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YIELD CURVE OF AGRICULTURAL COMPANIES BONDS AS A TOOL FOR FORECASTING SUSTAINABLE DEVELOPMENT OF THE INDUSTRY

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Abstract

The article considers the problem of financing environmental and social (ESG) projects in the field of agriculture through the placement of ESG bonds, which can serve as a tool for forecasting the development of the industry. In the study, when constructing the yield curve, the Nelson-Siegel model parameter estimation method is used. For the analysis, a sample of yields of agricultural companies' bonds based on the results of transactions was used, among which four groups with corresponding benchmarks were identified. As a result of the analysis of yield curves of corporate bonds of agricultural companies and benchmarks for each group, a conclusion and a forecast on the industry development were made.

Keywords: *agriculture, "green" bonds, ESG bonds, yield curve, bond pricing, forecasting.*

1. Introduction

The problem of sustainable development for agricultural enterprises is particularly relevant due to the dual nature of their functioning. Firstly, the agriculture is the largest source of greenhouse gases in the atmosphere and at the same time it is a large consumer of natural. Secondly, it provides the population with food and contribute to the development of rural areas.

From a global point of view, the strategic development of agriculture is inextricably linked with the implementation of ESG principles, which is determined by the popularization of “green”, “climate-oriented” agriculture. The ability and readiness of agriculture to cope with climate change is of great importance in context of sustainable growth and development.

In this regard, an important aspect is the need to search for various sources of financing that would allow them to fully implement environmental and social projects. ESG bonds are one of the most common market-based financing instruments for sustainable development projects. At the same

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time, adherence to ESG principles is the criterion that guides banks, investors and the state when making decisions on financing or allocating subsidies to agricultural producers.

Corporate bond markets have shown remarkable progress over the past decade and have created the conditions for intensifying the investment activities of agricultural market enterprises in order to expand sources of financing for innovation and increase competitiveness in the domestic and foreign markets. Developing countries have seen a significant expansion of their corporate bond markets.

At the same time, the state of the fixed income securities market for agricultural producers can serve as an excellent indicator of the state and indicator of the development prospects of the agricultural sector of the economy. The yield curve as a graphical representation of the dependence of the profitability of a financial instrument on its validity period can be used as a forecasting tool. To make this practical it is proposed to use the Nelson Siegel model, which well interprets the parameters from an economic point of view and quite accurately describes the available data.

The more general purpose of this study is to illustrate the real possibilities of enhancing the involvement of agricultural producers and food industry enterprises in the system of innovative exchange investment, as well as its use as a forecasting and planning tool. The results of this study can be considered as additional contemporary models and general frameworks that today's developing countries can refer to.

2. Main ideas: Climate Change and Investment in Agriculture

Agriculture is a vital part of the economy since it produces vital to society products and has enormous economic potential. The level of agricultural development largely determines the state of the entire national economic potential, the socio-economic situation in society and the level of food security. Recently, the growing demand for food has made the agricultural business more and more profitable, and the situation with investments in the agricultural sector is increasingly positive. While the world's developed countries invest billions of dollars in agricultural development programs, developing countries with huge agricultural land potential lag behind in agricultural production. At the same time, the agriculture is the most important sector of the economy of the developing countries, the level of its development determines the potential for food security of the state and the socio-economic situation in society and has a significant impact on the efficiency of the country’s national economy.

Sustainability is now becoming an increasingly hot topic for companies around the world against the backdrop of acute climate and social problems, society, including customers, owners and regulators, is beginning to place increased demands on the environmental and social aspects of companies’ activities [1]. For companies in the agribusiness, this problem is particularly acute, since on the one hand, agricultural companies are among the largest emitters of greenhouse gases into the atmosphere, the biggest consumers of land, water and forest resources, and on the other hand, they make a significant contribution to the elimination of hunger and the development of rural areas. About a third of the carbon footprint comes from agricultural enterprises, which necessitates transformation based on the introduction of new technologies for the production of agricultural products [2]. However, on the path to transformation, agricultural enterprises face a number of problems, largely related to the imperfection and obsolescence of the regulatory framework and acute need for financing [3].

The ESG concept is based on three key principles, the observance of which is mandatory in the pursuit of sustainable development: Environmental, which implies the need to protect the environment, Social, which implies the need to take care of both the personnel of agricultural enterprises and society as a whole, and Governance, which involves building a corporate governance system based on the principle of bearing responsibility for management steps taken [4].

Green transformation requires significant expenditures and the search for effective sources of financing. As a result, compliance by issuers with ESG principles becomes an integral element of its practical implementation, which determines the level of their investment attractiveness. In other words, there is a rapid spread of the ESG concept, which is closely related to the development of a green economy and the introduction of ESG investing. In addition, those enterprises that take into account environmental risks and public demands in relation to "responsible" production in their activities are characterized by more sustainable growth and stability [4, 5].

The trends in the spread of ESG investing in developing countries give some optimistic view, but its pace is not as fast as in developed countries. The share of investors who consider the impact of ESG factors when buying shares is only a fifth of all investors. However, more than half of systemically important agricultural companies already carry out ESG lending taking into account ESG indicators. However, agricultural enterprises are not yet actively using ESG financing tools and in the world only 11% of agricultural enterprises are interested in ESG loans and 5% in ESG bonds/stocks. Obviously, in developing countries this share is even lower [6].

Due to the long capital turnover period, it is difficult for agricultural enterprises to find funds for global projects, so they need long-term investments, i.e. borrowed capital for long-term use. For agricultural enterprises, the most suitable alternative to credit for raising borrowed funds is to organize a corporate bond issue. Raising funds by issuing own bonds for agricultural producers will be more effective than attracting a bank loan, but will require significant one-time additional costs [7].

Among the common ESG investment instruments there are ESG bonds as "green" bonds, social bonds, and sustainable development bonds. The key features of ESG bonds are targeted use of funds for environmental and social projects, independent verification of their compliance with generally accepted standards in the field of ESG, mandatory regular disclosure of non-financial reporting by the issuer, availability of the necessary infrastructure for the selection of projects by the issuer, monitoring the use of funds, etc. [8, 9].

3. Forecasting tool: Yield curve

Yield curves underlie the theory of fixed income asset pricing and are used to make investment decisions because they are the basis for studying the return of a securities portfolio. A yield curve is a representation of the relationship between market interest rates and the remaining time to maturity of debt securities with the same credit structure.

Yield curve risk refers to the risk that investors in fixed income instruments such as bonds experience as a result of unfavorable changes in interest rates. Yield curve risk arises from the fact that bond prices and interest rates are inversely related to each other, as bond prices decline when market interest rates rise, and vice versa. The dependence extends to the entire group of homogeneous financial instruments with similar quality indicators. Thus, the bond yield curve is constructed for securities of the same type (corporate, municipal, state) of similar credit quality [10].

The yield curve of bonds actually reflects the risk payment to holders of such securities. Indeed, unlike shares, which reflect the rights to own part of the issuing company, bonds, theoretically, do not have firm guarantees of the return of the investor's funds. Accordingly, depending on the current state of the economy or one of its sectors, the risks of investors providing loans to issuers of debt securities may vary depending on the maturity of the issue. Depending on the economic situation and market factors, the bond yield curve can take several different forms.

Investors can use the yield curve to predict the state of the economy and make investment decisions. If the bond yield curve points to an economic downturn, investors can move their money into defensive assets that traditionally perform well during a recession. If the yield curve steepens, it could signal future inflation. In this scenario, investors may avoid long-term bonds, whose yields will decline as prices rise.

Like government bonds, corporate bonds are subject to interest rate risk. In addition, corporate bonds also have credit risk or default risk that the borrower will not be able to repay the loan and default on its obligations. The level of default risk varies depending on the credit quality of the issuer. Therefore, yield curves for securities of corporate issuers allow to analyze company risks. The yield curve of Treasuries and other government bonds is a good market benchmark and allows us to assess the situation in the country's economy as a whole and its future prospects [11].

There are three main shapes of the yield curve: the normal curve with an upward slope, the inverted curve with a downward slope, and the flat curve. The slope of the yield curve predicts changes in interest rates and economic activity. The slope of the yield curve tells how the bond market expects short-term interest rates to move in the future, based on bond traders' expectations for economic activity and inflation.

The normal yield curve looks like a monotonically increasing convex line, asymptotically approaching some fixed value. This form corresponds to the normal processes of economic development and illustrates increasing risks of a temporary nature. Thus, the flatter the government bond curve becomes, the more its economy slows down. And an inverted curve (when long bonds yield less than short bonds) can be a sign of an impending recession. The smaller the difference between long and short issues, the smoother the curve [12].

Typically, the longer bond's maturity, the higher the bond's yield. The yields on long-term securities depend on inflation and fall when the economy weakens. Meanwhile, "short" yields are more susceptible to changes in the Fed key rate, and it is precisely the increase in rates that can lead to a weakening of the economy. In addition, due to the low yields of short-term issues, their fluctuations in percentage points are not so strong.

Analysis of graphical and tabular data allows assessing the current state of the market, calculate the size of fair premiums, calculate bond prices with the predicted movement of interest rates, etc. Thus, the bond yield curve is an indicator of market expectations regarding impending inflation and serves as a tool for assessing current and future economic conditions. Consequently, accurate estimates of the yield curve help in forecasting inflation and monitoring economic stability, and are therefore indispensable for central banks aimed at conducting effective monetary policy. In addition, the term structure helps to present the current economic situation in the context of the cost of lending, allows you to assess the availability of credit resources, the state of liquidity in the banking sector, etc. [12].

The term structure of interest rates also serves to estimate the fair value of bonds, calculate credit spreads, actuarial valuation and other risk management and financial engineering purposes. Among other things, it is used to develop investment strategies taking into account the urgency of borrowing, the level of risk, hedging, assessing speculative strategies, and analyzing the feasibility of arbitrage over time. Thus, using the term structure of interest rates, one can successfully examine the state of the financial market.

4. Methodology: Nelson-Siegel model

The development of reliable methods for modeling the term structure of interest rates and their correct application is of particular importance for financial market participants. In finance, it is often necessary to estimate the future risk and return of an asset based on current conditions. The problem of modeling a term structure is to describe the yield curve as best as possible, taking into account the market prices of financial instruments and the promised cash flows on them. This task is quite difficult to accomplish under conditions close to reality.

One of the obstacles to such an assessment is the lack of sufficient data. Zero coupon bonds and money market rates are commonly used to construct a zero-coupon yield curve. If the desired number of zero-coupon bonds is not available in the market, they can be artificially constructed by treating each coupon bond as a portfolio of zero-coupon bonds. And in markets where there is insufficient liquidity in the short term, interbank money market rates are also used. In practice, it may also be necessary to extract spot rates from more complex securities, such as swaps and forward rate agreements. Market-based instruments such as cash deposits and futures are also used [11].

After determining the sample of bonds needed to build the term structure of interest rates, the investor can use one of the approaches to its construction. Thus, methods for assessing the term structure can be divided into three large classes: simple, parametric and spline methods. Parametric methods assume that the zero-coupon yield curve belongs to some pre-selected class of parametric functions. They were used back in the 1960s and are currently the most common method of constructing a term structure for spot rates. The construction of the yield curve in any market is determined by the choice of the approximating function and the method of sampling. For a market characterized by extremely low and volatile liquidity, the Nelson-Siegel model is most suitable. There is also an extension of this model proposed by Svensson, but for the purposes of this study the original model will suffice.

The procedure for estimating the parameters of the Nelson-Siegel model is based on minimizing the sum of squares of the difference between the realized and calculated bond prices. Clarifying coefficients and terms can be introduced into the model for calculating the zero-coupon yield curve to ensure increased accuracy and maximum compliance with the results of exchange trading. The valuation price of each security is the present value of all cash flows associated with the security, so zero-coupon and fixed-coupon debt instruments can be used in the same data set.

Once the parameters of the Nelson-Siegel model are estimated, the yields corresponding to different maturities can be easily calculated due to the explicit functional form of the Nelson-Siegel model curve, which corresponds to the continuously compounded zero-coupon yield over the maturity universe. For correct interpretation of the constructed curve, its publication is accompanied by metrics of the degree of correspondence to actual returns and the age of the sample.

The zero-coupon yield curve is given by the following equation:

$$Z(m,b) = \beta_0 + (\beta_1 + \beta_2)\frac{\tau}{m}\left[1 - \exp\left(-\frac{m}{\tau}\right)\right] - \beta_2 \exp\left(-\frac{m}{\tau}\right)$$

An important advantage of the Nelson-Siegel model is the direct interpretation of its parameters. Economically, the coefficients of the model can be interpreted as short-, medium- and long-term components of the forward rate curve, and, therefore, the yield curve [13]. The model has an interesting economic interpretation of the parameters and good asymptotic characteristics [14].

The parameter value β_0 (Beta0) represents the asymptote of the yield curve function as the remaining maturity and can be interpreted as the long-term interest rate. The value of parameter β_1 (Beta1) can be interpreted as the short-term interest rate. The sum of the parameters $\beta_1 + \beta_2$ represents the initial value of the forward curve, which can be interpreted as an instantaneous guess about the interest rate, thus requiring $(\beta_1 + \beta_2) > 0$. The value of the parameter β_2 (Beta2) represents the deviation of the function values from the asymptote and can be intuitively explained as curvature of a function or as the difference between long-term and short-term forward interest rates. The decay parameter τ (Tau) determines at what maturity this component reaches its maximum.

5. Data and Assessment Procedure

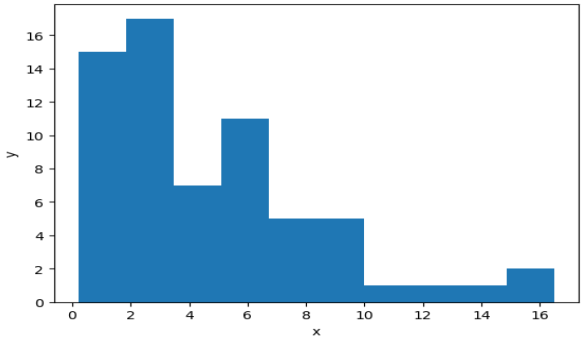
This study uses four groups of bonds with corresponding comparative benchmarks. The first group consists of bonds of the world's largest agribusiness companies, which can be compared with the performance of high-quality corporate bonds. The second group consists of green bonds of global agro-industrial companies, and green bonds of the world's largest companies were selected as comparison. The third group is bonds of agro-industrial companies in developing countries, and the fourth group is green bonds of agro-industrial companies in developing countries. Bonds of developing country companies are used as a benchmark and these are green bonds of developing country companies.

The data comes from several sources such as: CBonds, Euronext, Morningstar, Wint Wealth[1]. The yield is estimated based on data on corporate bonds of agricultural companies available on the debt securities market based on the results of transactions. Statistics on traded securities made it possible to estimate the volume and nominal value of securities issued by agricultural and food industry enterprises and their capitalization. Therefore, the yields estimated in the study reflect information for the period from August 1, 2021 to the end of January 2022.

The distribution of bond maturities is asymmetrical to the right *(Figures 1-4)*. The longest bond maturity is observed to be just over 15 years. Bonds with longer maturities are typically floating rate coupon bonds, which are excluded from the document because the future cash flows of these securities are unknown. On the other hand, fixed coupon bonds are included in the analysis because each coupon payment can be treated as a zero coupon bond. Securities with a maturity of less than 1 month were also excluded from the study.

[1] https://cbonds.com, https://www.euronext.com, https://www.morningstar.com, https://www.wintwealth.com

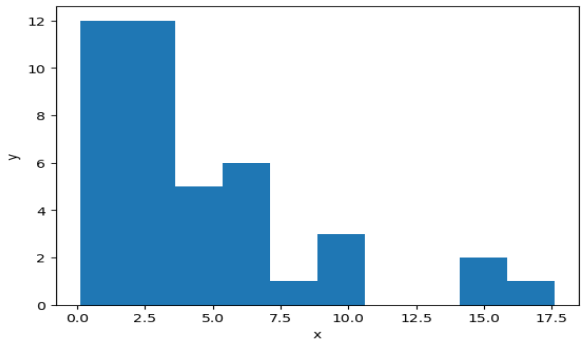
Figure 1. Maturity of corporate agricultural bonds in developed countries, x=years, y=n



count 65.000000
mean 4.602393
std 3.749784
min 0.205556
25% 2.180556
50% 3.633333
75% 5.938889
max 16.508333
Name: Maturity, dtype: float64

***Source**: author's calculations*

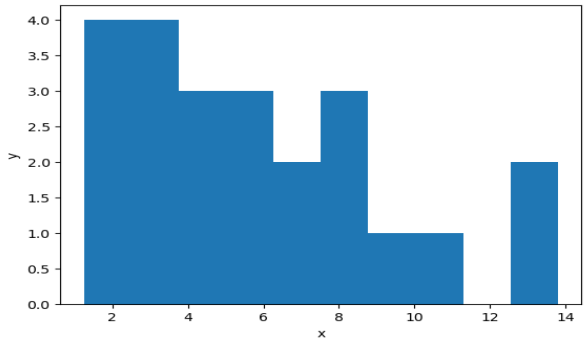
Figure 2. Maturity of ESG corporate agriculture bonds in developed countries, x=years, y=n



count 42.000000
mean 4.429595
std 4.114459
min 0.101000
25% 1.505000
50% 2.926000
75% 6.469250
max 17.624000
Name: Maturity, dtype: float64

***Source:** author's calculations*

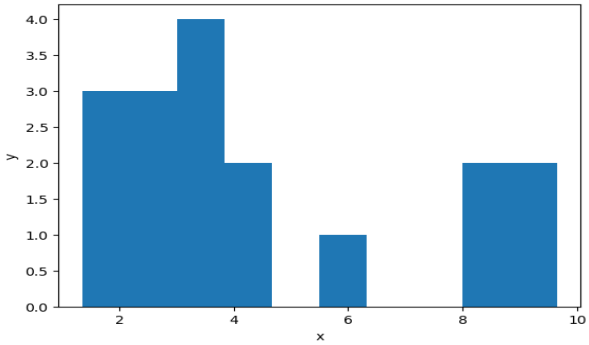
Figure 3. Maturity of corporate agricultural bonds in developing countries, x=years, y=n



count 23.000000
mean 5.833913
std 3.670002
min 1.250000
25% 3.115000
50% 5.200000
75% 7.820000
max 13.800000
Name: Maturity, dtype: float64

***Source:** author's calculations*

Figure 4. Maturity of ESG agricultural corporate bonds in developing countries, x=years, y=n



count 17.000000
mean 4.439869
std 2.843196
min 1.355556
25% 2.644444
50% 3.388889
75% 5.591667
max 9.650000
Name: Maturity, dtype: float64

***Source:** author's calculations*

As the figures show, bonds with longer maturities are not traded frequently. Thus, the corporate yield curve will provide more reliable information about the shorter end of the yield curve. However, over time, the longest maturity of the yield curve is expected to increase as the number of long-term securities traded increases.

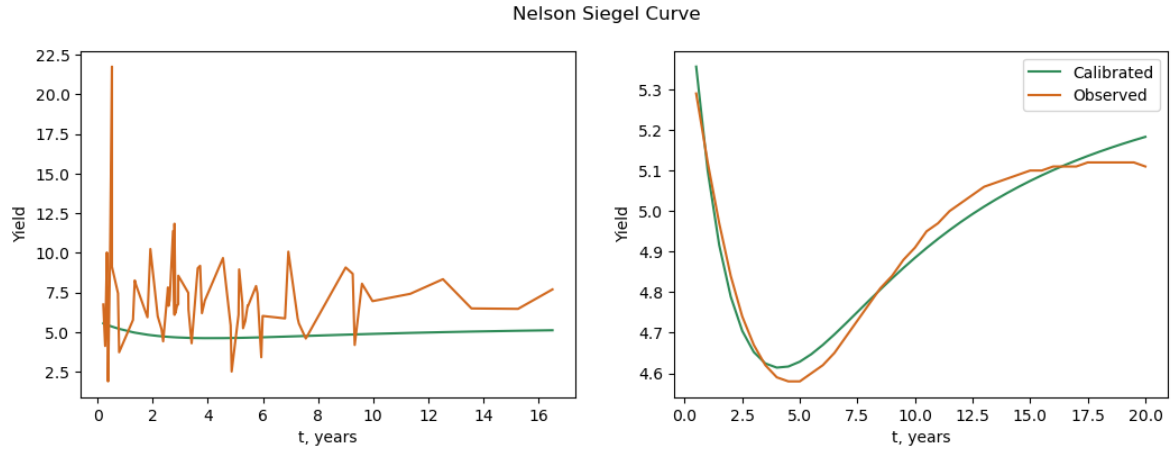
As mentioned above, the Nelson-Siegel estimation procedure involves estimating four parameters, so in order to accurately estimate these parameters it is necessary to have at least four different trading data points. The small number of parameters and the limited flexibility of Nelson-Siegel are important when there are a small number of observations and a large spread of prices. The method of forming the sample ensures its representativeness, although at the expense of loss of synchronicity, and the sample consists of the last 10 transactions in each of the four maturity ranges [15].

The corporate bond market is segmented in terms of default risk. Corporations with different credit ratings and balance sheet structures are combined into the same data set due to missing data. However, there may still be differences between financial institutions in terms of risk premium and liquidity that are not reflected in credit rating differentials. Therefore, it may be optimal to divide the data into subgroups with similar risk profiles and construct a separate yield curve for each subgroup. Unfortunately, since the number of bonds traded is still small, this approach cannot be implemented.

When constructing a yield curve, it is optimal to use securities that are close to each other in terms of risk premium and liquidity. However, it is known that there are some differences between firms in terms of their risk premium and liquidity. In this data set, differences in bond risk premiums do not significantly undermine the estimation results, since most firms have similar ratings. On the other hand, since the Nelson-Siegel yield curve is not very sensitive to the performance of individual bonds, the overall shape of the yield curve is reliable, although there is some degree of heteroscedasticity in all of the samples.

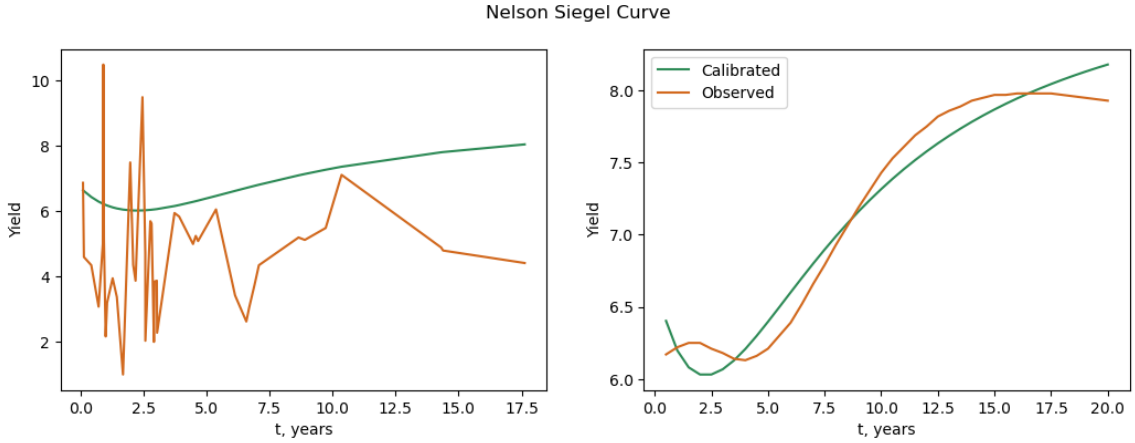
6. Results of Estimation

Figure 5. Yields on agricultural corporate bonds (left) and corporate bonds in developed countries (right), percentage



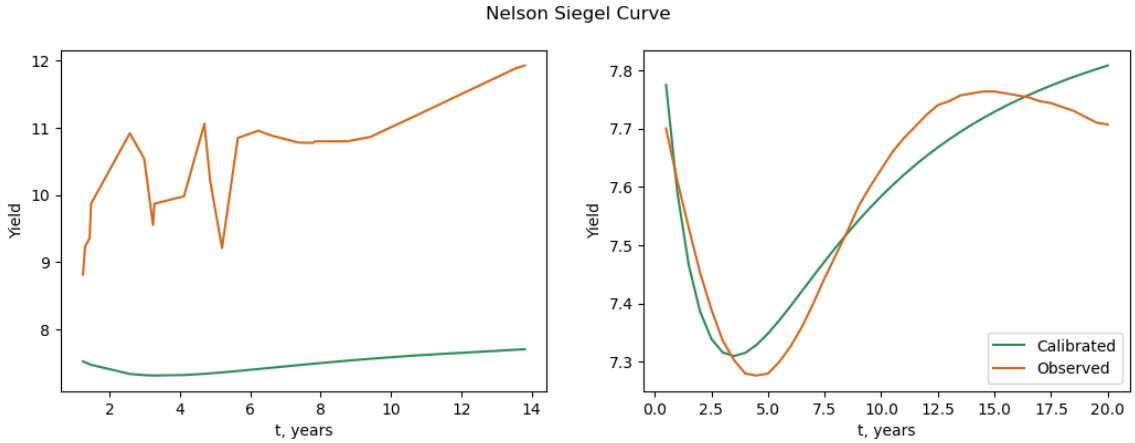
Source: *author's calculations*

Figure 6. Yields of ESG corporate bonds in agriculture (left) and ESG corporate bonds in developed countries (right), percentage



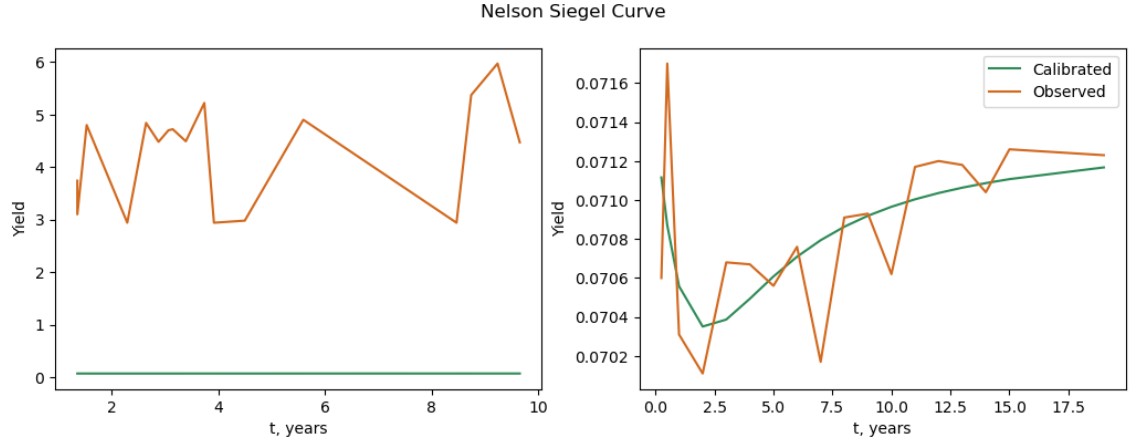
Source: *author's calculations*

Figure 7. Yields on agricultural corporate bonds (left) and corporate bonds in developing countries (right), percentage



Source: *author's calculations*

Figure 8. Yields of ESG corporate bonds in agriculture (left) and ESG corporate bonds in emerging markets (right), percentage



Source: *author's calculations*

As the figures show, the yield on corporate bonds of agricultural companies is much more volatile than the yield on all corporate bonds with corresponding maturities. This situation may be due to the inherent riskiness of corporate returns as well as possible estimation errors due to a less populated data set. Since the maturity of traded agricultural corporate bonds is shorter compared to the maturity of whole-market corporate bonds, the results of estimating whole-market corporate bond yields are much more stable.

However, as the maturity of traded agricultural corporate bonds increases, the stability of bond yield estimates is expected to increase. Although the volatility of agricultural corporate bond yields is higher than that of whole-market corporate bond yields, it is observed that both yields tend to decline over the assessment period. Another source of differences between agricultural corporate and whole-market corporate returns may be the liquidity premium. Whole-market corporate bonds are trading much more actively compared to agricultural corporate bonds, which may prompt traders to include a liquidity premium in whole-market corporate bond yields.

In addition, the figures show that there is a persistent difference between corporate and benchmarks, reflecting the additional risk premium inherent in agricultural corporate bond yields. However, it is difficult to determine the exact nature of these premia due to the high dispersion.

As discussed above, the three Nelson-Siegel components are clearly interpreted as short-term, medium-term and long-term components and are the result of each element's contribution to the yield curve.

Table 1. Yields on agricultural corporate bonds and corporate bonds in developed countries

Yields on agricultural corporate bonds in developed countries	**Yields on corporate bonds in developed countries**
Nelson Siegel Model ========== beta0 = 11.422581100163988 beta1 = -2.879035265969747 beta2 = -11.062931224145208 tau = 5.407135482550816 _____ ========== Calibration Results ========== CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH Mean Squared Error 454.7210852990105 Number of Iterations 35	Nelson Siegel Model ========== beta0 = 5.518074868794588 beta1 = 0.19127329014302263 beta2 = -3.3221096932581773 tau = 2.141978161775085 _____ ========== Calibration Results ========== CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL Mean Squared Error 0.05553829280086667 Number of Iterations 26

Source: *author's calculations*

The Beta0 value indicates that the long-term rate is higher than the benchmark, and Beta1 indicates that the short-term rate is lower, even negative, thereby the Beta2 value is negative for the parameter of interest, and for the benchmark it is negative, but significantly greater in absolute value. Such indicators may indicate the prospect of more moderate development of the agricultural sector than the economy as a whole.

Table 2. Yields on ESG corporate bonds in agriculture and ESG corporate bonds in developed countries

Yields of ESG corporate bonds in agriculture bonds in developed countries	Yields on ESG corporate bonds in developed countries
Nelson Siegel Model ========== beta0 = 4.945158820281685 beta1 = 1.2294004520692632 beta2 = -3.534419210329447 tau = 0.563566376462221 _____ ========== Calibration Results ========== CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH Mean Squared Error 139.80736106752832 Number of Iterations 19	Nelson Siegel Model ========== beta0 = 9.141358242702415 beta1 = -2.4147267262414442 beta2 = -6.0146392036855865 tau = 2.282340098456244 _____ ========== Calibration Results ========== CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH Mean Squared Error 0.8292538091917365 Number of Iterations 28

Source: *author's calculations*

The Beta0 value indicates that the long-term rate is lower than the benchmark, and Beta1 indicates that the short-term rate is higher, thus the Beta2 value is negative for both the parameter of interest and the benchmark, but greater in absolute value. Such indicators indicate the prospect of more active development of the ESG component in the agricultural sector than in the economy as a whole.

Table 3. Yields on agricultural corporate bonds and corporate bonds in developing countries

Yields on agricultural corporate bonds in developing countries	Yields on corporate bonds in developing countries
Nelson Siegel Model ========== beta0 = 14.844989159676231 beta1 = -5.695818463438755 beta2 = 0.0033185886645731204 tau = 10.054964027831547 _____ ========== Calibration Results ========== CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH Mean Squared Error 5.04300936151161 Number of Iterations 41	Nelson Siegel Model ========== beta0 = 8.049028547916816 beta1 = -0.00948859617978467 beta2 = -2.4618984855110226 tau = 1.9534519313266676 _____ ========== Calibration Results ========== CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL Mean Squared Error 0.11460304864045184 Number of Iterations 25

Source: *author's calculations*

The Beta0 value indicates that the long-term rate is significantly higher than the benchmark, and Beta1 is negative in both cases, the Beta2 value for the parameter of interest is close to zero, which indicates that there is no difference between long-term and short-term forward interest rates.

Such indicators indicate a possible prospect of stagnation in the development of the agricultural sector in some developing countries.

Table 4. Yields on ESG corporate bonds in agriculture and ESG corporate bonds in developing countries

Yields on ESG corporate bonds in agriculture in developing countries	Yields on ESG corporate bonds in developing countries
Nelson Siegel Model ========== beta0 = 24.05028448649415 beta1 = -20.19551453590103 beta2 = -15.170154697451629 tau = 29.99983979953675 _____ ========== Calibration Results ========== CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH Mean Squared Error 13.828386473210342 Number of Iterations 63	Nelson Siegel Model ========== beta0 = 0.07139261207729784 beta1 = 5.052629240482447e-05 beta2 = -0.0035832374963918764 tau = 1.2124504980615665 _____ ========== Calibration Results ========== CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL Mean Squared Error 1.8045963035802661e-06 Number of Iterations 12

Source: *author's calculations*

The value of Beta0 indicates that the long-term rate is significantly higher than the benchmark, and Beta1 is negative, thus the Beta2 value is negative for both the parameter of interest and the benchmark, but much larger in absolute value. Such indicators are the result of a small number of observations both in ESG corporate bonds in agriculture and ESG corporate bonds in developed countries used as benchmark and cannot be interpreted correctly.

7. Conclusion

Due to the high contribution of agricultural companies to climate change and to the development of the social sphere, companies in the agro-industrial complex are increasingly faced with requests from owners, clients, and creditors about the need to invest in reducing ESG risks. Such investments, as a rule, have a relatively low profitability, so agricultural companies need tools to reduce the cost of financing. Corporate bonds, including ESG bonds, are one of the main market instruments for financing general business development, as well as social and environmental projects. A bond yield curve is a curve showing the yields or interest rates on different bond issues. This property allows the bond yield curve to be used as a forecasting and planning tool in the industry, including in the field of ESG investing.

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Kənd təsərrüfatı şirkətləri istiqrazlarının gəlir əyrisi sənayenin davamlı inkişafının proqnozlaşdırılması üçün bir vasitə kimi

Xülasə

Məqalədə sənayenin inkişafının proqnozlaşdırılması üçün alət kimi çıxış edə bilən ESG istiqrazlarının yerləşdirilməsi yolu ilə kənd təsərrüfatı sahəsində ekoloji və sosial (ESG) layihələrin maliyyələşdirilməsi problemi nəzərdən keçirilir. Tədqiqatda gəlir əyrisi qurularkən Nelson-Siegel modeli parametrlərinin qiymətləndirilməsi metodundan istifadə edilib. Təhlil üçün əqdlərin nəticələrinə əsasən kənd təsərrüfatı şirkətlərinin istiqrazlarının gəlirlilik nümunəsindən istifadə edilib, onların arasında müvafiq göstəriciləri olan dörd qrup müəyyən edilib. Kənd təsərrüfatı

şirkətlərinin korporativ istiqrazlarının gəlirlilik əyrilərinin və hər bir qrup üzrə etalonların təhlili nəticəsində sənayenin inkişafı ilə bağlı nəticə və proqnoz verilib.

Açar sözlər: *kənd təsərrüfatı, "yaşıl" istiqrazlar, ESG istiqrazları, gəlir əyrisi, istiqraz qiymətləri, proqnozlaşdırma.*

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Кривая доходности облигаций агрокомпаний как инструмент прогнозирования устойчивого развития отрасли

Резюме

В статье рассматривается проблема финансирования экологических и социальных (ESG) проектов в сфере сельского хозяйства посредством размещения ESG-облигаций, которые могут служить инструментом прогнозирования развития отрасли. В исследовании при построении кривой доходности используется метод оценки параметров модели Нельсона-Зигеля. Для анализа использована выборка доходностей облигаций сельскохозяйственных компаний по результатам сделок, среди которых выделено четыре группы с соответствующими бенчмарками. В результате анализа кривых доходности корпоративных облигаций сельскохозяйственных компаний и бенчмарков для каждой группы сделан вывод и прогноз по развитию отрасли.

Ключевые слова: *сельское хозяйство, «зеленые» облигации, ESG-облигации, кривая доходности, ценообразование облигаций, прогнозирование.*