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Improving economic development and sustainability: Macroeconomic Impact of Gender Diversity in Board Composition for European Economies

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Abstract. Following the recent focus of the European Union on gender diversity with the imposition of EU-wide diversity quotas on listed company boards of directors, this paper aims to explore the potential macroeconomic impact of this regulation. The paper conducts several stages of econometric analysis meant to isolate a statistically valid effect that diversity can have upon a country's macroeconomic performance, starting from the premise that there are indicators that are "close" enough to the actual economy to capture an effect that may be due to diversity changes, especially if they are related to the sustainability performance of that economy. Utilizing resource productivity as such a macroeconomic indicator, the paper successfully shows that there is a positive, significant and statistically relevant im-pact that gender diversity in board composition can have upon a country's economy as a whole, within modelling limits. Further on, only seven countries out of 29 analyzed, individually exhibit statistically relevant positive influences of gender diversity upon eco-nomic performance, while a panel data analysis concludes that the EU can potentially expect a 0.7 increase in its countries' resource productivity index for each percentage point increase in diversity, within conceptual limits.

Keywords. gender diversity, macroeconomic impact, board composition, European Union

1. Introduction

When determining whether or not the Board is meeting its tasks effectively, the board's independence, size, and makeup (including the diversity of its members) are all important factors to consider. A crucial board job in this regard is to assist in the shaping and direction of the company's long-term strategic orientation within its industry. It might be claimed that the board of directors' membership is critical to its effectiveness, as tack-ling strategic challenges necessitates a varied pool of skills and perspectives.

Progressive boards recognize the need of having an ideal composition that represents the company's strategic aims as well as the diversity of its stakeholders [1]. Boards are increasingly understanding that persons with a diverse range of ages, experiences, and backgrounds are more likely to support productive debate and more accurate decision-making [2]. The issue of the impact of diversity upon board performance continues to be an investigated issue, both in literature as well as in private research conducted. While there seems to be some debate as to the direct relationship of diversity with performance, the general consensus is to this day that greater diversity generally leads to better and more sustainable decisions. Gender diversity on the board of directors can be investigated at several levels, including the individual, firm, industry, and the board itself. A female member of a board of directors, for example, can act as a role model on a personal level and at the same time, gender diversity in the workplace can have an impact on organizational legitimacy and corporate oversight [3].

In an overarching literature review of verifiable diversity impact upon various aspects of economic activity, the conclusion has still been startlingly inconclusive in proving the existence of a measurable and undeniable impact that an increase in diversity could produce upon the wider economy as has been lauded over the years [4].

While several attempts have been made to clearly define the positives of having equitable representations in company leaderships based on gender criteria, evidence remains minimal, and to some extent even negligeable as to whether diversity does improve the situation, beyond some marginal performance improvement that has been declared as statistically irrelevant [5].

Beyond this, when studying into the particular impact of forced gender diversity measures in company leadership in particular in Italy, it has been found that there was no significant, measurable impact of the quotas introduced [6].

Surprisingly, just a few peer-reviewed empirical research papers on raising the number of women on corporate boards have been published [7]. However, results from some of the available research show a substantial link between female directors on boards and innovation effectiveness as evaluated by R&D spending and citations, particularly in industries where innovation and creativity are key [8].

Gender and ethnicity, as well as independence from the firm's internal constraints, are frequently discussed in discussions concerning board diversity. The main point of the argument for a diverse board is to go beyond selecting members based on their fit into one of these categories. Effective board discussions necessitate a diversity of viewpoints, which is promoted by varied composition by definition. Selecting directors based on filling a category to satisfy the desired composition without evaluating if the director can satisfy the need for diverse perspectives decreases the chance for robust debate and well-rounded decision-making.

A board's composition should reflect variety of thought, background, skills, experiences, expertise, and a range of tenures relevant to the company's existing and future conditions. It is plausible to assume that diverse backgrounds and experiences on corporate boards, particularly those of directors who represent a broad spectrum of society, increase board performance and encourage long-term shareholder value development [9].

Overall, if we are to take a look at the most recent research on the macroeconomic impact of gender diversity in top-end academic literature, which in this case is taken as literature present in Scopus and Clarivate (Web of Science) databases, we can notice a general disregard for the subject. A search for “gender diversity macroeconomic impact” restricted to economic fields yields just 10 results in the case of Scopus and 14 results in the case of WoS. Of these, the most

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relevant articles still lean more towards the microeconomic level, focusing on company level analyses, or types of companies.

Of particular relevance to our work recent research has shown that gender diversity is one of the contributing factors for improved sustainability reporting for listed companies [10]. Perhaps unsurprisingly since it has indeed become a standard for listed companies to include diversity actions and progress in their sustainability reports [11]. Additional recent papers find that leveraging diversity can have an impact on the performance of commercial banks [12], while at the same time there is evidence that gender quotas in Norway did not produce statistically significant effects upon the valuation of companies [13].

Given the existing literature on the matter, this paper proposes that statistically valid evidence of the impact of diversity at the economic level may be found in macroeconomic indicators that are closely related to the performance of companies within the economy and are related to the sustainability performance of the economies in question.

Overall the paper is aiming to establish whether:

- There is a measurable and statistically relevant influence of diversity upon a country's resource productivity.
- The sign (positive or negative) nature of that relationship if there is one

Outside the scope of the above main objectives, the paper will also try to identify the magnitude of the relationship between diversity and resource productivity using additional statistical modelling

2. Materials and Methods

This paper attempts to introduce a new approach for assessing the potential impact of diversity, by relying on the argument that macroeconomic indicators, especially ones that are less aggregate in nature, can actually capture the effect that gender diversity on boards may have as a whole. What this means concretely is that for a given territory, there could be a statistically testable effect of gender diversity on boards, by virtue of the idea that the economy relies mainly on companies and those boards in order to improve, and as such, if there is a compound economic effect that diversity produces, it will be seen in the relationship between diversity and the "close" macroeconomic indicator chosen.

There is a particular emphasis on contrasting the case of Romania to the rest of the European Union in order to both serve as a proof of concept for the analysis method, as well as to serve the general argument of the paper. The paper's argument is built around comparing Romania to other the rest of the EU regarding this aspect of diversity and then moving forward to applying the same methodology for multiple countries in the EU. Thus, In order to serve the general objective of the paper, which is to provide statistical proof of the increased benefits of an increased level of diversity in a country's economy, this paper has focused on conducting two different levels of analysis.

The first level of analysis, and the most simplistic, is based off of the basic premise of the paper: that there is a clear statistically significant relationship between the lower-level or "close" macroeconomic indicator, closely related to the engine of the economy, namely centered around the major enterprises within a country's economy. An additional potentially helpful aspect identified in literature is that sustainability related indicators in past research have been more conducive to exhibiting effects related to variance in diversity. Thus, resource productivity is taken as a proxy for the general performance of the enter-prises within an economy, making the first level analysis essentially a regression of a country's resource productivity (as a dependent variable) against the board gender diver-sity in that country (independent variable). In addition, resource productivity as a macro-economic indicator can be considered as directly related to the sustainable practices within that economy due to the fact that one of the main aspects of sustainable business is related to reduced, more efficient consumption and one of the main components of country resource productivity is Domestic Material Consumption.

The second level of analysis is an in-depth look at the statistical relevance of the first level regression analysis in order to investigate whether those regression results are trustworthy, and if not, correct the model in order to obtain a more accurate representation.

2.1. Data

In order to gather the necessary data for our statistical analysis, the Eurostat database was employed as a source of secondary data. Unfortunately, when it comes to diversity in company leadership, the only type that is present in the form of actual data is specifically gender diversity. Thus, as far as the analysis within the following section of this paper is concerned, diversity refers specifically to gender diversity unless otherwise stated.

Specifically, the following data tables have been collected from Eurostat for the stated purpose [14]:

- Positions held by women in senior management positions [SDG_05_60] in the form of a percentage out of total positions available for boards.

The indicator percentage of females present on the boards of the 50 largest publicly listed companies for a given territory, in this case Romania. These companies are usually maintained by an Exchange into an index for the local stock market and thus only those companies registered in the target country are taken into consideration. Board members refers to both the members of the management board as well as those of the board of di-rectors, thus making the measure uniform across all systems of corporate governance, be they a single tier or two-tier format. This means that for each company the measure includes the chairperson, as well as the senior executives present on the board, together with non-executive directors, as well as employee representatives where it is applicable. As mentioned, in the case of a two-tier system the highest body is represented by the supervisory board, which normally should not have any executives present, while the board of directors of the unitary governance system contain both executives and non-executive di-rectors [14].

- Resource productivity and domestic material consumption (DMC) [SDG_12_20] in the form of Purchasing Power Standard per Kilogram.

Resource productivity is gross domestic product (GDP) divided by domestic material consumption (DMC), the latter which measures materials directly used by an economy for the purpose of production. It is calculated using the quantity of raw materials within the targeted territory, adding all physical imports and then subtracting all physical exports. The reason that PPS/kg was used is to make the series more easily comparable between countries when expanding the analysis across multiple economies.

The data series were taken for Romania and the EU-28 average (for diversity and productivity) from years 2003 to 2019. The reason for this timeline is the fact that 2003 is the earliest extent to which data on diversity was found in the Eurostat database, thus establishing the beginning year of the analysis period.

The reason for also extracting the aggregate series is because we are using the EU-28 as a benchmark of comparison for Romania’s progress itself in our analysis. Essentially, the analysis now tests whether when Romania had a better diversity makeup that the rest of the EU-28, did it also have an actual better performance in terms of resource productivity.

It should be noted that due to lack of data at the level of individual countries, it is not possible to reach the minimum threshold (25) for a potentially accurate representation of the relationship between diversity and resource productivity given the respecting of regression validity conditions. However, the existing data (17) is more than sufficient to establish whether there really is a relationship between the two variables and its shape (in this case positive, negative or neutral). For the fulfilment of the main objective of our re-search it is considered sufficient to have statistically valid proof of the sign of the relationship between the two investigated variables, which require a minimum of 8 data points for low-variance situations [15].

2.2. Data Processing

As mentioned, the data requires a bit of processing in order to bring into a shape ready for analysis.

For the first stage analysis, it has been theoretically conceived that the impact of gen-der diversity may get easily blurred within the multitude of factors that decide a country's macroeconomic progress. As such, the data was taken through another step of processing, meant to analyze the immediate impact that diversity may have upon resource productivity, which is in itself a macroeconomic indicator that is more directly impacted by the performance of a country's companies.

Thus, for analyzing the impact of diversity on resource productivity, not only was the EU-27 average taken out from both series as implied by the comparison, but we also proceeded to extract the year-to-year progress made by Romania when compared to the EU. In consequence we obtained two new series for analysis, designated Prod_Prog_v_EU and Div_Prog_v_EU, produced by first subtracting the EU-28 average resource productivity and diversity out of their Romanian respective equivalents, and then subtracting each previous yearly difference from the next one in order to obtain the progress series.

It should be noted, that the second set of transformations are also inherent in the application of the Engle-Granger regression correction method (the first difference of the series Prod_diff and Div_diff) which will be applied when conducting the general analysis over multiple economies [16].

2.3. Tools and methods employed

The statistical tools employed for this analysis essentially revolve around using Re-gressions in order to determine the relationship between the diversity and each macroe-conomic indicator. The specific software used for producing the results was Eviews ver-sion 12 SV, whose outputs were utilized in the results section.

Specifically, simple linear regressions (Lease Squares and ARMA) were used in test-ing whether there is a relationship between diversity as an independent variable, and re-source productivity of a country as a dependent one.

For the regression, full testing was employed in order to verify the validity of the re-gression results. This means that the full battery of tests includes:

- F-tests for regression model fitness
- T-tests for coefficient significance
- Durbin-Watson test for presence of autocorrelation in residuals
- Jarque-Bera test for residual normality
- Breusch-Pagan-Godfrey heteroskedasticity test

Failure of a regression in testing would automatically lead to the attempt to correct for any data errors which lead to the inaccurate regression model. In order to correct the re-gression, employing the typical Engle-Granger approach or moving on to alternatives, further testing is required, namely [16]:

- Dickey-Fuller tests for the stationarity of the data series
- Johansen cointegration tests vectors of cointegration
- Error-corrected regression model testing based on the results from the previous two types of testing.

Ultimately, following regression correction a decision was made whether there is significant statistical evidence using these models in order to conclude that there is indeed an impact produced by diversity upon macroeconomic performance. In this case, mixed results have led the analysis to move into further regression models, specifically Panel re-gressions in order to overcome data limitations:

- Panel Least Squares (Panel LS and AR)
- Panel Estimated General Least Squares (EGLS) with Seemingly Unrelated Regression (SUR) period weights

It should be noted that due to the shift to panel regressions and their higher reliability and data availability (after applying SUR specification to address heteroskedasticity and autocorrelation), no further robust standard error investigations were conducted for individual countries mainly due to the low value of only being able to reliably establish the sign of the relationship at the country level as a result of limited data.

3. Results

This study is in some respects a response to previous analysis of the European Commission's impact assessment of establishing gender diversity quotas. While the EU's impact assessment claims that increased diversity would be beneficial for improving the performance of a company's leadership, previous research identifies that the effectiveness of achieving such an aspect through quotas is very hard to determine [9].

The impact of gender diversity quotas would require a more in-depth evaluation and slightly more specific criteria for analysis especially given that it is very difficult to identify whether gender itself is indeed the determining factor in improved performance, or whether it is another aspect such as functional or ethnic diversity as women themselves tend to pick different career paths than men [9].

3.1. Impact of gender diversity on resource productivity in Romania

Moving on to the actual testing the impact of diversity on the country's resource productivity, we have made significant processing to the data in order to isolate more accurately the potential macroeconomic impact of board diversity in order to justify creation of a generalized analysis approach for determining gender diversity impact.

First of all, diversity and resource productivity are not tested directly, but rather their changes. What this means is that we're testing whether the change from one year to the next in board diversity is actually producing a significant effect in the growth or decline of resource productivity for Romania, when compared to the performance of the European Union as a whole. This means that the data introduced into this series of testing has undergone the following transformations:

- The data values of the basic series for the entirety of the European Union (meaning average of the EU-28 diversity and resource productivity) have been subtracted from the values registered for the country of Romania, similar to what was done in the first analysis but only for Diversity. Both these series have been denominated Div_Diff and Prod_Diff respectively.
- The second step involved obtaining the yearly change in these two new series, which was done by subtracting the corresponding value for one year from the corresponding

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value for the previous year. In the case of diversity, this has resulted in the pro-cessed series indicating the Diversity progress of Romania compared to the EU, designated Div_Prog_v_EU. This series contains data indicating the amount of percent-age points that Romania has managed to gain or lose during that respective year, when compared to the general progress of the EU as a whole.

- Unlike diversity, resource productivity was not presented in a percentage format, as such, the decision was made to modify the series indicating the progress of resource productivity of Romania when compared to the EU. Designated as Prod_Prog_v_EU, the difference in productivity for Romania compared to the EU from one year to the next, was divided by the earlier value and multiplied by 100. The resulting series of data gives us information regarding the Percentage change that Romania's resource productivity has undergone from one year to another when compared to the EU.

Thus, our regression analysis has the following format after the series have under-gone all their changes:

Prod_Prog_v_EU = C(1) + C(2) * Div_Prog_v_EU

Conducting the linear regression, we obtained the following results in Figure 1:

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-1.431829	1.749693	-0.818332	0.4269
C(2)	1.040987	0.354565	2.935957	0.0108

R-squared	0.381074	Mean dependent var	-3.325125
Adjusted R-squared	0.336865	S.D. dependent var	7.989494
S.E. of regression	6.506091	Akaike info criterion	6.699823
Sum squared resid	592.6090	Schwarz criterion	6.796397
Log likelihood	-51.59859	Hannan-Quinn criter.	6.704769
F-statistic	8.619845	Durbin-Watson stat	1.840544
Prob(F-statistic)	0.010843		

Figure 1. Regression Resource Productivity Progress v Diversity Progress compared to EU in Romania

Looking at the Adjusted R-squared value, this model indicates that there would an over 33% impact in variances of Resource Productivity of the country that are determined by a change in diversity, which seems like a rather large number given the usual statistical insignificance of diversity at the macro level in previous literature, which is a first indica-tor that serious validity testing is necessary for all following analyses.

When moving onto validity testing for the model, we notice an F-Statistic that is well within the 5 percent significance level that we are looking for. Moving into testing for the coefficients, we can see that the c2 coefficient, which is the slope of the relationship is also well within the 5 percent significance level, even almost entering the 1 percent. This means that preliminary validity of the model has been verified.

The only concern, so to say, would be the c1 coefficient, which is not statistically significant, meaning that it could be 0 or even positive. This is actually in line with the logical analysis of the relationship, as when there is no growth or decline in diversity, we cannot really guarantee just on this model that there would be a decline in the Romania's progress in terms of productivity. The fact is that there are too many factors involved in the way an economy performs, not least of which are the other types of diversity other than gender diversity that can perhaps fill in the gap to a certain extent.

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Moving further into validity testing of the model we can see a markedly different sit-uation in terms of autocorrelation. The Durbin-Watson statistic of 1.84 is close enough to the ideal value 2 that we can declare that the model presents no autocorrelation. The main reason for this is likely that the amount of processing that was made to the data prior to its insertion into the regression model has already eliminated most elements such as stationarity which would normally lead to the presence of autocorrelation.

Given that there is no autocorrelation, before jumping to the conclusion that the mod-el is accurate, there are other two validity conditions, namely homoskedasticity and re-sidual normality investigated in Figures 2 and 3.

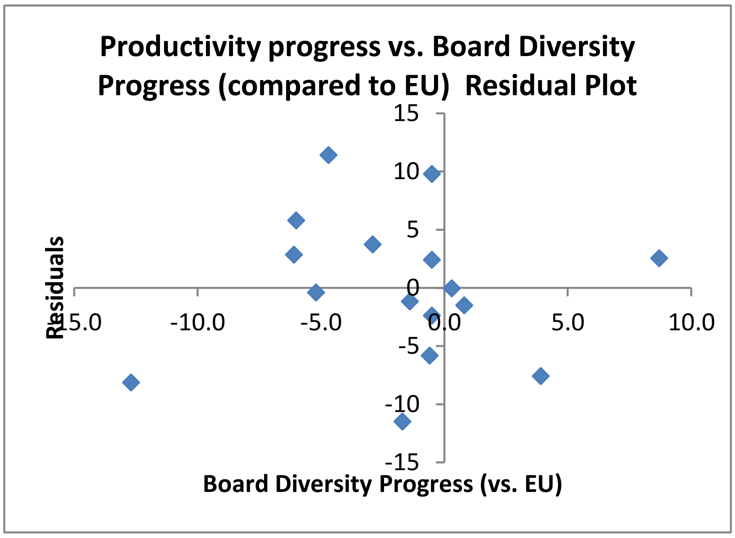

Figure 2. Residual Plot Resource Productivity Progress v Diversity Progress compared to EU in Romania

Looking at the residual plot for this regression we notice that the distribution of the residuals does not really present any specific pattern, being apparently randomly dis-persed both in terms of sign as well as in terms of magnitude. As such we can say with a fair amount of confidence that the residuals for this regression are indeed homoscedastic.

This final regression assumption left to be tested is the normal distribution of the re-siduals. While it may not be directly obvious from the graph itself as there are certain sec-tions within the distribution that are actually missing, upon conducting the Jarque-Bera test for normality we obtain a value of 0.2, which is very close to the ideal value zero. It is close enough that the probability of the residuals being normally distributed is over 90 percent. While not perfect, it is well enough to conclude that the residuals for this regression respect the assumption of normality.

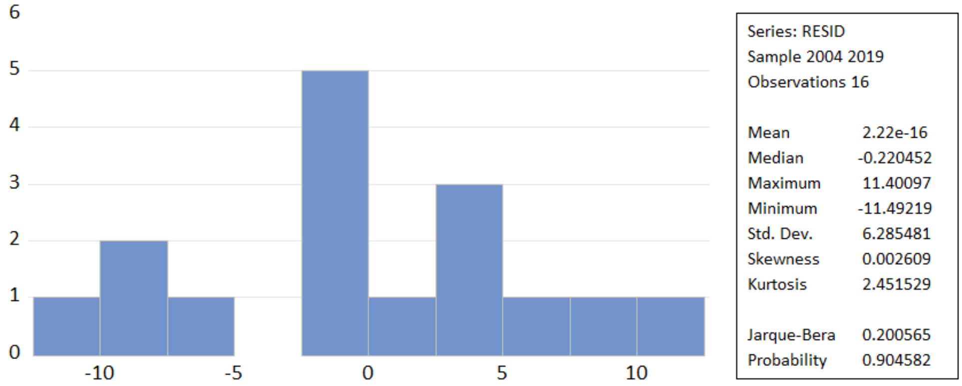

Figure 3. Residual Distribution Productivity Progress v Diversity Progress compared to EU in Romania

Finally, after going through all necessary testing we can conclude that the predictions made by this second regression model are statistically valid and can be used to build our argument that gender diversity does indeed have a verifiable, positive macroeconomic impact upon resource productivity. The magnitude of that impact however, denoted by coefficient c(2), cannot be considered accurate beyond its positive nature due to the limited amount of data and would require further exploration.

3.2. *Expanded analysis*

While in the case of Romania we found that there is a statistically relevant positive impact of board diversity upon resource productivity, this level of analysis was mainly used in order to test the initial viability of the premise that there is a verifiable macroeconomic impact of diversity detectable in resource productivity.

In order to make for a more suitable analysis over multiple economies, the analysis method utilized above has been slightly adapted for ease of general application, an aspect that was slightly simplified by the fact that the purpose of the general application was not to identify as accurately as possible the impact of gender diversity on resource productivity, but rather to more simply establish whether that impact actually exists and is statistically relevant and verifiable across all countries of analysis.

Thus, data series have been selected in order to make the analysis generally applicable to the area of interest, which in this case is the European Union and closely related economies.

Thus, the following generalized approach has been established for analysis of multiple countries:

- First stage regression analysis relies on using resource productivity as a dependent variable, and diversity as an independent variable. This has been designated as a Type 1 analysis, meaning that there was no further processing done to the data be-yond the basic raw data obtained from Eurostat.
- Type 2 format first stage analysis has been established for those countries where additional processing of the data has been done, in a similar manner to Romania in the original analysis (subtracting the EU-27 average from the series before running the regression).

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- Selection between type 1 and type 2 is done based upon the higher apparent strength of the relationship identified between diversity and resource productivity, which usually corresponded to a lower AIC and higher Adjusted R-squared in our analysis.
- First stage analysis is concluded by verifying the statistical significance of the regression results (Durbin-Watson test for autocorrelation and Jarque-Bera test for residual normality).
- Second stage analysis will be conducted using established regression error correction procedures such as Engle-Granger or alternatives, in order to get a more statistically truthful representation of the relationship that is analyzed [16].
- The output coefficient format is always maintained the same, c(1) represents the intercept while c(2) represents the independent variable coefficient, with the appropriate interpretation based on the stage and type of the regression.

It should be noted that the above modifications have led to Romania's test results being slightly different compared to the initial conceptual analysis, but with no actual changes in the conclusions, the analysis interpretation having the same results as originally.

3.2.1. Expanded analysis data

Further analysis, when adapting to a format that can be utilized over multiple Euro-pean economies, ran into some problems due to major changes affecting the data:

- Geopolitical changes due to Brexit
- Eurostat structural database changes
- Legislative changes due to European Directive imposing gender diversity quotas in listed company boards of directors [17]

These major events and economic uncertainty have led the expanded analysis to be conducted in multiple stages in order to improve validity.

Thus, additional data extraction was conducted in 2022, which had 2020 instead of 2019 as final year of valid data, while eliminating the UK from analysis. The benchmark used for the EU has been switched to the EU-27, in order to reflect the current geopolitical status of the economies analyzed.

Finally, due to the European wide imposition of gender quotas in company boards starting with the year 2024, a final extraction and analysis of the database was conducted in 2025, which included 2023 as final year of reporting for the two series used. This was done in order to verify whether the additional 3 years of data produce any substantive changes to the analysis results [17].

As such, the expanded analysis over the European economy was initially conducted using the following data [18]:

- Period: 2003-2020, database extracted in 2022
- Positions held by women in senior management positions [SDG_05_60] in the form of a percentage out of total positions available for boards.
- Resource productivity and domestic material consumption (DMC) [env_ac_rp] in the form of Purchasing Power Standard per Kilogram and Index 2000 for Panel data analysis.

The final analysis was initially conducted using the following data:

- Period: 2003-2020, database extracted in 2022
- Positions held by women in senior management positions [SDG_05_60] in the form of a percentage out of total positions available for boards [19].
- Resource productivity and domestic material consumption (DMC) [env_ac_rp] in the form of an Index using year 2000 as a base [20].

3.2.2. Expanded analysis results – first level

Applying the analysis algorithm described above upon all countries in the Eurostat extracted database has produced results that we've obtained the following results (Table 1):

Table 1. First level analysis – Regression results (resource productivity vs. diversity).

Country	Type of analysis	Adj. R-squared	Durbin-Watson (1.5-2.5)	Jarque Bera (p>0.15)
Austria	1	0.793467421	0.37	0.38
Belgium*	**1**	**0.898173122**	**1.6**	**0.24**
Bulgaria	2	0.798178399	1.36	0.95
Croatia	1	0.504699612	0.98	0.67
Cyprus	1	0.690839327	1.12	0.68
Czechia	1	0.110750802	0.26	0.45
Denmark	1	0.808312078	0.69	0.34
Estonia	2	0.918154032	1.16	0.65
Finland*	**1**	**0.81930705**	**1.76**	**0.17**
France	1	0.926904792	1.02	0.64
Germany	1	0.933527281	0.8	0.85
Greece	1	0.399015149	1.21	0.01
Hungary	2	0.186960794	0.61	0.19
Iceland	1	0.58374851	1.45	0.11
Ireland	1	0.794175323	0.48	0.44
Italy	1	0.922258526	0.48	0.4
Latvia	1	0.429961638	1.19	0.34
Lithuania	1	0.837585999	1.47	0.08
Luxemburg	1	0.615109908	0.33	0.71
Malta*	**2**	**0.355281008**	**1.91**	**0.7**
Netherlands	1	0.883504374	0.5	0.69
Poland	1	0.855078954	1.14	0.51
Portugal	1	0.658142091	0.51	0.55
Romania*	**2**	**0.885901494**	**1.51**	**0.39**
Slovakia	1	0.297285199	0.38	0.61
Slovenia	1	0.214733483	0.28	0.32
Spain	1	0.867206735	0.32	0.64
Sweden	2	0.412852371	0.52	0.76

* Highlighted items represent results deemed as valid after residual testing

First of all, it should be noted that all models had the regular statistical relevance measures such as F-values and t-tests for coefficients that were well within the 5% significance level, normally indicating a high degree of statistical reliability. In addition, as we can see, over 20 countries show a very high determination coefficient between diversity and resource productivity (over 50%). If we're to take this at face value, it is very tempting to directly conclude that there is a major influence of diversity upon the resource productivity of a country.

Looking closer at regression validity testing however, we notice that most countries regressions actually fail basic statistical validity assumptions such as the absence of autocorrelation of residuals and the normality of the residuals.

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Out of the 29 countries subjected to this scrutiny, only 4 exhibit potentially reliable results, namely Romania, Malta, Finland and Belgium, based of F-statistic, t-statistics and residual diagnostics for normality and autocorrelation. These country regressions were subsequently also subjected to a Breusch-Pagan-Godfrey heteroskedasticity test, which they all passed at all standard significance levels (1%, 5%, 10%).

3.2.3. Expanded analysis results – second level

Given that 25 of the analyzed countries exhibit strong, but misleading results in terms to the strength of the relationship between diversity and resource productivity, the second level analysis is essential in establishing statistical validity of such a relationship, with results summarized in Table 2.

Table 2. Second level analysis - Engle-Granger ECM.

Country	Type of analysis	Adj. R-squared	Durbin-Watson (1.5-2.5)	Jarque Bera (p>0.15)
Austria	1	0.58	1.67	0.44
Bulgaria	2	0.84	2.25	0.79
Croatia	1	0.47	1.71	0.61
Cyprus	1	0.17	1.5	0.4
Czechia	1	0.95	2.4	0.98
Denmark	1	0.19	1.37	0.04
Estonia [1]	**2**	**0.04**	**1.57**	**0.61**
France	1	0.76	1.91	0.17
Germany [1]	**1**	**0.12**	**2.35**	**0.42**
Greece	1	0.08	2.98	0.27
Hungary	2	0.22	1.45	0.79
Iceland	1	0.02	1.22	0.35
Ireland	1	0.31	1.84	0.3
Italy	1	0.38	2.13	0.51
Latvia	1	0.36	1.98	0.01
Lithuania [2]	*1*	*0.01*	*1.41*	*0.7*
Luxemburg	1	0.25	1.95	0.84
Netherlands [2]	*1*	*0.09*	*1.47*	*0.85*
Poland [1]	**1**	**0.01**	**1.56**	**0.57**
Portugal	1	0.62	2.08	0.19
Slovakia	1	0.32	1.91	0.59
Slovenia	1	0.88	2.02	0.64
Spain	1	0.69	1.51	0.08
Sweden	2	0.83	2.88	0.96

[1] Highlighted items represent results deemed as valid after residual testing
[2] Possibly valid results after slightly relaxing autocorrelation requirements (within 0.1)

Conducting the second level analysis with similar testing parameters as the previous level we find that only 3 additional countries, namely Estonia, Germany and Poland, exhibit relationships that are statistically relevant between diversity and resource productivity. If we are to stretch the validity cutoffs in terms of autocorrelation limits, then Nether-lands and

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Lithuania can also be considered as exhibiting noticeable economy-wide impacts of diversity increases upon the country's resource productivity.

Thus, using the analysis algorithm, we have been able to identify a significant and statistically valid impact of increasing diversity upon the economies of 7 countries, out of the 29 analyzed. If we are to consider certain small adjustments, such as eliminating outlier points (large residual deviation years) or slightly lowering the accepted autocorrelation bound for statistical relevance, then we reach a full one-third of analyzed countries exhibiting evidence that diversity does indeed improve economic performance, seen in Table 3.

Table 3. Diversity impact coefficients.

Country	Type	Stage	Diversity series coefficient*
Belgium	1	1	0.04
Estonia	2	2	0.008
Finland	1	1	0.02
Germany	1	2	0.006
Lithuania	1	2	0.03
Malta	2	1	0.04
Netherlands	1	2	0.05
Poland	1	2	0.05
Romania	2	1	0.02

* the slope of the regression, C(2)

The specific impact itself, based on the statistically relevant results depends individually upon the type of analysis and stage in which the relationship was verified. However, taking a generalized look, the countries above have exhibited 1 – 5 percentage point improvements in their economies' resource productivity (in either the short-term or the long-term), for every extra percentage of women introduced nationwide in boards of di-rectors of the top companies.

3.3. Final analysis – Panel LS and EGLS

While the previous mentioned analyses can be considered to have yielded some statistical evidence of the positive impact of increased diversity upon resource productivity within European economies, the limited number of countries (9) where this occurs, as well as the limited amount of data, do not indicate that it is a statistically undeniable fact.

3.3.1. Initial Panel investigation (2003-2020)

In order to obtain a more generalized result, the research has been moved in the direction of Panel Regressions in order to overcome the individual country data amount limitation while also permitting a more accurate result when it comes to the diversity coefficient in the regression. It should be noted that all countries that exhibited some level of statistical relevancy when it comes to the relationship between diversity and resource productivity are actual full members of the European Union. As such, further analysis was restricted to European Union members that at most have a one-year difference in years of reporting compared to the full period of analysis, in order to restrict unbalanced data effects.

In addition, the data usage in terms of resource productivity has been switched from an absolute measure of pps/kg to an index type measure using year 2000 as a baseline, in order to help improve temporal cross-section comparability between points of data.

Thus, reorganizing the data available into a longitudinal panel format per year and country and cross-sections, using Eviews the following results were obtained, where DIV_T is Diversity percentage while C represents the intercept, equivalent to previous C(2) and C(1) respectively (Figure 4):

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DIV_T	0.973415	0.148867	6.538815	0.0000
C	108.2447	2.724136	39.73541	0.0000

R-squared	0.085043	Mean dependent var	123.5854
Adjusted R-squared	0.083054	S.D. dependent var	31.07600
S.E. of regression	29.75753	Akaike info criterion	9.628361
Sum squared resid	407335.0	Schwarz criterion	9.646264
Log likelihood	-2222.151	Hannan-Quinn criter.	9.635410
F-statistic	42.75611	Durbin-Watson stat	0.126334
Prob(F-statistic)	0.000000		

Figure 4. Panel LS regression 2003-2020

We can observe that while the model again appears relevant in terms of t and F statistics, the panel adjusted Durbin-Watson statistic indicates that the model at the very least suffers from autocorrelation errors in the residuals. Running further validity testing using a Likelihood ratio tests for skedasticity of the residuals we have found that the model suffers from heteroskedasticity for both cross-sections as well as periods.

As such, model corrections should be done by using a methodology that is robust both in terms of correcting for serial correlation as well as heterosketasticity. As such, the regressive model was reconducted using an Estimated Generalized Least Squares (EGLS) method with Period Seemingly Unrelated Regression (SUR) weights due to the lower number of periods available in the data (Figure 5):

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Sample: 2003 2020
Periods included: 18
Cross-sections included: 27
Total panel (unbalanced) observations: 462
Linear estimation after one-step weighting matrix

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DIV_T	0.784841	0.069330	11.32044	0.0000
C	107.8750	1.590119	67.84086	0.0000

Weighted Statistics

R-squared	0.230045	Mean dependent var	0.184626
Adjusted R-squared	0.228371	S.D. dependent var	3.597760
S.E. of regression	0.965630	Sum squared resid	428.9226
F-statistic	137.4375	Durbin-Watson stat	1.972845
Prob(F-statistic)	0.000000		

Unweighted Statistics

R-squared	0.070265	Mean dependent var	123.5854
Sum squared resid	413914.4	Durbin-Watson stat	0.123188

Figure 5. Panel EGLS with Period SUR 2003-2020.

The corrected results, which appear valid from the point of view of the F-statistic and coefficient t-statistics, now exhibit a coefficient of approximately 0.8 for the relationship between board diversity % and the resource productivity index.

As the corrected model is robust against heteroskedasticity and autocorrelation errors, seen also in the adjusted Durbin Watson statistic (~2) in the case of autocorrelation, the only additional investigation that could lend more credence to the results would be the verification of the normality of residuals seen in Figure 6:

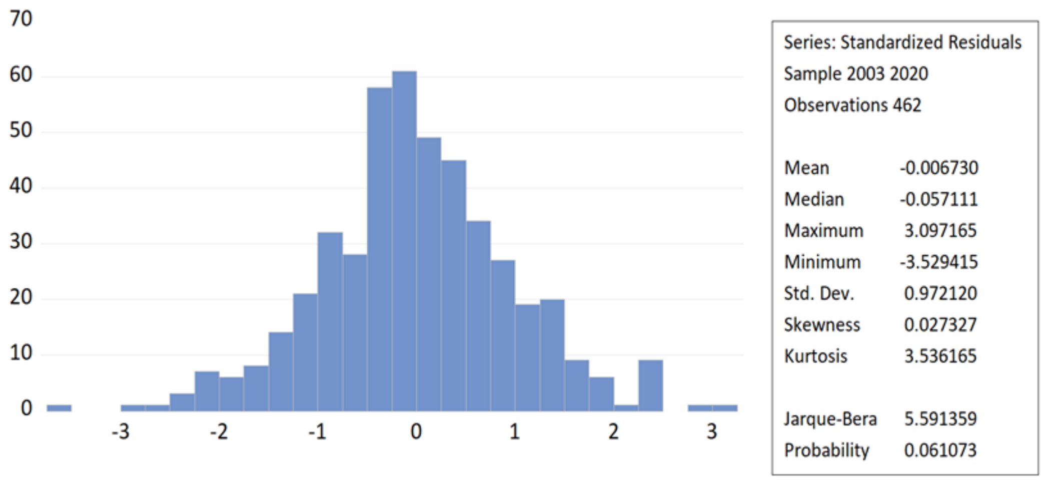

Figure 6. 2003-2020 EGLS with SUR Residual Histogram

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The Jarque-Bera test indicates that the residuals of the adjusted model fulfill the normality condition at the 5% significance level.

3.3.2. Additional investigation pre-quota directive implementation (2003-2023)

For the rerun of the model using the 2003-2023 data, prior to official implementation of gender quotas in national legislation in 2024, the results have been largely maintained despite the nearly 100 additional data points added to the analysis:

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	109.4496	2.063978	53.02849	0.0000
C(2)	0.693064	0.047174	14.69169	0.0000
Weighted Statistics				
R-squared	0.325432	Mean dependent var		0.858438
Adjusted R-squared	0.324221	S.D. dependent var		2.529000
S.E. of regression	0.896245	Sum squared resid		447.4135
F-statistic	268.7136	Durbin-Watson stat		1.811989
Prob(F-statistic)	0.000000			
Unweighted Statistics				
R-squared	0.074140	Mean dependent var		126.0471
Sum squared resid	675978.7	Durbin-Watson stat		0.112062

Figure 7. Panel EGLS with Period SUR 2003-2023

The difference in results pertains mostly to a higher intercept of ~109.45 and a slight-ly lower coefficient for diversity of approximately 0.7. with the normality of the residuals still being respected at the 5% significance level (Figure 8).

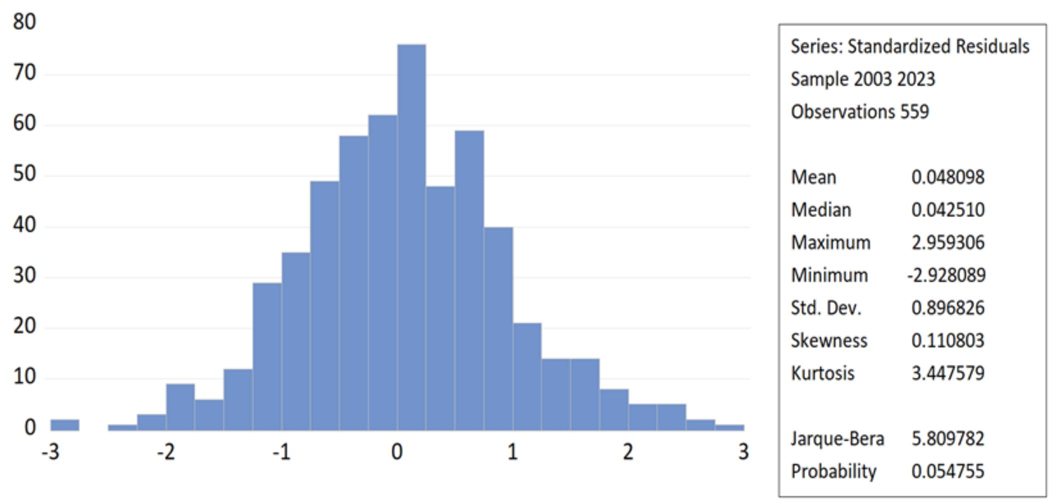

Figure 8. 2003-2023 Panel EGLS with SUR Residual Histogram

Thus, there is no significant change in the results of the analysis when pertaining to the main objectives after the addition of 25% more data. The model maintains the existence of a statistically valid relationship between diversity and the corresponding resource productivity index based on the EU panel data collected.

4. Conclusion

Overall, based on the final results, the implementation of gender diversity quotas in the European Union could expect an increase of 0.7 in the national productivity of EU member states for each percentage point increase in the board diversity of listed companies in their respective countries, with significant caveats that limit the model results to be discussed below. At the same time, this generalized expectation should be tempered by the fact that only a third of the member states, when analyzed, have exhibited evidence of a statistically valid relationship between national resource productivity and gender diver-sity percentage in their top-50 listed companies.

4.1. Limitations and Potential improvements

The first, and most obvious, would be the relative lack of data at the individual country level. Data on gender diversity has not been collected in a systematic manner except following 2003. This means that up until today we have barely 21 data points for each country upon which to conduct statistical modelling, which is relatively insufficient in order to build truly robust statistical models at the level of individual economies. At the same time, it is unlikely that the effects of a change in diversity within an economy would be apparent in any time period shorter than one year despite the models used showing valid results without time-lags. Thus, currently there is no realistic option of increasing the amount of data available for analysis other than waiting for real data to be communicated by the national authorities. In consequence, the model and its conclusions as presented in this study would have to be revisited repeatedly in order to verify validity. This is also compounded by the fact that the so-called "real" data present in the database is itself subject to change, which has indeed been observed in the progress of this investigation: the data extracted in 2025 presented small differences in almost all datapoints for the resource productivity series compared to 2022 and 2021.

The data limitations are not restricted to the above. There is also the aspect that gen-der diversity has been collected in the database only for the top 50 publicly traded companies of each country. Given that the top 50 companies, despite their likely large size and market coverage, cannot account for the entire economy of a country. Thus, it is impossible to say for certain whether the model would hold up when increasing the analysis range of analyzed companies that do not have gender diversity reporting requirements. It is also possible that there are countries where there is more female representation outside of the top 50 companies, or even that due to the recent entrepreneurial surge, lots of women have decided to build their own companies rather than serve as board directors, depriving the big companies of valuable, diverse, human resources.

The conceptual model shape is also a potentially significant drawback in terms of accuracy despite the statistical relevance of the results and the Non-Linear Least Squares (NLS) base method applied automatically by Eviews. There are indications that the actual shape of the impact of diversity on resource productivity is more of an S-shape, due to the likelihood of diversity not having a pronounced impact in the lower range (0-10%) simply due to the underrepresented gender not having enough influence to produce measurable effects. At the same time, in the upper range (40-50%) it will again likely have a reduced impact due to the influence of the two genders reaching parity regardless of small number disparity. This aspect is supported by the results: if we are to compare the linear panel model prediction at the intercept with the real resource productivity index across the EU-27. The model predicts a 107.675 and ~109.450 productivity index (2000) for the analysis periods up to 2020 and 2023 respectively, while the actual productivity index ~101.893 and ~101.667 respectively for the year 2003, which is much lower than expected. Given that the actual diversity percentage averaged across the EU-27 in 2003 was around 8.2%, the likelihood of the S-shape is higher.

Given these aspects, it is likely that any future modelling, beyond using models that are robust in terms of serial correlation and heteroskedasticity or corrected for structural and temporal shocks, could benefit from using a fixed intercept based on real data for the EU-27 and the assumption that board diversity percentages below 10% produce diminished or insignificant returns in the economy.

4.2. Impact of diversity

Overall, even if we are to discount the Panel based model, the results produced at the individual level still show a verifiable impact produced by improved gender diversity for several countries, namely Belgium, Germany, Finland, Poland, Estonia, Malta and Romania. Even if the magnitude of that impact is unreliable due to insufficient data, the existence of a verifiable positive relationship can be considered sufficient to economically justify, at the very least for these countries, the imposition of gender diversity quotas.

For Romania in particular where our analysis has started, it has been identified that gender diversity is a problem leading to women being categorized in the company as a disfavored group. At the same time, these aspects have motivated women to engage in entrepreneurship in order to gain independence from the existing, non-gender diverse companies [21].

It could be argued to some extent that gender diversity is something that will be solved in time, especially given that the Romanian business environment is giving more and more attention to standardization in their management. However, despite the major impact that a national economy could gain based on the results of this paper's analysis, aspect which makes it seem that the drastic legal measures of imposing quotas are necessary, research does not identify diversity among business-critical aspects, especially in terms of crisis resilience and business continuity management [22]. In fact, forced gender quotas may be detrimental in such scenarios, where meeting the quotas with qualified personnel might become a challenge.

Ultimately however, it is true that for the majority of analyzed economies the study indicates that there is no statistically valid relationship at the individual macro-level, thus supporting to some extent previous research where only tentative relationships between diversity and the economy were identified. Still, beyond the statistically relevant panel data results for the European wide analysis, the fact that nearly a third out of all countries analyzed have a significant and proven positive relationship between gender diversity on boards and macroeconomic performance even at the individual level, is a sufficient sign that the gender diversity quotas in the EU are justified at the board member level. It is also apparent that this type of analysis method can be refined and expanded to include other types of "close" macroeconomic indicators such as value-added of the private sector or employee productivity, where gender diversity may be seen to have a significant impact. It also makes it apparent that gender diversity can potentially be included in macroeconomic modelling if its relationship with macroeconomic indicators can be verified as done in this paper.

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