

Education in the Imperative of Sustainability. A Step towards the Impact of Science and Technology

Elena-Gabriela Dobre

University of Economic Studies, Bucharest

dobregabriela10@stud.ase.ro

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Abstract

Sustainable Development (SD) heterogeneity outlines the diverse challenges of achieving economic growth. The strategy for the SD is framed within the broader framework of biodiversity ecosystems. This roadmap enhances resource management and education, both fundamental for achieving social progress and ensuring performance. Education in the SD strategy represents a significant challenge to the status quo in the domain of complementary education studies, with implications for employment in science and technology. According to Eurostat, the Human Resources in Science and Technology (HRST) index reported that in 2023, 71.8 million people were employed in science and technology within the European Union (EU). Researchers in this domain signal limitations on the education sector's ability to plan for the future, particularly regarding the constraints imposed by resource scarcity and economic growth. Highlighting the challenges of inquiry, this paper explores more specifically the key factors that shape HRST potential, considering the common context of all economies, the natural environment, which substantiates the performance equation that entails household economic growth and investments. Therefore, to grasp the trends of HRST, an analysis of Eurostat

indicators was performed. The paper's result was regressed in the landscape of statistical information ranging between 2014 and 2023.

To properly manage the performance context that biases science and technology, attention was focused on the primary keys of ecosystems, such as environmental protection actions, forestry, construction, and agricultural land. Moreover, the construction investment parameters imprint a significant behavior on science and technology, even if environmental protection activities don't have yet a corresponding impact in statistics, as Türkiye case, unlike Western Europe, which creates an influence between environmental protection activities and science and technology.

This framework aims to delineate the scientific and technological potential in achieving sustainable development goals, considering that innovation, science and technology are an imperative for society that connects the educational environment to economic performance.

Keywords: Science and technology, Resources, Education, Sustainable Development.

1. Introduction

The general lesson that sustainable development affirms in the context of the world economy imperative establishes the management of natural ecosystems' complexity in a sensitive social norm to the possibility of changing behaviors by emphasizing statistical reality. But listing corroborating facts does not necessarily mean proof. Moreover, can we construct a general rule according to observation confirmations, or do we approach the truth through negative examples? The linearity of confirmation observations (which mainly occurs after the action is completed) in SD is argued by the rationality of credible information that establishes a plurality of value judgments. An education conducted for democratic purposes establishes a critical evaluation of controversial evidence and develops the ability to judge controversial issues with solidly constructed arguments; practice for controversial discussions develops a deeply analytical thinking, increasing the ability to identify false statements and arguments (Kahne and Bowyer, 2017).

Human capital was considered an important and liberating step for the scientific community and subsequently for the economic environment, and the concept of approaching education as an investment and not as an experience is a fundamental idea in SD (Becker, 1993). Moreover, in SD, the individual rate of return and the social rate of return are reinforced by the return on environmental protection actions (the Edison company conducted a behavioral experiment on energy consumption among employees, signaling consumption outside of profitability) (Becker, 1993, and Thaler et al., 2016).

The starting point of the research is that the SD effect in education is not universal, and individual motivational processes create behavioral patterns that seek supporting evidence (confirmation bias) and behavioral patterns that seek counterarguments or exercise skepticism and negative inferences for behavioral patterns (disconfirmation bias) (Kahne & Bowyer, 2017). One explanation for SD is that its inferences have stood the test of time, and its advocacy of referential correctness and concern for fairness is economically and socially significant (employers who violate fairness rules have diminished profitability, and retailers with unfair policies may lose sales shares) (Kahneman, 2015). Keeping in mind the principle of education as an investment, SD goals balance the effect of education in the principle of multilateralism and appearance, so that almost certain outcomes receive less weight than their probability justifies. The imperative for sustainable development brings a qualitative change instituted at the expense of the certainty effect (expectation and confirmation bias) and recalibrates the utility of the educational institution to be more in line with economic needs (Tomlinson, 2017). The decisional weight in circumspect inference, which education capitalizes in SD goals, highlights the individual utility exercised in educational constructivism represented by the diversity of cultural, social, and human capital factors (Tomlinson, 2017).

An imperative for the value function is manifested even if utility theory is a logic of rational choice, choices are not always perfectly rational, and an educational pattern that includes attitudes, emotions, and perceptions represents a sustainable strategy for assessment and

capitalizing the diversity effect in SD (Banihashem et al, 2023). Even if we would be tempted to say that emotions and intensity, influence the availability and evaluations of educational performances, in the logic of rational choice the probability of an event is deprived of overestimation and overweighting, considering the educational commitment of students in effort, attention, persistence, and their emotional reactions (Korpershoek et al., 2020).

To this literary contribution, this study participates with a predicative analysis between the pillars of SD and human resources in science and technology. Considering that performance in SD is very probable, in the study we focus on the factors that influence it. A wide literature analyzes the rate of return in education with research probabilities that instrument qualitative or quantitative variables, as the educational act is a decision for its yield, this study proposes to increase the effects horizon within the limits that biodiversity establishes.

For this purpose, analysis includes statistical indicators capitalized by NUTS and Eurostat, such as forestry, environmental protection, construction investment, and agricultural land, analyzed in the HRST effect. Considering HRST as a predictor for education, the statistical analysis performed observes how various ecosystems influence the HRST effect. In the paper, it was analyzed whether HRST is influenced by anthropogenic ecosystems more than by natural ecosystems, and to what extent investments in SD (anthropogenic and natural) contribute to the variation of HRST. The results are capitalized by statistical executions, and the probabilities are calculated with hetregress fits linear regressions.

Considering SD as a result maximizer, the study reveals that parameters such as forestry, environmental protection, and construction exert benefits on HRST, although it establishes both social and economic responsibilities capitalized over time, in the SD goals. Time, the unit of measurement, is a parameter used in the profitability capitalization in the SD strategy. Central and Western European countries invest in environmental protection actions and forestry in maximizing the HRST effects, while Eastern European countries and Türkiye invest in construction. Of course, in utility theory, compatibility under all circumstances increases the

instance for "in provement" as a model of national choice. But the external perspective (diversity exogeneity) that SD establishes is a remedy for biased value judgment, and from this point of view, the study is a contribution.

The study is divided into the following sections: in section 2 literature review is presented. Section 3 presents the theoretical framework and data. Section 4 depicts results and discussion. In 5 are presented the conclusions, recommendations, and the scope for future research.

2. Literature Review

The imperative for education right, professional training, and learning is reconsidered in the event horizon of the principle of education, equal opportunities, and inclusion broadly regulated in UN resolutions regarding Sustainable Development (SD) and the fact that the education system erosion substantiated in inequality, time and resources establish a framework for cooperation and development meant to facilitate SD goals and the future of next generations (ONU, 2024).

Education missions in the SD goals reveal an intrinsic relationship between time and action, coordinates that develop a strategic framework for actions: European Commission's endeavor for the European Education Area until 2025, Digital Education Action Plan 2027, European Cooperation in the Education field until 2023, European Research Area develops epistemological limitations, and grants propensity to a robust and synergic thought that interoperates traditional disciplines with empirical and scientific learning establish the principle for a universal education empowered by european states and at the same time preventing parallel instruments and practices (UE Council, 2021). Following the agreements of the member states of the UN Framework Convention for an efficient and progressive response to climate change treaties, recognizing that education is a strategic priority (Paris Agreement, 2015), operationalizing SD goals in education involves prioritizing information, allocating resources and measures the effects so that the burden

of proof intervenes in a system of non-linearities and error amplification (concerning change climate trends) (Filho et al., 2019).

Sustainable education principles develop securitized institutional practices performed in the European Center for Digital Education with qualified resources and digital infrastructure, which enhance access, connectivity, and exchange of good practices. Forward education in the SD amplifies value chain effects and the corresponding expertise in the creative approach of green education, becoming an imperative for the green transition in the digital and green economy (UE Council, 2021).

Developing sustainability, these implementations create a contingent of social, economic, and environmental challenges, which increase the pursuit of solid evidence with interconnected educational resources for learning, communication, and reflection. This develops a world vision and a sensitivity to values. In SD, becoming intellectually conscious implies no longer ignoring statistics. Invisible statistical risk and historical retrospective risk are studied through integrity judgments based on scientific results, and not on biased judgments. Categorical necessities in SD imply decreased general asymmetries generated by social, economic, and environmental pillars, so that education must prepare students for the global context; moreover, ideal scenario learning addresses education global objectives not only correlated with a single discipline, but enhancing SD goals in which disciplines with particular objective regarding: water and sanitation, healthy lives, well being, health sciences, this type of programs performs in Nottingham UK, Victoria University of Wellington, New Zealand (Filho et al., 2019).

Although education in SD implies a heterogeneously multilateralism, at the same time develops value judgments that can be discussed but cannot be calculated. In a dynamic system, we can have rigorous thinking at the limit of authoritarianism, which conceives learning as an authoritarian form of control. Biesta (2015) defines this system's *Learnification* that defines new opportunities for learning, new experiences in learning, and environmental learning. In contrast with the principle according to which the student has to learn abstracts and general information,

educational assumption precision depicts that students learn something with a reason from somebody; this strategy accords education a sense of scope. Biesta brings in his research in the educational field, the positive effects of socialisation, which establishes a necessity for the accuracy of the intercorrelated effects of environment, culture, politics, religion, history, and traditions. A niche of researchers considers climate justice as a framework for formal education, creating a teaching methodology that addresses the issue of climate change in a way that confronts both economic and social issues (Trott et al., 2023).

The ability to see education futures can generate a complicated reflex, caused by the inequality of the educational system. Mishra's (2019) study makes a net and qualitative distinction on the factors regarding social networks, social capital, and social support that play a role in the academic process and the mechanism through which these factors bias academic performance. Its result confirms the fact that family plays a role in academic performance, and social support compensates for fundamental disadvantages alike: black female students in STEM disciplines, and underrepresented engineering students. Community influence in compensating lack of information, the positive impact of cultural resources and material, and the importance of networking resources in academic performance. Teachers' beliefs in constructivist theory are enhanced by technological advances, but teachers who position only institutional values in the educational process use technologies following the curriculum, which suggests that technologies in education will be used when teachers consider them an irreplaceable tool (Tondeur et al., 2017).

In a different research branch, the educational gender quality paradox identifies a major context that appears in countries with high levels of gender equality, which theorizes the biggest educational differences in secondary and tertiary education. Theory of value expectancy is an instrument used in decision-making by students, which optimizes academic decisions according to their performance. Social factors that manifest themselves in performance and economic sustainability bias value judgements in STEM careers regarding costs and benefits. The

jurisdictions with higher economic risks and lower opportunities can make higher-paid STEM occupations, a scenario that sacrifices economic security in the long term and education investments (Stoet & Geory, 2018). Moreover, business and education enhance the scope to change inherited inequalities, and Nordic countries support an egalitarian education and a mission for research (Marginson, 2016).

Continuous education makes us conscious of the environment. According to Kopnina (2020), SD education develops the individual intellectual condition of human beings and is not intended to serve economic purposes. SD goals optimization restricts libertarian actions, which enhance rational behavior for the future in the sustainable hypothesis of economic growth, coupling resource consumption with ecosystem boundaries. *Critical pedagogy* has an ideological utility that is settled beyond the biased interest of the state and industry, capitalised on cultural democracy, sovereignty, and human rights. Western European educational models develop analytical thinking and the capacity to make decisions without a general theory, involving quality of life indicators and ecosystem integrity. If SD phase a resource consumption counterfactually (Kopnina, 2020), human nature anticipates a *fine adjustment in the green transition* under the Student for Carbon Dividends (fiscal redistribution for the population of companies winnings still depend on carbon technologies) (Ionescu et al., 2022). Although SD brings incentives in technology, Loughurst (2020) identifies anxieties among students who learn online with uncertainty for their educational future and the resources that engage students in the institutional process. Environment predictive utility in the establishment of educational foundations is researched by Mouroe and his team (2017); their approach for a pedagogical constructivism generates context about climate change, which students analysed with activity surveys. Deliberate discussion and interactions with the scientific environment eliminate misconceptions and missing information, and students develop their pieces of knowledge by being involved in the climate project projections and implementations.

3. Theoretical Framework and Data

This study examines the empirical dynamics of SD pillars as a determinant of HRST performance, incorporating the effects of other control variables.

Knowing that a wide literature analyses science and technologies effects on the economy and on the environment as one of the leading factors that contributes to reducing the economic gap, increasing investment, and improving the employment rate. This study aims to code HRST in the associated probability of SD pillars, assuming that HRST exerts a dual correlation both in SD goals and in the economy. Aim performed with the following research question: *SD incorporating the expectancy of economic and environmental assessment has a dynamic outcome on HRST.*

To test the SD pillars' impacts in research and development, according to the following execution syntax, it is understood the level of forestry, as HRST proxy, together with other input factors, as agricultural land, environmental protection, and construction.

To determine the relationship between sustainability and the HRST was model the below multiple econometric regression, (Zahar et al, 2022).

$$HRST_{it} = \beta_0 + \beta_1 forestry_{it} + \beta_2 environmentprotection_{it} + \beta_3 construction_{it} + \beta_4 agriculturalalland_{it} + \varepsilon_{it}$$

Where the dependent variable is HRST, β_0 is the constant, and $\beta_1 - 4$ is the slope of the independent variables, i is the country, and t represents period, and ε_{it} count standard error.

3.1 Data

The list includes dates reported by 33 countries as follows: Belgium, Bulgaria, Czechia, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, Norway, Switzerland, Bosnia and Herzegovina, North

Macedonia, Serbia and Türkiye. Panel observations were retrieved from the Eurostat database, regarding Eurostat, it is the statistical official website of the European Union. Panel data contains non-financial observations, and the research sample includes the countries for which the required variables are available for 2014 - 2023. Dates are capitalised in the Eurostat framework by country reports, provisionals, and values imputed by Eurostat or other receiving agencies. Given the heterogeneity of the dates, reported in different measurement units: HRST, person with tertiary education employed in science and technology in thousand person, forestry with an annual frequency, reported in million euro, environment protection reported in million euro for the undertaken activities, construction reported in production volume index and agricultural land reported by arable land in euro per hectare, the final panel dates for statistical and regression execution contains median of the period 2014 - 2023, performed for which variables. To ease the interpretation of results, moreover, the advantages of using median are that the results would be in point elasticities, tending towards convergence.

3.2 Methodology

The major challenge for the distribution performed was the fact that HRST dynamics are not exogenously related to various macroeconomic variables. Given the difficulty of finding reliable variables beyond the lagged value of HRST, a large literature uses GMM to deal with possible endogeneity, considering internal instruments, since such a setup is not appropriate for our analysis, requiring a large number of dates in cross cross-sectional time dimension (Combes et al., 2024).

Keeping in mind the orientation from reality to possible explanatory models, and taking into account that there is a similarity between the different processes of nature and the behavior of social groups, and taking into account that the information in the theory of dynamic systems can be fragmented or even insufficient or unavailable. Considering that in OLS the significance level was not reached due to the number of observations, we considered the variance fractal (asymptotic approximations with low influence, Ghosh et al, 2016; unknown signal steering, Liu

et al., 2013), managing to calibrate it with hetregress fits linear regressions (heteroskedastic model in cross-section time, Blazsek et al., 2024; multinomial distribution in heteroskedastic robustness, Landa et al., 2021). We applied this method under the assumption that the average is correctly determined, according to the best knowledge we have, which determined a correct variance model for the exponential function. In this inference, variance might increase with the HSRT likelihood.

4. Results and Discussions

Taking into account the properties of the dynamic systems in which HRST manifests, even if HRST manifests a critical exponent of the nature of well-being in the effects horizon of the variables, this is independent of the details of the dynamic systems in which it manifests itself by the fact that HRST generates a response reaction and not a confirmation of reality. Moreover, the logarithmic method used may indicate an advancing process of HRST conferred by ecosystem dynamics. Forestry and Environmental protection are performed in HRST as a descriptive forecast. The transition from descriptive to reality is rendered even more precisely by the predictability of the constructions in HRST, although the inference must be approached from the perspective of incompleteness and scalable results; nevertheless, the obtained model invokes the transition towards an open and analytical thinking.

4.1 Statistical results

The distribution model was statistically analyzed regarding the properties of the distribution. Symmetry of the distribution was examined with the Skewness test, and to test the characteristics of the distribution tails was applied to the Kustosis test. For each variable, the minimum, mean, and maximum orientation were determined. Summary statistics are represented in **Table 1**.
Descriptive statistical results.

Descryption	Min	Mean	Max	Skweness	Kurtosis	SD
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HRST	0	264	3718	2,653175	7,259930	31,96914
Forestry	0	663	8668	1,907507	2,784315	31,96914
Environment protection	0	161	6917	4,211249	20,00759	31,96914
Construction	82	98	118	0,319374	1,034726	31,96914
Agricultural land	0	8271	11706	-1,10168	-0,533449	31,96914

Table 1. Descriptive statistical results

Source: Author research

Notes: Statistical technique determined for the dependent variable HRST and for the independent variables Forestry, Environment protection, Construction, and Agricultural land, the dynamics of min, mean, and max. The distribution's distinctiveness was analysed symmetric and tailored.

Skewness test indicates a positive distribution except for the agricultural land parameter, achieving a negative effect. Symmetry of the distribution indicates two different types of tails. While Construction, Forestry, and Agricultural land assemble a light tail, with results near to zero, HRST and Environment protection perform a heavy tail, giving robustness to the distribution. This indicates an asymmetrical but balanced distribution. Even though the result of the Kurtosis test can be considered a regression, with a higher error weight (HRST and Environment protection >3 , leptokurtic tail), in fact, the characteristics of the dates generate a scaling amplitude.

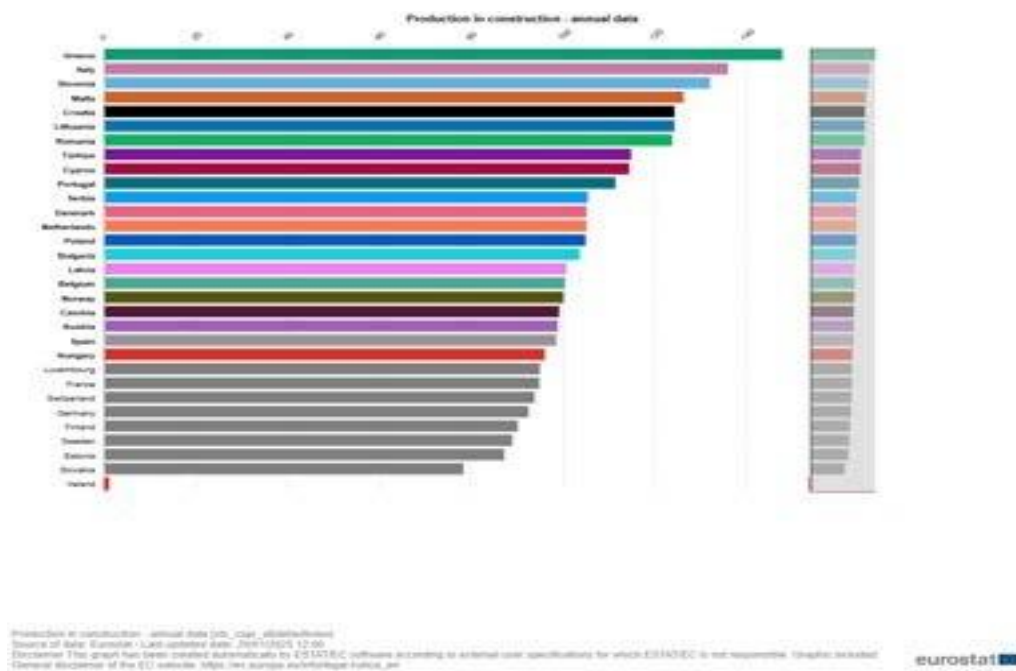


Figure 1. Production in construction

Studying statistical results from the perspective of time (panel contains dates between 2014-2023) suggests that the SD pillars take effect in the last part of the analysed period. Taking into consideration that all variables have a minimum of 0, the large distance between mean and max indicates that the action in SD was capitalized in effects (actions and dates) in recent times. The exception to this inference is construction with a constant presence during the cross-section time. This can be seen in the average presence of states in Eastern Europe, Southern Europe, but also in countries like Türkiye. **Figure 1** represents countries in construction production. If the construction contingent is mainly represented by countries from southern and eastern Europe, investments in science and technology are represented by central European countries and Türkiye, results shown in **Figure 2. HRST in Europe and Türkiye.**

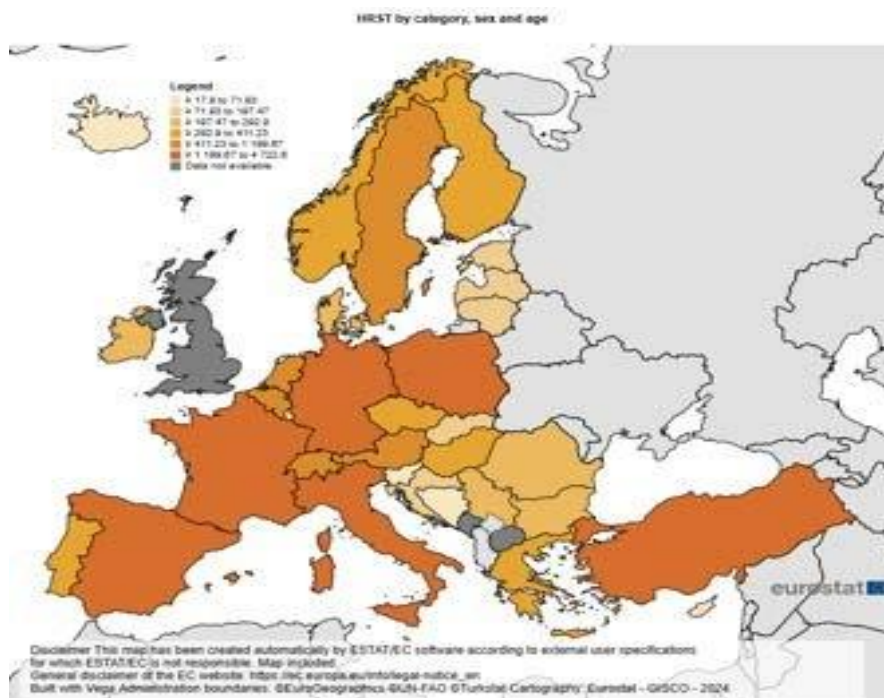


Figure 2. HRST in Europe and Türkiye

Source: Eurostat database

4.2 Regression results

The combination of events established for the research assumption analyzed under the impact of the probability effect of the SD pillars on HRST reveals the complexity of the statistical correlation of the social dimension (represented by HRST) with the statistical dimension represented by the SD pillars. In the study, the popularization that science and technology achieves in the complex systems of biodiversity explains the existence of analogies between the different processes of nature and social behavior, moreover, the analysis reveals a hypothesis for equilibrium signaled by the presence of natural ecosystems that outpace critical phenomena in social science. However, the analysis highlights that there is more statistical support for natural ecosystems (forestry, agricultural land) that outpace anthropic parameters (construction, environmental land) in the variation of human resources in science and technology. I said in the

statistical analysis that the dynamics of the system is independent of its critical points, a scaling that the countries of Central and Western Europe manage to achieve, in the regression analysis, the hypothesis is tested by the forestry significant effect on HRST. Is construction a predictive model for HRST, or is it the best proxy for some states? Analyzing the inference for Central Europe does not represent a valid model, but for Eastern and Southern Europe and Türkiye, it represents the optimal land for HRST.

Statistically argued the benchmark model depicts a result that calibrates a nonlinear process in favor of the research hypothesis. Under the uncertainty revealed by SD (the essence of sustainable development is based on a functional rationalism), science and technology can be compatible with this. The performance that the study achieves (with a very small dataset) maximizes the probability of the variant under the effect of informational entropy (Log likelihood = -144,43). **Table 2** represents regression results.

	β coefficient	Std. err.	Z-Test	$p > z $
HRST				
Forestry	.365775	.0344238	10.63**	0.000
Environment protection	.4680971	.0816201	5.74**	0.000
Construction	-5.197598	.1347402	-38.57*	0.000
Agricultural land	.0035001	.0003624	9.66**	0.000
Log likelihood	-144.4313			
Wald chi2	323566.56			
prob>chi2	0.0000			

Note: ** z test > 1,96, and * z test < 1,96

Table 2. Regression results

The regression model performed with the Wald test demonstrates the weak contribution of the independent variables to the variation of the dependent variable HRST (low influence Ghosh et al., 2016) with a probability $\text{prob} > \chi^2 = 0.0000$, which generates constraints on the statistical parameters, including estimated precision, incidence of which is also contributed results of $p\text{-value} = 0.000$, we can conclude for the low materiality of the panel observations.

The theorized distribution with the Z test places the significance level in the critical region $(-\infty; 1,96] \cup [1,96; +\infty)$, a predictive result considering the abstraction obtained for the $p\text{-value}$. However, the model is a suggestive example for SD research, while many studies analyze SD performance using statistical tools with standard errors and linearities, for SD scenarios with a random degree of risk, traditional statistical tools may be out of date or meaningless. A representation of the econometric results is made in **Figure 3**, representing the impact of environmental protection in Europe, and the impact of construction investments is represented in **Figure 4**.

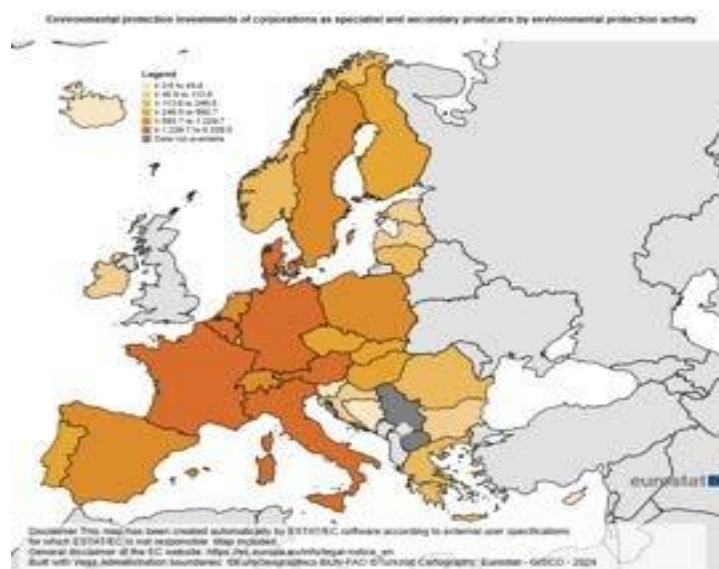


Figure 3. Environmental protection

Source: Eurostat

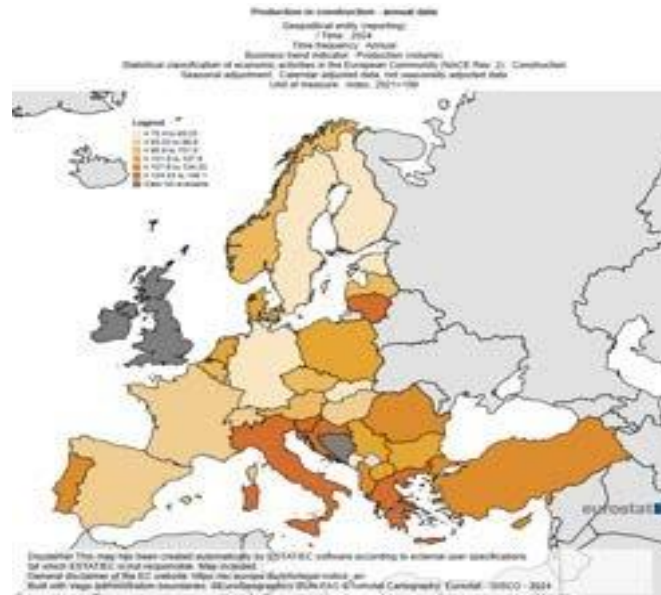


Figure 4. Construction

Source: Eurostat

5. Conclusions

The study highlights the relevance of environmental characteristics for the educational process. For the research objective, the prerogatives of education were exponentiated in the field of science and technology (HRST), resources anticipatory SD.

When higher education in society generates a qualified resource and not from regulation or economic pressures, but from the social need for higher educational opportunities, the role of the school context is reflected. But in a capitalist society, the opportunities that higher education introduces are not universal. In the expectation principle, the common form of education as a good increases the return on its opportunities, but also perpetuates inequalities and demonstrates the autonomous power of institutions to shape social outcomes (Marginson, 2016). The demand

for human capital (skills and productivity) unlocks institutional boundaries, and further value in rates of return is a trigger for accessing and performing in the educational system.

HRST also contributed to the teacher-student relationship, which can increase or decrease externalities generated by the environment. In the sense of connection to a group or community, it is a generating factor for institutional performance. *Engagement*, according to Korpershoek teams (2020), is a meta-construct for the relationship between the student and the environment, although many other studies define it as *behavior*, however, the inference establishes self-concept and efficacy to perform both in school and in the environmental system. The behavior of teachers centered on students adopts an educational process that is identified in constructivism theory or social constructivism, the information is capitalized under the relevant context oriented towards technology and applied sciences, a relevant context for SD where new information and experience call for relevance and meaning (Tondeur et al., 2017).

Time pressure, from the SD perspective, suggests both the obstacles that explicitly become rules for the educational system, but also the benefits that SD creates for the educational system, biased by the same institutional rules.

The present study, based on statistical research according to an observational panel collected for Europe and Türkiye (we considered it important to keep Türkiye in the study due to its contributory role in science and technology), highlighted stringent results, the smaller the number of observations.

The hypothesis research represents a direction of statutory correlation that the states of Western and Central Europe realize. According to it, the elements of diversity represented by environmental action protections and forestry have a significant impact on HRST. The presence of the natural element forestry is a parameter that acts positively on the HRST yield, which means that people include in their opportunity endorsements (in terms of education and profession) the weight of the diversity of natural elements. This parameter is amplified by the power effect of environmental protection actions. The investments made in this regard by the

above-mentioned states compete in the opportunity analysis for a choice made in HRST. That improves the HRST trend across the SD outcome.

But the same positive effect on HRST is also manifested in the Eastern countries and in Türkiye under the action of construction investments. The presence of construction investments is a median (and not only from the perspective of the statistical results obtained), it has a constant presence throughout the last 10 years analyzed and as a result of the dual function it performs, of investment and sustainable development, which can be considered a binder in SD and more precisely in HRST.

Limitations and future research

Given the world wide dimension of SD and HRST, the selection of interest centers may bring limitations. Europe is an operational center for SD, but equally are: Africa, Australia, America, Western Asia, so that studies increase in effectiveness the more the native criterion is present in a diversified manner. Future research may bring more into discussion the SD epistemology.

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