \; for \; all \; i, j \quad (6)$$

For every row i is valid $\sum_j P_{ij} = 1$.

For a random walk on a weighted graph, the transition probabilities are proportional to the sum of the weights. If vertices i and j are adjacent and w(i,j) denotes the weight of the edge connecting i and j. Let $\sum_{i \sim k} w(i,k))$ be the sum of weights of all edges connecting i with its neighboring vertices. The transition matrix is given by (7):

$$P_{ij} = \begin{cases} \frac{w(i,j)}{w(i)}, if \; i \sim j \\ 0, \; in \; all \; of \; the \; other \; cases. \end{cases} \quad (7).$$

A directed weighted graph is a graph in which the edges have a certain direction. For each pair of vertices i and j, one vertex can have an edge from i to j and one edge from j to i. In a weighted directed graph, there exists a weight function w(i,j) that gives the weights for the directed edge from i to j. Each branded chain can be described as a random walk on a weighted directed graph whose vertex set is in the state space of the chain.

This graph is called the transition graph of the brand chain (8):

$$P_{ij} = \frac{w(i,j)}{\sum_{i \sim k} w(i,j)} = \frac{w(i,j)}{w(i)} \; for \; all \; i \; and \; j \quad (8).$$

It is noted that the elements of the matrix are non-negative and the sum of each of its rows is 1 - (9):

$$\sum_j P_{ij} = \sum_j \frac{w(i,j)}{w(i)} = \frac{1}{w(i)} \sum_{j \sim i} w(i,j) = \frac{w(i)}{w(i)} = 1 \quad (9).$$

Simulations

Simulation is a powerful tool for studying branded circuits because in practice circuits arise whose state sets are large and for which matrix algebra methods are not practical or even possible to apply. A Markov circuit can be simulated from the initial distribution and from a transition matrix. To simulate a branded order $X_0, X_1, \ldots$, one starts by simulating random variables sequentially dependent on the value of the previous variable.

This means that X_0 is first simulated against the initial distribution. If $X_0 = i$ then X_0 from the i-th row of the transition matrix is simulated. If X_0 =j, then X_2 is simulated from the j-th row of the transition matrix and so on. To simulate a finite Markov chain in R, the function *Markov(init, mat. N)* is applied. Executing the function generates a vector with (n+1) elements (X_0,… X_n).

Limiting distribution

In many cases, brand chains reach a limiting distribution over a long period. The chain settles into an equilibrium distribution that is independent of its initial distribution. If X_0, X_1,... is a branded chain with a transition matrix P, the limiting distribution for the chain is a probability distribution λ , which for each i and j has the property (10):

$$\lim_{n\to\infty} P_{ij}^{n} = \lambda_j \quad (10)$$

This is equivalent to the definitions:

- For any initial distribution and for any i and j – (11):
$$\lim_{n\to\infty} P(X_n = j) = \lambda_j \quad (11)$$
- For any initial distribution α - (12)
$$\lim_{n\to\infty} \alpha P^n = \lambda \quad (12)$$
- In the cases, where **Λ** is stochastic matrix, with all rows are equal to λ this is written asn (13):
$$\lim_{n\to\infty} P^n = \mathbf{\Lambda} \quad (13).$$

The interpretation of λ_j, is that it is the long-run probability that the circuit will enter state j. From the uniqueness of the boundaries, if a brand chain has a boundary distribution, then this distribution is unique. The limiting distribution gives the long-run probabilities of reaching each of the states of a given Markov chain. It can also be interpreted as the long-term proportion of time that a circuit spends in each of the states. If $X_0, X_1, \ldots$ is a Markov chain with a transition matrix P and a boundary distribution λ , indicative random variables are determined for each state j - (14):

$$I_k = \begin{cases} 1, & \text{if } X_k = j, \\ 0, & \text{in all other cases}, \end{cases} \quad (14).$$

If $\sum_{k=0}^{n-1} I_k$is the number of times the circuit visits state j in the first n steps when $X_0$is the first step.

Stationary distribution

If the limiting distribution of a given chain is denoted as its initial distribution. If the limiting distribution is expressed by (15):

$$\lambda = \left(\frac{q}{p+q}, \frac{p}{p+q}\right) \quad (15)$$

and if λ is the initial distribution, then the distribution X_1 is (16):

$$\begin{aligned} \lambda P &= \left(\frac{q}{p+q}, \frac{p}{p+q}\right)\begin{pmatrix} 1-p & p \\ q & 1-q \end{pmatrix} \\ &= \left(\frac{q(1-p)+pq}{p+q}, \frac{qp+p(1-q)}{p+q}\right) = \left(\frac{q}{p+q}, \frac{p}{p+q}\right) = \lambda. \end{aligned} \quad (16).$$

This implies that λP= λ. Probability vector π that satisfies the equation πP=π , then π is a stationary distribution of the Markov chain – (17):

$$\pi_j = \sum_i \pi_i P_{ij}, \text{ for any } j \quad (17).$$

The term stationarity means that if a chain starts out in its stationary distribution, then it stays in that distribution.

Regular matrices

A matrix M is called positive if all elements of M are positive and denoted by M>0. Analogously x>0 for a vector x whose elements are all positive. A transition matrix P is regular if a certain degree of P is positive. This is denoted $p_n \geq 0,\ n \geq 1$. If the transition matrix of a Markov chain is regular, then the chain has a boundary distribution, which is the only stationary distribution of the chain – (18) :

$$\lim_{n\to\infty} P_{ij}^n = \pi_j, \quad \text{for any } i, j, \text{ whereas } \sum_i \pi_i P_{ij} = \pi_j \quad (18)$$

Equivalently, there exists a positive stochastic matrix Π such that (19) is satisfied:

$$\lim_{n\to\infty} P^n = \mathbf{\Pi} \quad (19),$$

where Π has equal orders of the general order **n** and **n** is the only probability vector that satisfies (20):

$$\pi P = \pi \ (20).$$

If it is assumed that π is a stationary distribution for a Markov chain with transition matrix P, then (21) holds:

$$\sum_i \pi_i P_{ij} = \pi_j, \text{ for any state } j \quad (21),$$

which gives a system of linear equations. If P is a kxk matrix, the system has k equations and k number of unknowns. Since the rows of P have a sum of 1, the kxk system will contain one more equation than necessary. For the general case of a two-state circuit, this is expressed in (22):

$$P = \begin{pmatrix} 1-p & p \\ q & 1-q \end{pmatrix} \quad (22)$$

The equations are:

$$\begin{array}{l} (1-p)\pi_1 + q\pi_2 = \pi_1 \\ p\pi_1 + (1-q)\pi_2 = \pi_2. \end{array} \quad (23)$$

They are redundant and lead to π_1 p=π_2 q. If neither p nor q are zero, then together with the condition π_1+π_2=1 , the only solution is (24):

$$\pi = \left(\frac{q}{p+q}, \frac{p}{p+q}\right) \quad (24).$$

Ergodic Markov chains

A Markov chain is called ergodic if it is infinite, aperiodic, and all values have finite expected return periods (this condition is always true for finite chains).This study deals with the construction of regular transition matrices on which the limiting stationary distribution is found, which can be an ergodic or absorbing chain.

Fixed income credit instruments

Credit risk - basic definitions

Credit risk is due to the possibility of insolvency of debtors or their counterparties in derivative transactions.

Default rates - intensity of default

There is a conditional and unconditional probability of default. The unconditional probability is a citation of historically obtained data and calculating the percentage probability from them. The conditional probability of default in a given period is the one that takes into account the probability of no such event in previous periods.

Recovery rate

When a company goes default, its debtors file claims against the company's assets. Sometimes a reorganization takes place, whereby creditors agree to partial payments of their claims. In other cases, the assets are sold off by a liquidator and the proceeds are used to pay creditors to the extent of the claims. Certain claims have priority over others and are accordingly paid out at a higher rate than non-priority ones. A bond's recovery rate is usually defined as the market value of the bond several days after default, calculated as a percentage of its face value.

Dependence of recovery rates on default rates

Average corporate bond recovery rates have historically shown a negative relationship with the size of defaults. It can be concluded that a bad year for bonds brings even more negativity for lenders, because of the deteriorating rates of return.

Calculating the probability of default from a corporate bond yield curve

One approach to calculating the probability of default is to look at bond yield curves. A bond's yield spread is the excess of the bond's yield above the risk-free yield. If the average default rate is assumed to be λ(T), then another way to express the average loss rate would be λ ̅(T)(1-R), where R is the estimated recovery rate. This means that it is approximately true that:

$$\bar{\lambda}(T)(1-R) = s(T) \quad (25)$$

$$\bar{\lambda}(T) = \frac{s(T)}{1-r} \quad (26),$$

as this equation works well in a wide range of situations. The standard risk-free rate used for corporate bonds is the Treasury bill yield, but in practice the Treasury bill yield is too low. In other situations, the base yield on which the risk-free rate is determined is Libor.

Credit risk in derivative transactions

Bilateral derivative contracts are governed by the main agreement of the International Swaps and Derivatives Association. Under its terms, netting is performed. This means that all current transactions between two specific companies are considered a single transaction for the purposes of:

- Calculating the amount of claims in the event of default.
- Calculating the collateral that must be provided.
- In the event of such a circumstance, there are two possibilities in which the counterparty will record losses:
- The total amount of transactions of the counterparty that has not defaulted is positive and greater than the collateral that has been provided by the counterparty that has defaulted.
- The total amount of transactions is positive for the counterparty that has defaulted and the collateral provided by the other party is greater than this positive amount.
- To the above two cases, the margin between buy and sell offers is added when replacing transactions with the company in difficulty by its counterparties.

Credit default swaps

The buyer of a CDS makes periodic payments to the seller until the end of the life of the instrument, or until a credit event occurs. In the event of a credit event, the settlement of the payment requires either physical delivery of the bonds or a cash payment. The most typical types of contracts are 5-year contracts, but 1, 2, 3, 7-year contracts also exist. A key aspect of the contracts is the definition of a credit event. This is usually defined as the inability to make a payment when it becomes due, debt restructuring, or bankruptcy.

Credit Default Swaps (CDS) and bond yields

CDS can be used to hedge a position in corporate bonds, with the yield margin over the risk-free rate being equal to the CDS yield. If the bond yield is higher, the investor can buy both, and if it is lower, borrow at a lower rate. The CDS-bond basis is defined as the difference between the CDS and bond yields, expecting the arbitrage basis to be close to 0, but in reality it varies.

Credit Indexes. Basket of Credit Default Swap. Synthetic Debt-Backed Obligations (SDOs)

Collateralized debt instruments are linked to assets, while synthetic CDSs use a portfolio of companies and CDS protection corresponding to the maturity of the structure. The principal of the synthetic CDS is the sum of the CDS principals. The originator receives cash flows from the CDS yield and pays when companies fail. Tranches are created with the cash flows distributed between them.

- Capital Tranche – responsible for paying out claims on CDSs until they reach 5% of the principal of the synthetic CDS.
- Mid Tranche – responsible for paying out claims from 5% to 20% of the principal.
- Maturity Tranche – responsible for paying out claims above 20% of the principal.

Role of correlation in a basket of CDS and SDO

The cost of protecting a defaulted CDS or a given tranche in SDO depends critically on the default correlation. The valuation of a given tranche of synthetic SDO also depends on the default correlation between individual companies. If the correlation is low, the more immature tranches are riskier, while the more mature tranches are safer. At the limits where the correlation is full and the recovery rate is 0, the tranches become equally risky.

Assessment of synthetic SDO

Synthetic SDO can be estimated according to the following algorithm. If it is assumed that the payment dates of the premiums due under a given synthetic SDO are at times $\tau_1, \tau_2, \ldots, \tau_m$ and $\tau_0 = 0$ and if $E_j$is defined as the expected principal for a given tranche at time τ_j and v(τ) is the current value per 1 unit of currency received at time τ, also, assuming that the premium margin on a given tranche is s basis points per year, with this margin paid only on the remaining principal, the present value for the regular annual payments of the SDO are then sA, where (27) is derived:

$$A = \sum_{j=1}^{m}(\tau_j - \tau_{j-1})E_j v(\tau_j) \quad (27)$$

The expected loss in the period between times τ_{j-1} and τ_je $E_{j-1} - E_j$ is calculated as follows. Assuming that the loss occurs at the midpoint of each time interval ie$0.5\tau_{j-1} + 0.5\tau_j$, then the present value of the expected benefit payments under the specific tranche of the SDO are (28):

$$C = \sum_{j=1}^{m}(E_{j-1} - E_j)v(0.5\tau_{j-1} + 0.5\tau_j) \quad (28).$$

The premium accrual for the first half of the period is calculated by sB, where:

$$B = \sum_{j=1}^{m} 0.5(\tau_j - \tau_{j-1})(E_{j-1} - E_j)v(0.5\tau_{j-1} + 0.5\tau_j) \quad (29).$$

The value of the tranche to the buyer of the protection is C-sA-sB and then the percentage premium for the protection is obtained when the present value of the payments made is equal to the present value of the payments received or (30):

$$C = sA + sB \quad (30).$$

The equilibrium premium rate is then (31):

$$s = \frac{C}{A+B} \quad (31).$$

If the exact principal amount of a given tranche on all payment dates is known and if the zero-coupon yield curve is known, then the equilibrium premium rate can be calculated from equation (31).

A model for assessing the effects of climate-neutral growth

Description of the data

The output data are statistically recorded levels of three groups of variables: macroeconomic indicators, environmental impacts of economic activity and financial effects. The data cover sectors such as "Electricity and Heating", "Forestry", "Manufacturing and Construction", "Transport" and "Waste Management".

Environmental data

The Environmental Impact Indicators group includes data from the World Resources Institute's CAIT, which combines various sources. The analysis uses static historical emissions figures from 1990 to 2018, measured in million tons of CO_2, CH_4 and N_2O. The study assumes constant technology and economies of scale.

Data on the produced added value by industry

The data on the value added produced are from the Eurostat database and present gross values for one calendar year. GVA is defined as the value of the production of final goods less intermediate consumption. The calculations cover the period from 1995 to 2020 and use chain-linked volumes and different growth rates.

Financial data

The financial indicators are from Eurostat, covering the period from 1995 to 2020. The main measures include compensation of employees, fixed capital expenditure, hours worked, operating surplus and taxes less subsidies. The calculations are made in monetary terms. The data on output are presented in millions of euros, and wages and salaries include miscellaneous payments.

Summary

The first part of the presentation describes the types, measures and content of the collected initial data, divided into three main groups: value added data, environmental pollution data and financial measures. The data are provided for five selected sectors and include a summary measure for the entire national economy. The sources and methodologies of collection are also indicated.

Chapter 3 Assessing the effects of climate-neutral growth

Main characteristics of the investigated indicators

Distribution, variation, collinearity. Describing the meaning of the data and looking at the data by industry.

Added value

The datasets are classified by the European Commission into the sectors Electricity and heating, Forestry, Manufacturing and construction, Transport and Waste management. These sectors do not cover the entire national economy of Bulgaria and can be expanded. The main statistics on value added by sector are presented.

Indicators for released greenhouse gases by sector

In the study, greenhouse gas emissions are considered as input elements in the production process, necessary resources for the production of added value. The concept is based on the macroeconomic theory of production factors and their dependencies. The relationship between emissions and production is analyzed.

A. Establishing the productivity of these production factors, i.e. establishing the amount of emissions that produce 1 euro of added value in the relevant sector.

B. Deriving a consistent mathematical functional form describing the dependence between the production factors "greenhouse gas emissions" and the produced added value, i.e. establishing the form of the production function valid for the periods considered for the given sectors.

Financial indicators

The aim of the study is to establish a statistically significant relationship between value added by sector and financial indicators, as well as an indirect relationship with greenhouse gas emissions. New variables are introduced to analyze these dependencies.

Social security contributions – the difference between the indicator "Personnel compensation" and "Wages" – expresses the amounts paid into the social security system (state and private) by the sector for a given year.

Corporate tax – 10% of the indicator "positive result" – expresses the amount of tax due on the income of legal entities for a given year in a separate sector.

Income tax – 10% of the indicator "Wages" – expresses the amount of tax on the income of individuals.

The remaining financial indicators used to calculate the functional dependencies are directly taken from the sources with observed data without transformations: **Thousands of people employed in the sector, Consumption of own capital, Wages.**

Summary

After entering the data, their statistical properties, including autocorrelation and stationarity, are examined, which is a preparatory stage for testing the research hypotheses. Non-uniform behavior of the value added and financial indicators is observed, as well as the presence of serial multicollinearity.

Climate-neutral growth and added value

In this part, hypotheses 2 and 5, and partially hypothesis 1, are tested to achieve the main objectives. The analysis shows linear relationships between value added indicators, assesses multicollinearity and the significance of the coefficients. The need for Ridge regression is established. After calibration, the values of the mean square error are calculated, showing that the model without a constant and with a lag variable has statistically significant estimates.

Table. 1 Root Mean Square Error term – in regressions of value added

Model	const no lag	no const no lag	no const lag	const lag
RMSE	8.72E-13	148.9036	70.17137	5.31E-13

Linear relationships can be used for short-term forecasts. With changes in the independent variables, a consistent forecast for total value added can be expected. A significant correlation relationship has been found between most of the independent variables, with an emphasis on multicollinearity.

Ridge regression model

To deal with multicollinearity, a Ridge regression model was applied, using sectoral value-added data as independent variables and total value added for the national economy as dependent. The observations were divided into a training (85%) and a test (15%) set. The regression was calibrated on the training set, and the results were validated by prediction. Fig. 1 shows the calculated versus observed values for the entire set.

Observations on the resulting graphs can conclude that both in the test and in the full set, the calibrated function has good predictive power.

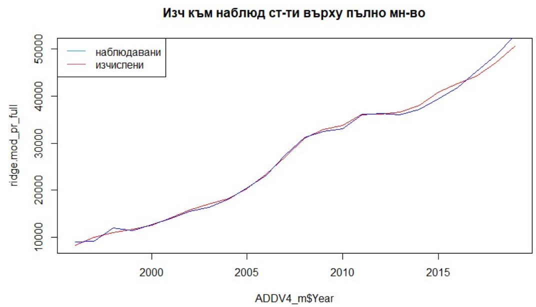

Fig. 1 Ridge regression – calculated to observed values – full set

Table 2 shows the coefficients of the dependent variables at the set lambda = 1,302.942.

Table 2 inferred coefficients of variables in Ridge regression

	electricity	forestry	man_constr	transport	waste	lagadd	Ridge_const
s0	2.114295	32.215	1.012724	3.480782	24.5313	0.196571	926.5197

Using logarithmic values of the variables, Ridge regression was applied again, following the same logic to determine the best lambda and calibrate the function. The data were transformed into natural logarithms. Fig. 2 shows the calculations against the observed values over the entire set.

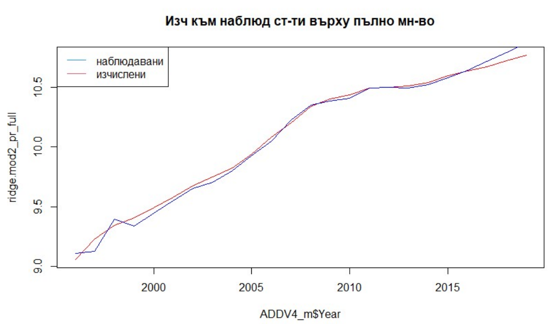

Fig. 2 Ridge regression - calculated to observed values - full set - logarithmic values

Influence of the released greenhouse gas emissions on the added value - by industry

The study models relationships between value added and greenhouse gas emissions by industry, with and without a constant, both for observed values and their logarithms. The results show that models with logarithmic values and without a constant give better results for R and R^2. The study focuses on short-term forecasts (up to one year), assuming that changes in industry variables will be mostly exogenous.

This part of the study contributes to the implementation of objectives 2, 8 and 9 and the testing of hypotheses 3, 5 and partially 1. The process begins with a simplified model to which independent variables are added, analyzing only linear dependencies due to the lack of sufficient data to test nonlinear relationships.

Impact of financial incentives and the tax system on added value by industry

At the beginning of chapter three, the variables describing the financial situation of five economic sectors and their main statistical characteristics are presented. Derived variables for corporate and personal income tax with a flat rate of 10% are added, which can be recalculated at different rates. The linear relationships between value added and financial indicators are calculated using the least squares method, with financial effects considered as a result of value added. The functional form is a linear relationship without a constant, showing good R^2 values with minor exceptions. 30 models with 6 financial indicators are developed, used in the subsequent stages of the study. This part supports objectives 3, 8 and 9, as well as hypotheses 4, 5 and partially 1.

Summary

The study proves the existence of motives for Ridge regression, built by determining the most appropriate value of the Ridge coefficient lambda. The models of linear dependencies between logarithmic values show better results than the observed values. For financial indicators, linear dependencies between financial indicators and added value have been derived for five examples. This part of the study supports the implementation of the main objectives 1,2,3,8 and 9 and the verification of hypotheses 2,3,4,5 and partially 1.

Optimal industry structure under conditions of climate-neutral growth

In this part, an empirical study is conducted of the possibility of observing the results on the value added produced in the economy and the financial variables derived in the previous empirical part, after the introduction of regulatory limits on the amount of greenhouse gas emissions in the national economy for the current period.

Regulatory limits for greenhouse gases emissions are adopted: the total amount must decrease by 10% to 15%. No sector can increase its emissions by more than 20% or reduce them by more than 20%. The forestry sector has a special status, as the consumption of emissions there must increase by 15% to 30%. The percentage limits are examples of the calculation method and can be changed without affecting the methods. These criteria are exogenous and entirely normatively set, with the aim of a balanced reduction in emissions. To achieve the goals of the optimization problem, mathematical transformations are performed. Ridge regression from logarithmic values has the functional form (32):

$$lnY_i = \beta_{i0} + \beta_{i1} lnx_{i1} + \beta_{i2} lnx_{i2} + \beta_{i3} lnx_{i3} + \beta_{i4} lnx_{i4} + \beta_{i5} x_{i4} + \gamma_i lnY_{i-1} + \varepsilon_i \quad (32).$$

From the parameters (ignoring the residual values), the lag variable and the constant are transferred from the right-hand side of the inequality, so that only the value-added variables in each industry remain on the left-hand side of the functional form (33):

$$F() = lnY_i - \beta_{i0} - \gamma_i lnY_{i-1} = \beta_{i1} lnx_{i1} + \beta_{i2} lnx_{i2} + \beta_{i3} lnx_{i3} + \beta_{i4} lnx_{i4} + \beta_{i5} x_{i4} \quad (33).$$

The derived functional forms of the dependencies between the added value for each of the five industries and the corresponding variable for separated greenhouse gas emissions in part have the form (34):

$$lnY_{jm} = \beta_{jm} lnx_{jm} + \varepsilon_{jm}\ , m\ \in |1,5| \qquad (34).$$

The equations are divided by the coefficients of the variables by the logarithmic values of the evolved gases (ignoring the residual values). Thus, an equation for greenhouse gas emissions is derived as a function of the amounts of added value (35):

$$lnY_{jm} * \frac{1}{\beta_{jm}} = lnx_{jm}\ , m\ \in |1,5| \qquad (35)$$

From (35), the sum of the logarithmic values of the released greenhouse gas emissions, total for the five sectors can be written as (36):

$$\sum_1^m lnx_{jm} = \sum_1^m lnY_{jm} * \frac{1}{\beta_{jm}}\ , m\ \in |1,5|. \quad (36)$$

The coefficient of the greenhouse gas function in the forestry sector is negative, since in the production of added value this sector consumes, rather than emits, emissions.

From (32) and from (33) the value of F() in (37) is calculated:

$$F() = lnY_i - \beta_{i0} - \gamma_i lnY_{i-1} = 4.811599143 \qquad (37)$$

The emission values are applied in (35) and from there the logarithmic values of the added values for each of the five monitored sectors for 2018 are derived. The total sum of the logarithmic values of greenhouse gas emissions for 2018 is 4.8478498, the calculated, according to the regulatory conditions 90% and 85% are 4.363065 and 4.120672, respectively. Applying (35) are calculated the coefficients $\frac{1}{\beta_{jm}}$.

From the data with the calculations applied to them, the limiting conditions for solving the linear programming problem can be derived. The limiting conditions are derived in (38). It solves an optimization problem that aims to maintain in the next period, after the introduction of the regulatory restrictions, the total added value produced in the national economy equal to the value in the year before the introduction of the restrictions – 2018. The solutions obtained by Simplex – Solver are shown in Table 3.

Table 3 calculated values of an optimization task by the Simplex method

Values of the logarithmic values of the parameters from Ridge regression - solutions of the optimization problem							
Constant	Electricity & heating	Forestry	Man. & Construction	Transport	Waste Mng	Lagged Value Added	Added Value for the economy
3.52	5.91	6.96	8.20	10.17	2.70	2.38	10.71

The solutions for added values by sector and the observed values for added value by the same sectors for 2018 are derived, as well as the percentage differences of the change in accordance with the derived conditions for limited growth and decrease in the individual sectors. The values of greenhouse gas emissions by sector are calculated corresponding to the values of added value calculated from the linear optimization in the respective sector.

P:

$$
\begin{aligned}
&LnY_{el} \leq 7.639\\
&LnY_{for} \leq 6.9634\\
&LnY_{man} \leq 8.195\\
&LnY_{tr} \leq 10.167\\
&LnY_{was} \leq 3.8145\\
&0.5048LnY_{el} - 0.6573LnY_{for} + 0.2294LnY_{man} + 0.2650LnY_{tr} + 0.4314LnY_{was} \leq 4.3631\\
&0.5048LnY_{el} - 0.6573LnY_{for} + 0.2294LnY_{man} + 0.2650LnY_{tr} + 0.4314LnY_{was} \geq 4.1207\\
&LnY_{el} \geq 7.639\\
&LnY_{for} \geq 6.9634\\
&LnY_{man} \geq 8.195\\
&LnY_{tr} \geq 10.167\\
&LnY_{was} \geq 3.8145
\end{aligned}
\qquad (38)
$$

, whereas

$\boldsymbol{LnY_{el}}$ *is the annual added value in sector 'electricity and heating",*

$\boldsymbol{LnY_{for}}$ *is the annual added value in sector 'forestry",*

$\boldsymbol{LnY_{man}}$ *is the annual added value in sector 'manufacturing and construction',*

$\boldsymbol{LnY_{tr}}$ *is the annual added value in sector 'transport',*

$\boldsymbol{LnY_{was}}$ *is the annual added value in sector 'waste management'.*

The general form of the derived linear dependences between each of the introduced financial variables and the corresponding value of added value for the given sector of the economy can be denoted as (39):

$$F_{im}^{n} = \beta_{im} + \varepsilon_{im}, m \in |1,5|, n \in |1,6| \quad (39).$$

From (39) the calculated values for each financial indicator, for each individual sector for 2018 are derived.

From the obtained values for added value for each sector as a solution of linear optimization with the coefficients of the linear dependence between the added value by sector and the derived financial variables, applying (39) the financial indicators by sector corresponding to the solution of the linear optimization problem are obtained.

The difference is derived, i.e. the net result on the financial variables from the application of linear optimization after the introduction of regulatory restrictions on the total amount of greenhouse gas emissions. These results are presented in Table 4.

Table 4 net change in financial indicators after solving an optimization task

difference	Corp Income tax	Pvt Income tax	Social payments	Employed people	Wages	Operatrional Surplus
Electricity & heating	-66.53	-37.72	-101.41	-20.66	-377.22	-665.27
Forestry	351.65	80.87	-446.80	215.69	808.68	239.22
Man. & Construction	-109.75	-244.53	-411.34	-266.00	-2445.32	-1097.53
Transport	782.98	874.77	1813.96	2349.40	8747.74	7829.84
Waste Mng	-11.81	-21.67	-38.12	-37.25	-216.69	-118.44
Sum	946.54	651.72	816.29	2241.18	6517.18	6187.82

The overall net results show that the change for each indicator in total for the five sectors is positive. The percentage change of financial indicators by sector after solving the optimization task compared to the observed values in 2018 are shown in table 5.

Table 5 net change in financial indicators after solving an optimization task - percentage parts

% Difference	Corp Income tax	Pvt Income tax	Social payments	Employed people	Wages	Operatrional Surplus
Electricity & heating	-84.91	-79.80	-78.98	-66.65	-79.80	-84.91
Forestry	560.57	351.45	454.53	536.80	351.45	191.53
Man. & Construction	-57.98	-68.07	-65.28	-43.02	-68.07	-57.98
Transport	1248.18	691.08	813.07	1119.40	691.08	1248.18
Waste Mng	-94.57	-94.17	-93.43	-92.71	-94.17	-94.82

Applicability of the obtained results

Through calculations are obtained the values of greenhouse gas emissions by industry, related to the regulatory conditions for production. On their basis, new indicators of added value have been calculated in order to maintain economic growth. The differences in financial indicators before and after the restrictions are derived, serving as a basis for short-term strategies for financial restructuring. Changes in the "Wages" indicator reflect expected financial flows, while changes in "Operating surplus" indicate free financial resources for investment, confirming the main hypotheses of the study 7 and 8 and the achievement of goals 5, 6, 8 and 9.

Modeling the behavior of residuals from inferred dependencies

Analysis of the obtained residual values from the derived dependencies.

One of the objectives of this study is to find the estimated expected value for the variable of logarithmic values of the total value added in the economy, in order to make a short-term forecast (one period into the future) for the expected financial effects and economic growth to be assumed when solving the optimization problem, under identical set regulatory constraints for the amount of greenhouse gas emissions. The distributions of the residual values from all derived dependencies are examined. The results are summarized in the following presentation.

General Value Added Model - Ridge Regression

The main statistical characteristics were calculated from the derived Ridge regression. The distribution has an expected value (mean) μ= 0.003779 and a standard deviation σ= 0.04109594. The values of the variable range from -1.69760 to 0.98824.

Variables representing environmental impacts

The following presentation shows the final results of the research on the distribution of residual values, from all dependencies derived in the study. From the calculations made for all five variables to simultaneously have significance in the interval 0.5<x ≤3 i.e. x∈(-0.5 ,3] is the set (40)

$$p_{eco} = p_{eq1.20}p_{eq1.21}p_{eq1.22}p_{eq1.23}p_{eq1.24} = 0.56188 \quad (40)$$

Impact of financial incentives and tax system. Dependencies in financial indicators.

Dependencies for the indicator Corporate Taxes (PRTX)

The probability for all five variables to simultaneously have significance in the interval -8<x ≤8 i.e. x∈(-8 ,8] is the set (41):

$$p_{prtx} = p_{eq2.0}p_{eq2.10}p_{eq2.5}p_{eq2.15}p_{eq2.20} = 0.041505 \quad (41).$$

Dependencies for the indicator Personal Income Tax - for all considered industries (INTX)

The probability for all five variables to simultaneously have significance in the interval -12<x ≤12 i.e. x∈(-12 ,12] is the set (42):

$$p_{intx} = p_{eq2.1}p_{eq2.11}p_{eq2.6}p_{eq2.16}p_{eq\ \ .21} = 0.33334 \quad (42).$$

Dependencies for the indicator Social Insurance Contributions to the Budget - for all industries considered (SOCIAL)

The probability for all five variables to simultaneously have significance in the interval -30<x ≤30 i.e. x∈(-30 ,30] is the set (43):

$$p_{social} = p_{eq\ \ .2}p_{eq\ \ .12}p_{eq2.7}p_{eq\ \ .17}p_{eq2.22} = 0.07795624 \quad (43).$$

Dependencies for the indicator Number of employed - for all industries considered (KPPL)

The probability for all five variables to simultaneously have significance in the interval -60<x ≤60 i.e. x∈(-60 ,60] is the set (44):

$$p_{kppl} = p_{eq2.3}p_{eq\ \ .13}p_{eq\ \ .8}p_{eq\ \ .18}p_{eq2.23} = 0.135103779 \quad (44).$$

Dependencies for the Paid Working Wages indicator - for each considered industry (WAGE)

The probability for all five variables to simultaneously have significance in the interval -40<x ≤40 i.e. x∈(-40 ,40] is the set (45):

$$p_{wage} = p_{eq2.4.1}p_{eq2.14.1}p_{eq\ \ .9.1}p_{eq\ \ .19.1}p_{eq2.24.1} = 0.024452026 \quad (45).$$

Dependencies for the indicator Operating Surplus - for each industry considered (SURPL)

The probability for all five variables to simultaneously have significance in the interval -50<x ≤50 i.e. x∈(-50 ,50] is the set (46):

$$p_{surpl} = p_{eq2.4.2}p_{eq2.14.2}p_{eq\ \ .9.2}p_{eq\ \ .19.2}p_{eq\ \ .24.2} = 0.004412381 \quad (46).$$

Results of a residual value study

The residuals and population distribution are analyzed for the derived dependencies. An intermediate hypothesis for a normal distribution of the series of variables is assumed, which is tested using methods such as those of Dornik-Hansen, Shapiro-Wick, Liliefors and Jacques-Bera. The results of the tests decide the acceptance or rejection of the hypothesis. If the hypothesis for a normal distribution is rejected, the autocorrelation functions are calculated. These series are considered to be randomly distributed, depending on the previous period. Intervals are created to facilitate the derivation of matrices from the residual values and transition matrices according to the requirements of Markov Chains. Through simulations of 1000 repetitions, the stationary distribution for the considered series is derived. This process introduces the probability of fluctuations in the obtained results, which can be used in predicting expected values of the studied variables. The results complement the achievement of the objectives of the study and support the main hypotheses 5 and 6.

Fixed income financial instruments supporting climate-neutral growth

The present part of the study deals with the changes that occur in the indicator "operating surplus" after solving the optimization problem. The subsequent analysis can also be done for other financial indicators, including a combination of indicators expressing the economic activity of the participants in the production process. In total, for the five industries, an increase in the net amount of "operating surplus" of 6,187.82 million euros is observed compared to the situation before the introduction of the regulatory restrictions. It is assumed that it is possible to carry out a secondary distribution of the financial result obtained as a result of the economic activity of the industries, on the credit market, so as to replenish the reduced resource as a result of the regulatory restrictions. At the same time, it is assumed that the risk of lending this resource can be relatively easily hedged. It is assumed that the required financial resource is the reduction obtained in the indicator "operating surplus" as a result of the introduced regulatory restrictions. In total, for the industries considered, the magnitude of the decrease is 1,881.24 million euros.

Risk assessment

In order to simplify the presentation of the calculation method, it is assumed that all companies constituting each of the sectors are rated with credit ratings equivalent to AAA by Standard & Poor's. The trading price of the XTXE index as of 28.12.2018. (due to the lack of quotation on 31.12.2018) is 117.82 basis points.

Yield curve. Discount Curve - function in R

The discount curve constructs a spot structure of interest rates and is based on market data that contains settlement dates, deposit rates, futures prices, swap quotes in various combinations. As a result, it gives the corresponding rates for the discount factors, the zero yield curve and forward quotes for a time vector that is specified at the beginning. The derived curves – of yield, discount curve and future value curve are shown in table 6.

Table 6 calculated maturities at zero yield, discount and future value curve

Curve/ Maturity	0	0.25	0.5	0.75	1
Zero Income curve	-0.443	-0.378	-0.334	-0.27	-0.206
Doscount curve	1	1.1	1.18	1.22	1.23
Future value curve	-0.4429	-0.334	-0.2062	-0.0785	0.0491

The result of the calculated function, the probabilities (intensities) of default for each of the considered maturities are shown in table 7.

Table 7 probability of default for maturity type

no	T	Default Intensity
1	0.25	0.000182629
2	0.5	0.003151119
3	0.75	0.002772238
4	1	0.003316136

The size of the operating surplus after the introduction of the regulatory restrictions shows a total loss of 1,881.24 million euros in the restricted sectors. In order to obtain the necessary motivation for restructuring, investment and innovation in the short term, these sectors must maintain an equal or higher level of operating surplus compared to the previous period.

It is expected that this resource will not be free. The profitability of the additional costs of the credit resource is the difference between the net present value of the return on investments in reorganization, innovation and restructuring. Not all investment projects will be successful, which means that some projects may generate a negative net result. This would lead to the inability to service the loans and potential default of the company. Creditors can protect themselves from default by purchasing protection on secured debt, with the debt divided into tranches tied to the part of the principal they protect, shown in Table 8.

Table 8 tranche intervals for protection

Tranche	0%-3%	3%-6%	6%-9%	9%-12%

The main assumptions of the underlying in the synthetic instrument are that the maturity of the swaps of the individual companies is the same length of 1 year, the protection premium payments are paid 4 times a year and the recovery rate for all instruments is 40%.

Calculations are made of the present values of the premium payments, indemnities and default charges. At equilibrium margin, the investment in a debt instrument has a risk comparable to risk-free bonds. It is not necessary to own Credit Default Swaps (CDS) to buy protection for tranches. An investor can take a long position when the equilibrium tranche premium is higher than the market value of the index, making the net present value positive. The contagion rates show that the probability of default in one year is 0.003316136, so the first tranche is the most expensive. Theoretical values are calibrated so that the buyer of 100% of the debt in the tranche has a final score of 0 after the first year. Table 9 shows the net change after intervention of the credit resource and the payment of the first premium for each tranche.

Table 9 net change in operating surplus indicator by industry after payment and crediting

Post redistribution on the credit market	**Op. Surplus (m. EUR)**
Electricity & heating	783.50
Forestry	364.12
Man. & Construction	1,893.00
Transport	8,457.14
Waste Mng	124.90
Total for the indicator	11,622.66
Change after selling instrument	1,881.24
Expenses for the 1st premium	26.16
Net change	**1,855.08**

Applicability of specialized financial instruments

This part of the study implements the tasks of main task number 8. The credit instrument is an alternative to government debt for financing restructuring industries. It transfers resources from surplus sectors to the decreased surplus industries and assesses the profitability of investments. This is not possible with government issued securities.

Conclusion

Summary

B Based on the initial data, the statistical properties of the series are examined. Basic characteristics of the distributions are derived, autocorrelation and unit root tests are checked. Three calculated indicators are introduced and dependencies from single to multifactor models are built. Dependencies between value added and greenhouse gas emissions for different industries are modeled, with logarithmic values giving better results than the observed ones. Linear dependencies without a constant also perform better. The study continues with dependencies between financial indicators and value added in five selected industries, registering a total of 30 linear models. In the next section, theoretical constraints on greenhouse gas emissions are assumed and optimization conditions are derived using the Solver method. The results found show emission values according to regulatory conditions.

The study also includes calibration of a Credit Default Swap for secondary redistribution of resources after optimization. The calibrated tranche prices are equilibrium, not market. It is concluded that the requirements of the study have been met, achieving the objectives in terms of quantitative dependencies for turnover, income and employment, which can be used for short-term financial policy. All hypotheses from the beginning of the study have been confirmed, fulfilling the main thesis.

Conclusions

In its entirety, through the methods of statistical analysis, mathematical calibration and computer programming, the study offers a theoretical method for studying existing quantitative relationships between added value, greenhouse gas emissions and financial indicators, by building a chain of functional dependencies that can trace the transmission of quantitative effects on the financial indicators under consideration. The study focuses solely on endogenous quantitative relationships and ignores all exogenous factors.

The derived system of quantitative dependencies can also be considered as a measure of the sensitivity of productivity and financial effects in a given sector of the economy to the amount of greenhouse gas emissions produced. Information about this sensitivity is also a partial basis for the development of financial and budgetary policy for restructuring in the event of a need to transition to climate-neutral production.

IV. Directions for future research on the dissertation topic

Based on the research results, the following recommendations can be made for continuing the research:

- Increasing the granularity of the collected data, by collecting data with a semi-annual, quarterly or monthly frequency.

- It is recommended to produce input data with maximum granularity, including data for individual enterprises or small cluster groups.

- Expanding the scope of the study to include all sectors of the economy, considering the economy as an open system.

- Increasing the spectrum of environmental effects.

- Expanding the target scenarios for a transition economy with the inclusion of new target values.

- Introducing long-term effects and forecasts to assess the consequences of economic and financial policies.

- Including endogenous factors affecting productivity in order to support long-term planning of economic and budgetary policies.

V. Reference to the scientific and scientific-applied contributions in the dissertation work

Modern economic theory offers a range of studies of economic growth while accounting for environmental effects. The theoretical formulation of the environmental Kuznets curve according to Smulders (SMULDERS, Sjak; BRETSCHGER, Lucas. Explaining environmental Kuznets curves: how pollution induces policy and new technology. 2000), examines the relationship between income growth, i.e. increase in consumption and increase in pollution. The models of Aghion and Howitt (AGHION, Philippe; HOWITT, Peter W. The economics of growth. MIT press, 2008) develop a specific type of growth influenced by the theory of "creative destruction" introduced by Schumpeter in 1942. Stokey's model (STOKEY, Nancy L. Are there limits to growth?. International economic review, 1998, 1-31) is based on determining the state of nature as a resource, the pollution of which is equivalent to the consumption of this resource.

Based on the derived theoretical foundations for economic growth when accounting for produced pollution, the present study examines the negative effects on the environment as production factors of the produced added value and financial results achieved in selected sectors of the national economy of Bulgaria. Aims to prove the presence of statistically significant quantified relationships between the negative effects on the environment and the resulting added value and financial effects, thereby deriving a quantitatively measured for a given sector of the economy, productivity of the given negative effect. The proof of statistically significant relationships is considered as a tool for evaluating the effects of implementing reactive economic and financial policies to compensate for the normatively set limitations with a given constant technology of production in the short term. The results can be quite important for practice, especially in the context of the overall estimate of €620 billion needed for the Green Deal and the REPowerEU plan.

The main scientific contributions that this research brings can be systematized as:

1. Application of a translogarithmic production function in the context of climate impact, taking the negative effect as a resource quantity.

2. Derived linear quantitative relationships for the national economy of Bulgaria, between the produced added value and the released greenhouse gas emissions during production.

3. Inferred linear quantitative relationships between main financial indicators and emitted greenhouse gases.

4. Proposed models that take into account the movements caused by random factors and in this way fluctuations caused by cyclical or seasonality of the data and the produced results are also taken into account.

5. Derived theoretical instrument for quantitative measurement in derivation and implementation of financial policy in the context of regulatory and restrictions and the need for restructuring in a short period.

VI. List of PhD student's publications

1. PRODUCTIONS, AUTOMATION IN DISCRETE. INTERNATIONAL SCIENTIFIC JOURNAL.ISSN 2534-8523,TU-Sofia Publisher, P9-18, T Anev "QUANTITATIVE RELATION BETWEEN GREENHOUSE GASES EMISSIONS, ECONOMIC AND FINANCIAL AGGREGATES"

2. Thrace Journal of Sciences, Vol. 20, Suppl. 1, pp 33-41, 2022 Copyright 2022 Trakia University Available online at: http://www.uni-sz.bg, T. Anev, "FINANCING THE PRODUCTION AND SUPPLY OF COVID-19 VACCINES"

3. Scientific Works of FISN Faculty, Plovdiv University ""Paisii Hilendarski"" vol 12, 2023, Plovdiv University Press, Plovdiv 2023 ISSN: 1313-227X, p. 453 -479 T. Anev "Quantitative effects on economic growth and aggregated financial indicators, after introducing normative restrictions on pollution"

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