BC3412 Team 4

Final Report Presentation

Team members:

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Date : 16th April 2025

Project Background and Problem Statement

With the **assumption and problem statement**, we choose to focus on the **Energy sector as proof of concept for future work**

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Background and Problem Statement

Governments worldwide push for the Energy Transition with focus on sustainability and reduced carbon emissions

ESG emerges as a widely acknowledged indicator of corporates' performance in upholding its social responsibilities, used by different stakeholders:

Regulators
To assess companies' adherence to guidelines and policies

Insurers and investors
To assess companies for financial decision-making such as insurance underwriting

Companies are under pressure to improve its ESG performance, but are **faced with challenges in choosing the suitable transition method**

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Assumption: Better ESG score is associated with reduced business risks

Problem statement: How can we

- Identify the **main drivers** for ESG score?
- Build models that could **recommend the best transition** pathway for each company, considering its own financial and operational capabilities?
- How to make the solution **scalable** and **adaptable** to companies regardless of industries or geographical locations

Industry selection: Energy sector

Macro environment factors

Companies in the energy sector is well-positioned to lead the Green Energy transition due to external threats and opportunities:

Threats

- Stringent regulatory pressures
- Growing social pressures
- Main contributor to carbon emissions

Opportunities

- Technological advancements
- Incentives from governments

Data availability

The availability of companies in energy sector in AON's client database enables the models to be tested on a larger data set

The Energy sector is chosen to be proof of concept for analytics and model developments

Analytic Approach and Methodology

We integrate data from **multiple credible sources** and created a **2-phase plan** to analyze the data and achieve our goals.

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Data Sources and Integration

1. Bloomberg ESG Data

- SASB-aligned, industry-standard ESG scores
- Covers overall ESG, pillar (E/S/G) scores, and disclosure scores
- Chosen as target variable for predictive modelling

2. S&P Capital IQ

- Market capitalization and financial data
- Used for company scaling and peer group benchmarking
- Integrates into both prediction and strategy phases

Building on our initial models, we have identified that incorporating ETVI data significantly strengthens our ESG strategy optimization by embedding country-specific risk profiles. This ensures our action plans are tailored to the unique transition readiness of each company's operating environment.

3. Energy Transition Vulnerability Index (ETVI)

- **Country-level transition risk** profiling (IEA, World Bank, UN data)
- **Measures:**
    - Exposure (fossil fuel reliance)
    - Sensitivity (socio-economic vulnerability)
    - Adaptive Capacity (institutional readiness)
- **Aggregated into R_Vulnerability Score** for model integration
- Enhances **realism with macroeconomic & regulatory alignment**

Phase 1: Two – Layer Architecture

Layer 1

Use of **Random Forest Regressor** to study the relationships between variables, hence predicting ESG component scores

Layer 2

With the component scores derived from Layer 1, **OLS Regression** is used to predict the final ESG score

Outcome: Quantitative ESG baseline to understand current positioning for each company

Phase 2: ESG Strategy Optimisation Model

Feature Weightage and Selection

Identify the most **influential variables driving ESG outcomes** using feature importance analysis from our predictive models.

Reinforcement Learning Model

- Incorporates ETVI to model external **country-specific risks**
- **Action Space:** 60 actionable ESG initiatives
- Agent learns to balance ESG improvement, cost efficiency, and financial sustainability
- Uses curriculum learning to progressively optimise ESG pathways

Action Stage

- Practical ESG playbook for companies, supported by data-driven insights and regulatory alignment.
- Customisation ensures global best practices meet local realities.

Data Analytics and Initial Model Development

Pillar scores alone can predict ESG scores, and **Random Forest** is the best model for individual Pillar scores.

Determining Significant Variables for ESG Score

Hypothesis

ESG Score is derived from Pillar scores and Disclosure scores

```
                            OLS Regression Results
=======================================================================================
Dep. Variable:          BESG ESG Score   R-squared (uncentered):                   0.999
Model:                             OLS   Adj. R-squared (uncentered):              0.999
Method:                  Least Squares   F-statistic:                          1.695e+05
Date:                 Thu, 03 Apr 2025   Prob (F-statistic):                        0.00
Time:                         18:54:29   Log-Likelihood:                          625.31
No. Observations:                  850   AIC:                                     -1237.
Df Residuals:                      843   BIC:                                     -1203.
Df Model:                            7
Covariance Type:             nonrobust
=================================================================================================
                                    coef    std err          t      P>|t|      [0.025      0.975]
-------------------------------------------------------------------------------------------------
BESG Environmental Pillar Score   0.4849      0.003    146.339      0.000       0.478       0.491
BESG Social Pillar Score          0.2920      0.003     96.257      0.000       0.286       0.298
BESG Governance Pillar Score      0.2371      0.004     58.428      0.000       0.229       0.245
ESG Disclosure Score              1.3460      2.766      0.487      0.627      -4.083       6.775
Environmental Disclosure Score   -0.4486      0.921     -0.487      0.626      -2.257       1.360
Social Disclosure Score          -0.4476      0.920     -0.486      0.627      -2.254       1.359
Governance Disclosure Score      -0.4503      0.924     -0.487      0.626      -2.264       1.364
==============================================================================
Omnibus:                      516.981   Durbin-Watson:                   0.570
Prob(Omnibus):                  0.000   Jarque-Bera (JB):            13041.986
Skew:                           2.287   Prob(JB):                         0.00
Kurtosis:                      21.636   Cond. No.                     9.40e+04
==============================================================================

Notes:
[1] R² is computed without centering (uncentered) since the model does not contain a constant.
[2] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[3] The condition number is large, 9.4e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

Result:

- **High p-values** (above 0.6) for **Disclosure scores → statistically insignificant at 5%.** *Reanalyze with only Pillar scores*
- **High R^2** (0.999) → Relationship is **linear**

```
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Omnibus:                      510.684   Durbin-Watson:                   0.567
Prob(Omnibus):                  0.000   Jarque-Bera (JB):            12613.919
Skew:                           2.254   Prob(JB):                         0.00
Kurtosis:                      21.326   Cond. No.                         6.33
==============================================================================

Notes:
[1] R² is computed without centering (uncentered) since the model does not contain a constant.
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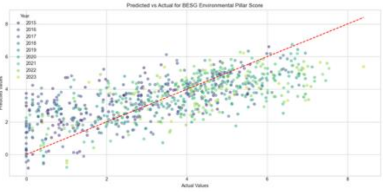
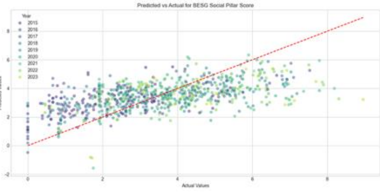
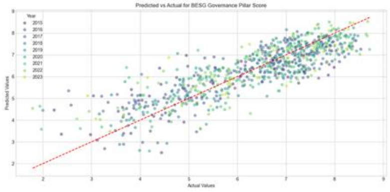
```

Result: **R^2** maintain at **0.999** (99.9% of variance in BESG Score explained by Pillar Scores → **only Pillar scores necessary to predict ESG score**

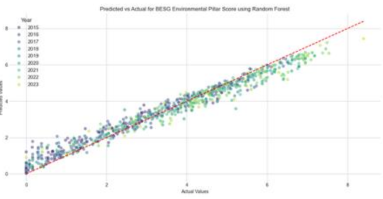
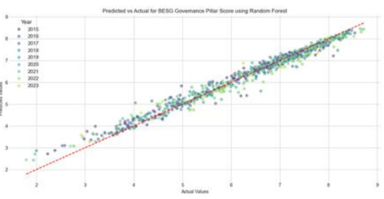
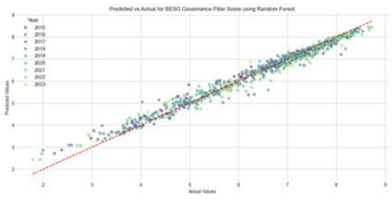
Model Selection for Pillar Scores

Initial Approach:

OLS regression for each Pillar score

Environmental	Social	Governance
		
R^2: 0.486	**R^2: 0.316**	**R^2: 0.714**

Problems: Non-linear relationships, clustering, feature interactions, skewed/ bimodal distributions
Solution: Random Forest – more robust compared to linear regression

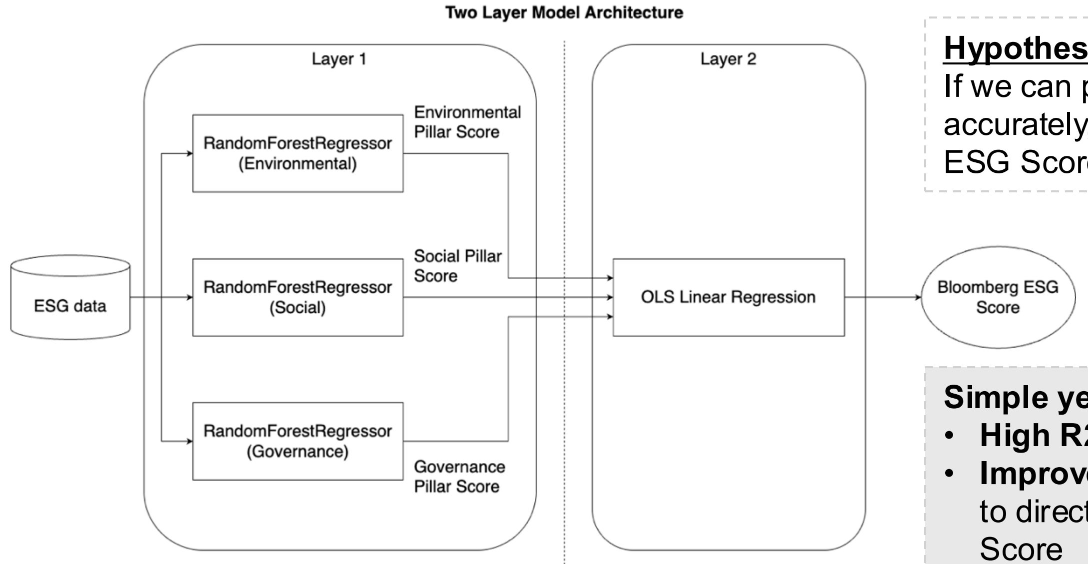
Environmental	Social	Governance
		
R^2: 0.957 ↑197.9%	**R^2: 0.943 ↑97.0%**	**R^2: 0.975 ↑36.4%**

Big improvements to R^2 → Random Forest model **better explains** the models for each Pillar Score.

Phase 1: Two Layer Model – Initial Insights

The model achieved superb predictive results, and the insights gathered were used for **further research into ESG transition**.

Two Layer Model Architecture

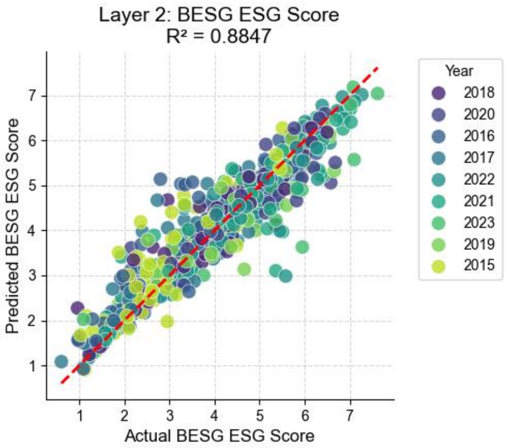


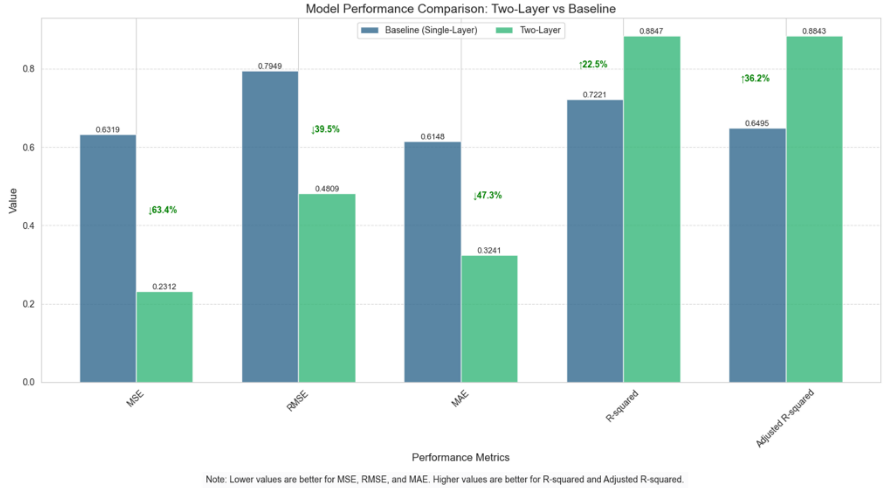
Hypothesis

If we can predict the Pillar Scores accurately, we can predict the ESG Scores accurately

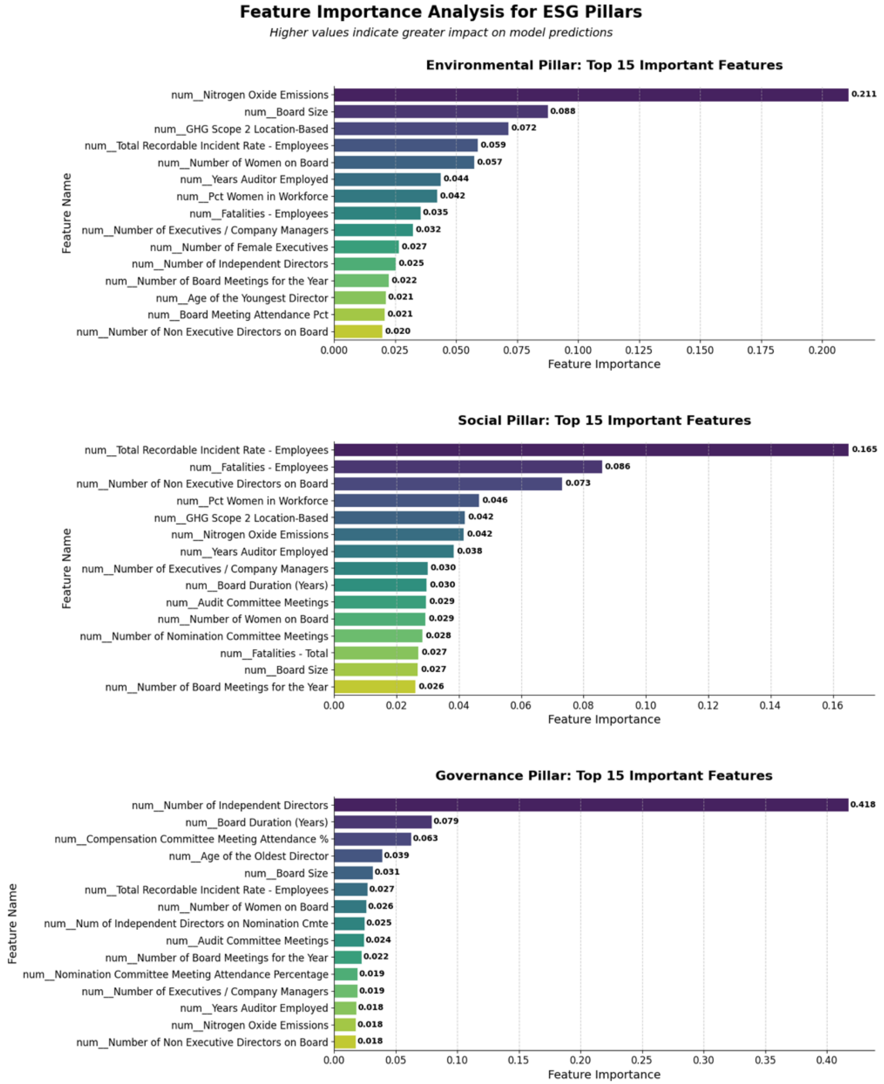
Simple yet effective model

- **High R2** of **0.8488**
- **Improved metrics** compared to direct prediction of ESG Score





Most important features



Phase 2: Reinforcement Learning – Action Plan

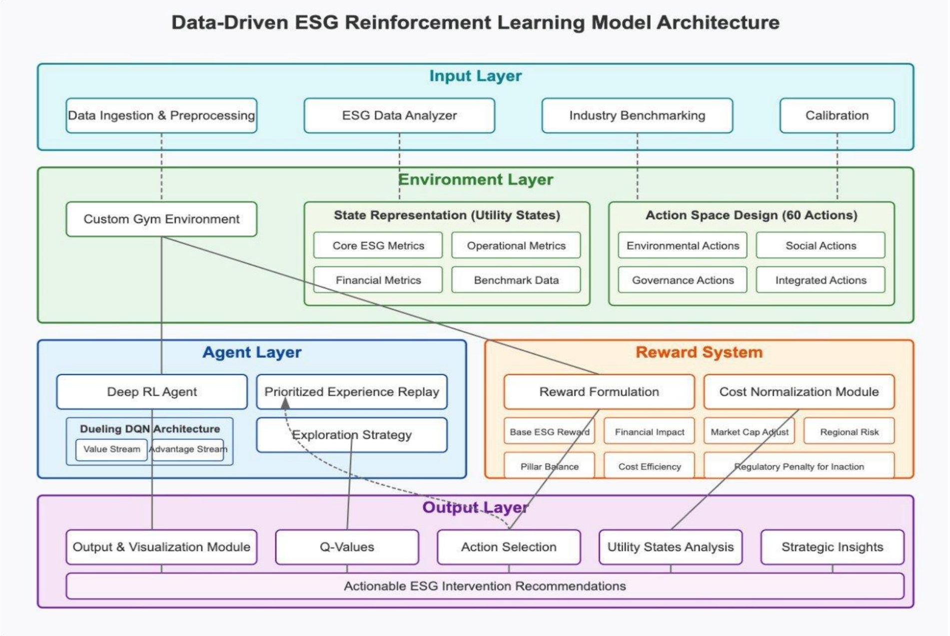
The reinforcement learning model outputs in a step-by-step action plan, helping to guide companies in ESG transition.

Reinforcement Learning Solution

Problem

Challenges deciding ESG transition pathway with just the predicted ESG Score and important variables.

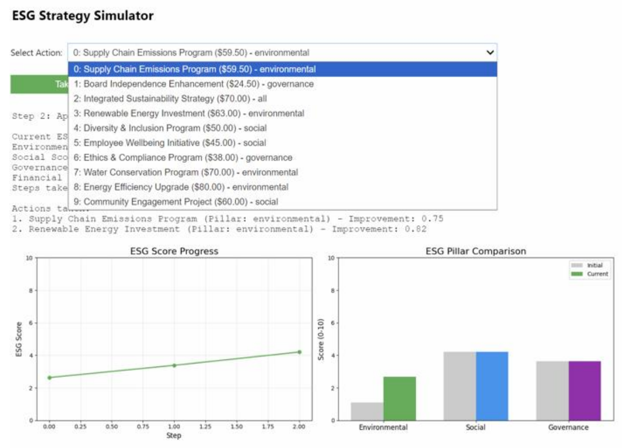
- Which ESG initiatives will deliver the greatest **impact**?
- In what **sequence** these actions should be implemented?
- How to balance short-term **costs** against long-term **benefits?**

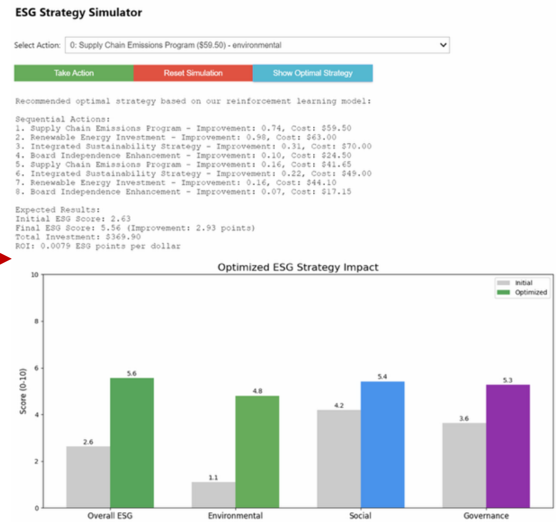


Output: Most **optimal action sequences** tailored to each company's specific situation.

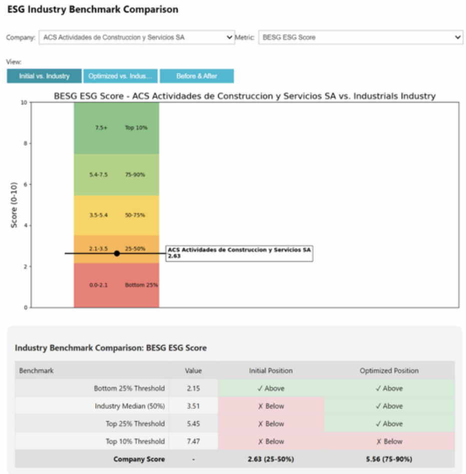
Dashboard Demonstration

ESG Strategy Simulator





ESG Industry Benchmark Comparison



Benchmark	Value	Initial Position	Optimized Position
Bottom 25% Threshold	2.15	✓ Above	✓ Above
Industry Median (50%)	3.51	✗ Below	✓ Above
Top 25% Threshold	5.45	✗ Below	✓ Above
Top 10% Threshold	7.47	✗ Below	✗ Below
Company Score	-	**2.63 (25-50%)**	**5.56 (75-90%)**

Thank you!

OLS Regression with All Pillar Scores and Disclosure Scores

OLS Regression Results

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OLS Regression with Pillar Scores Only

```
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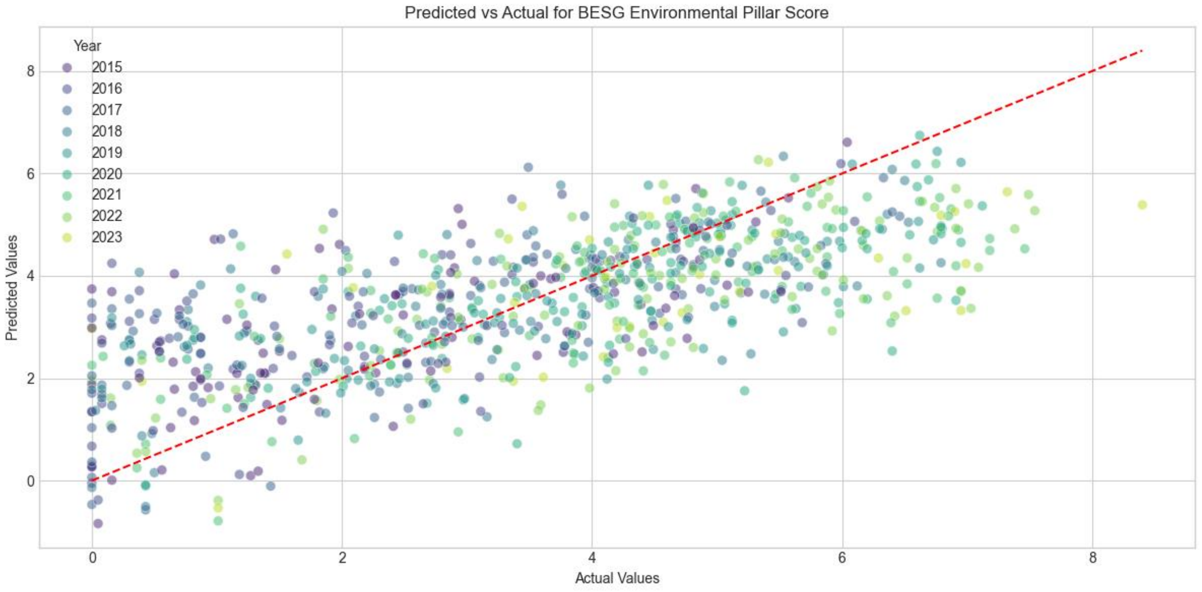
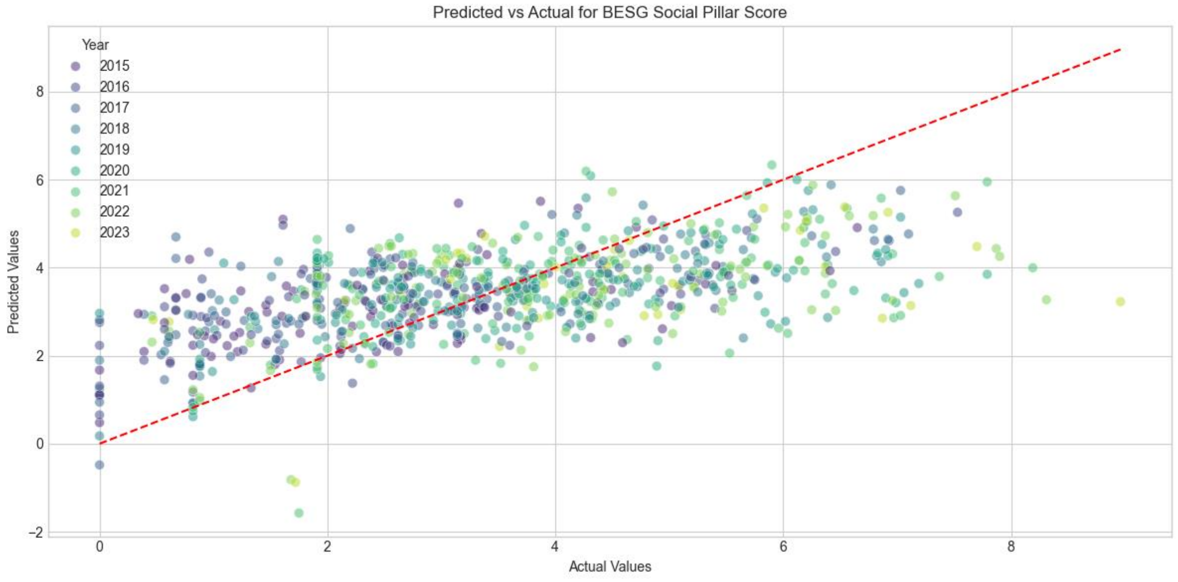
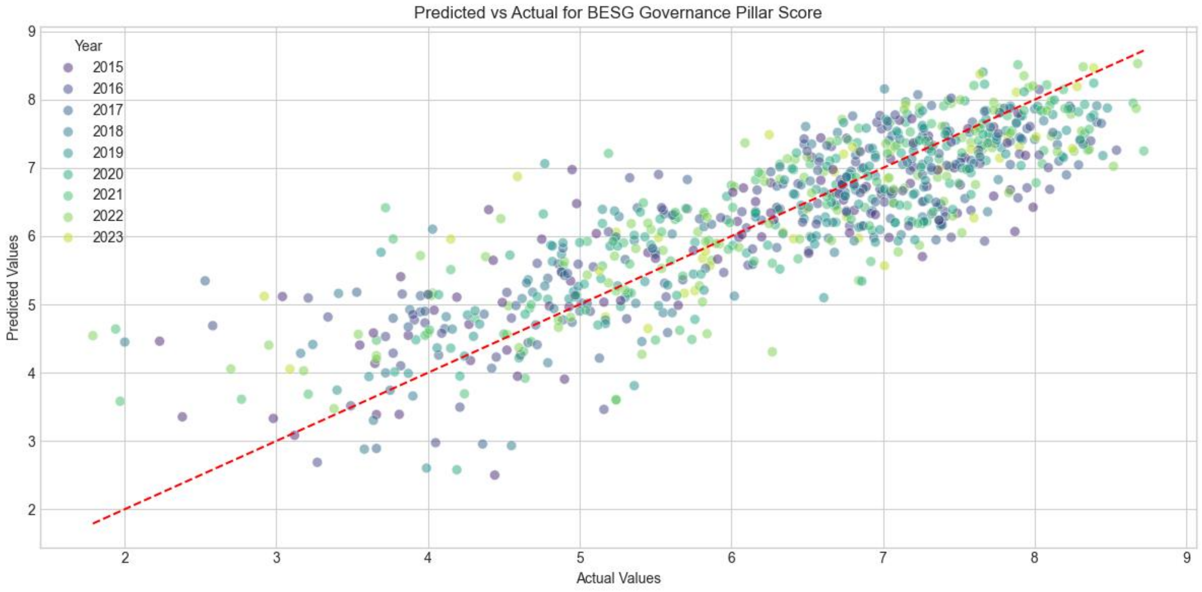
```

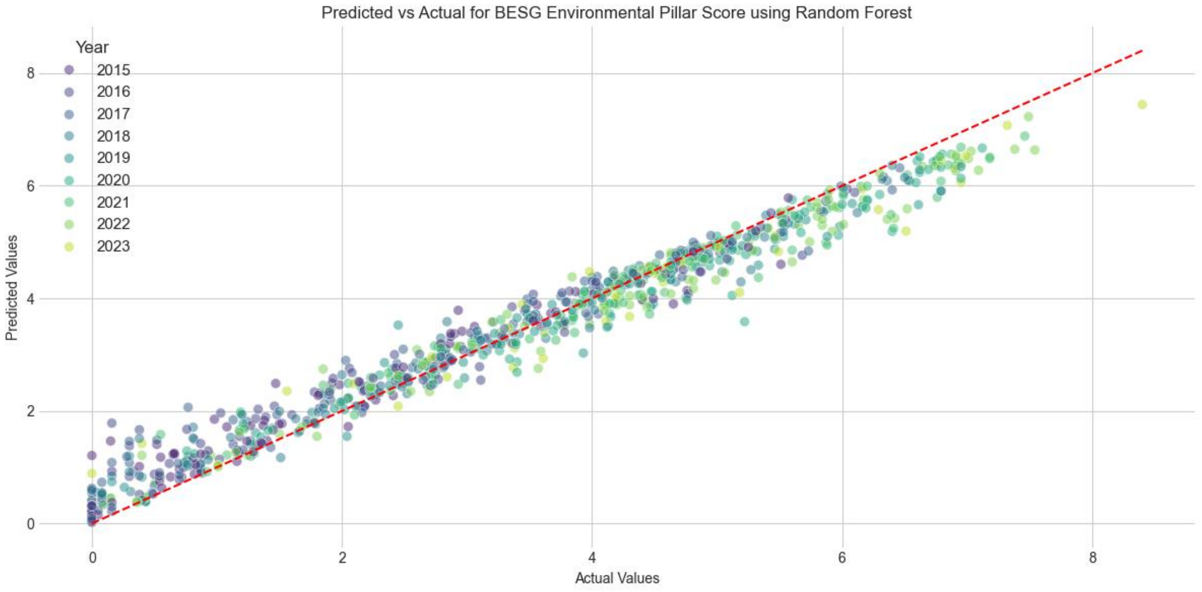
Predicted vs Actual Values for OLS Linear Regression of Pillar Scores

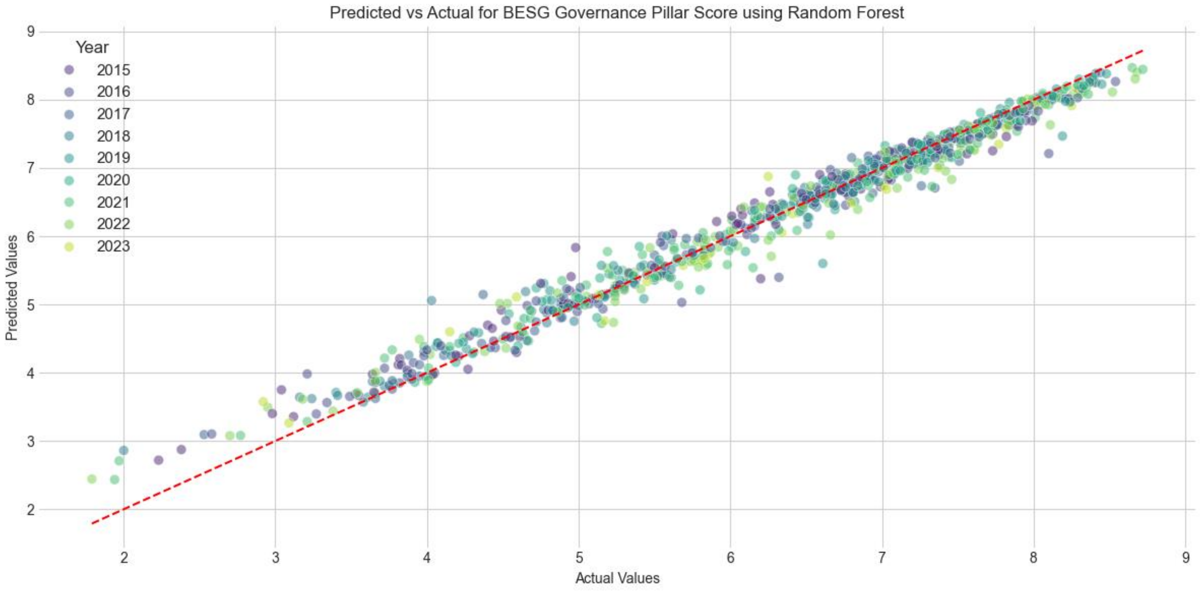


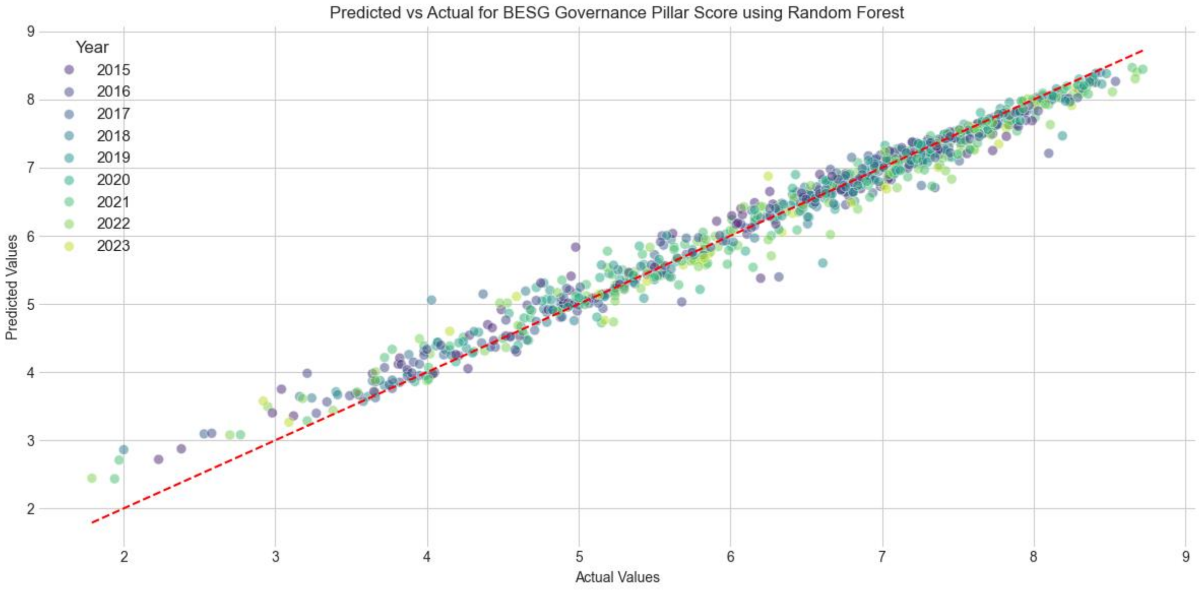




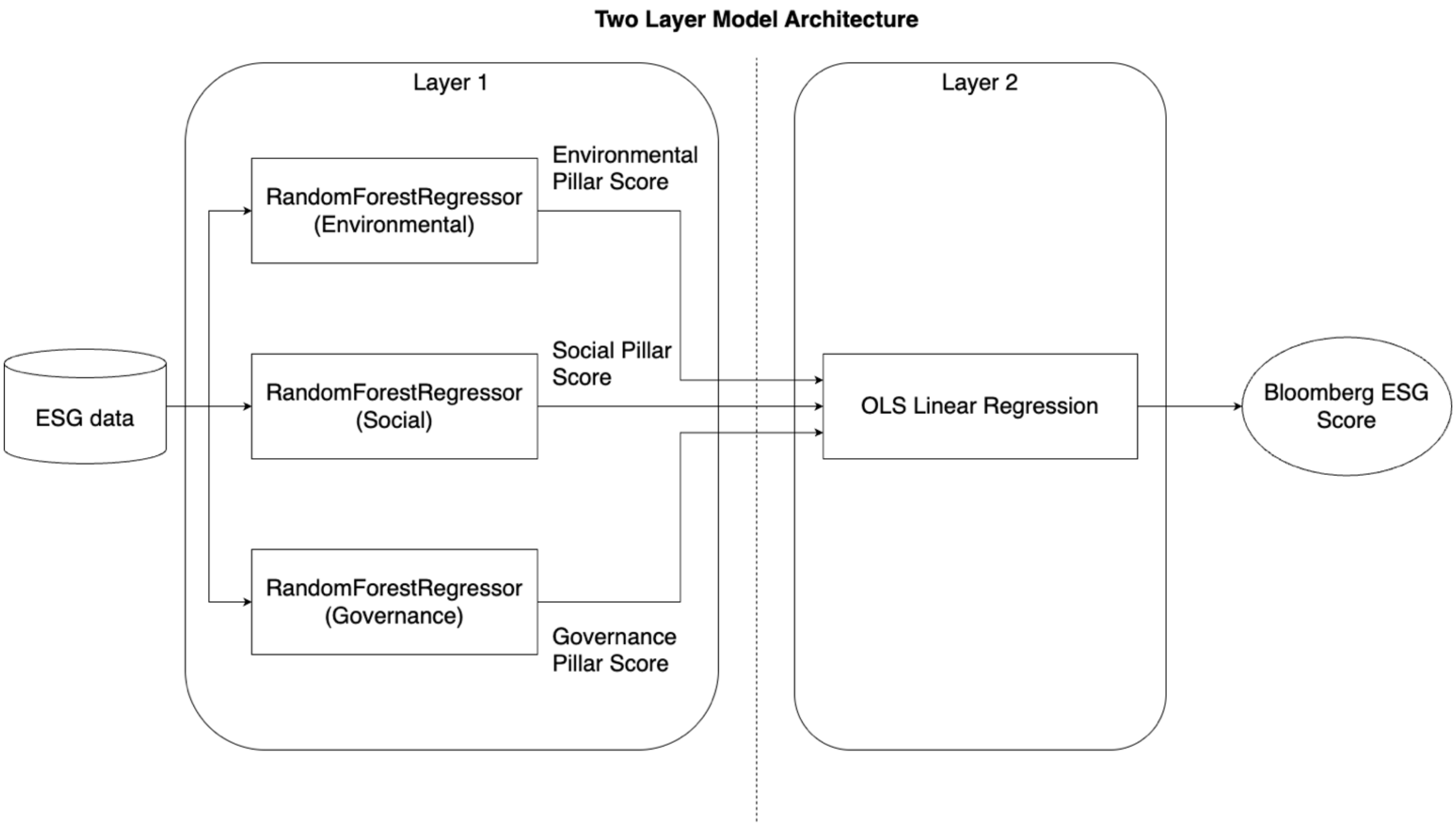
Predicted vs Actual Values for Random Forest Regression of Pillar Scores



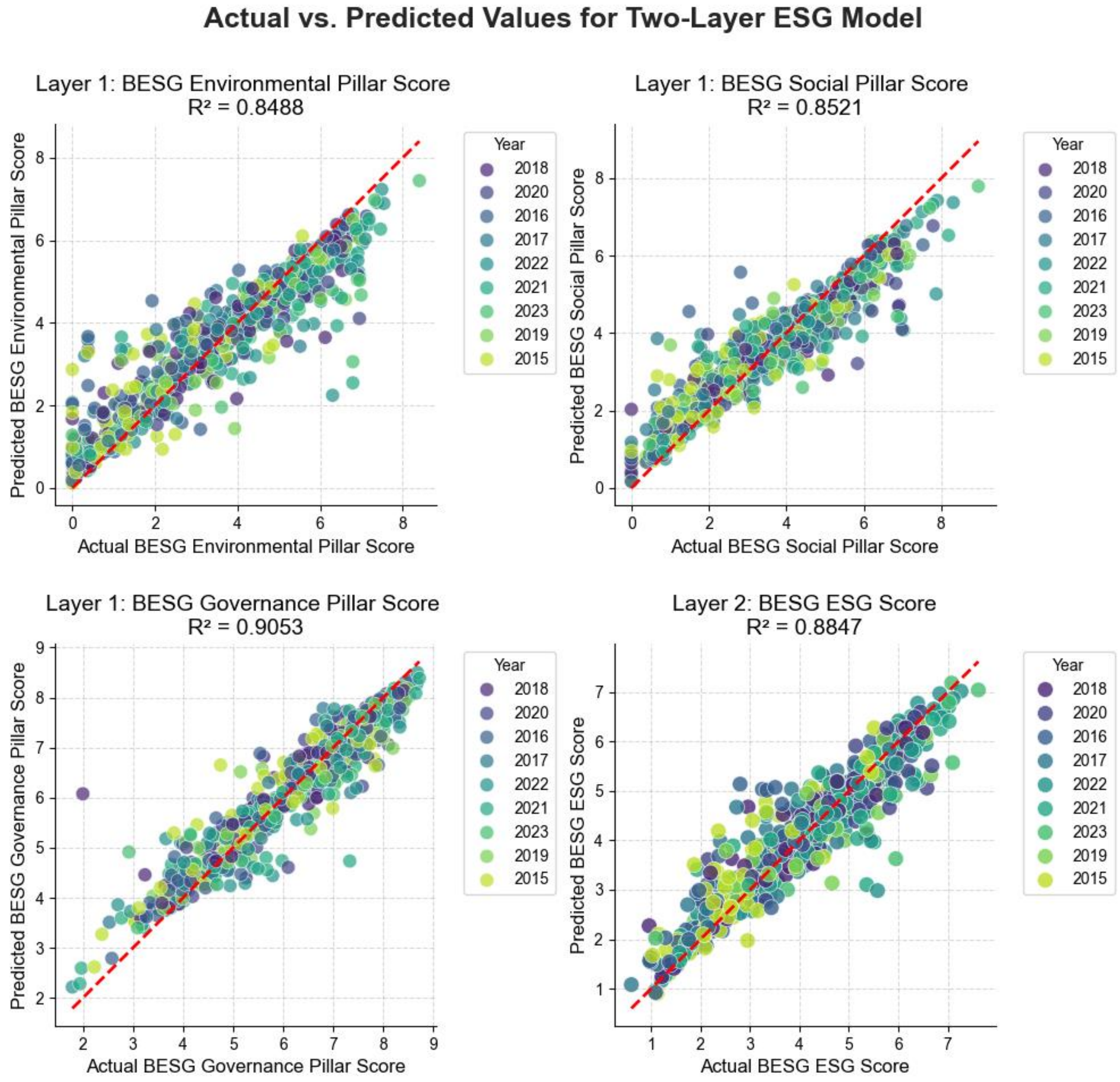




Two Layer Model Architecture

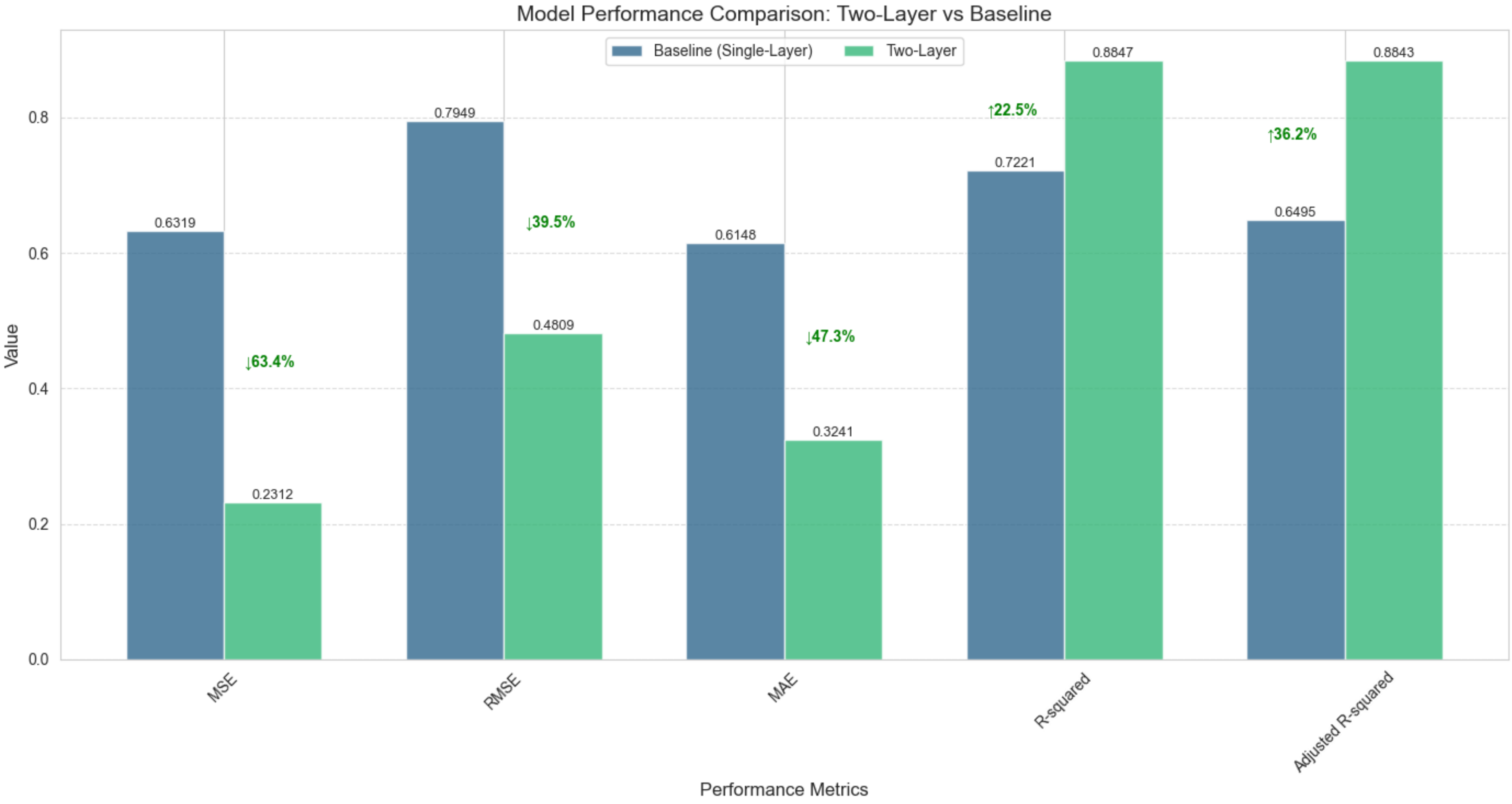


Predicted vs Actual Values for Two Layer Model



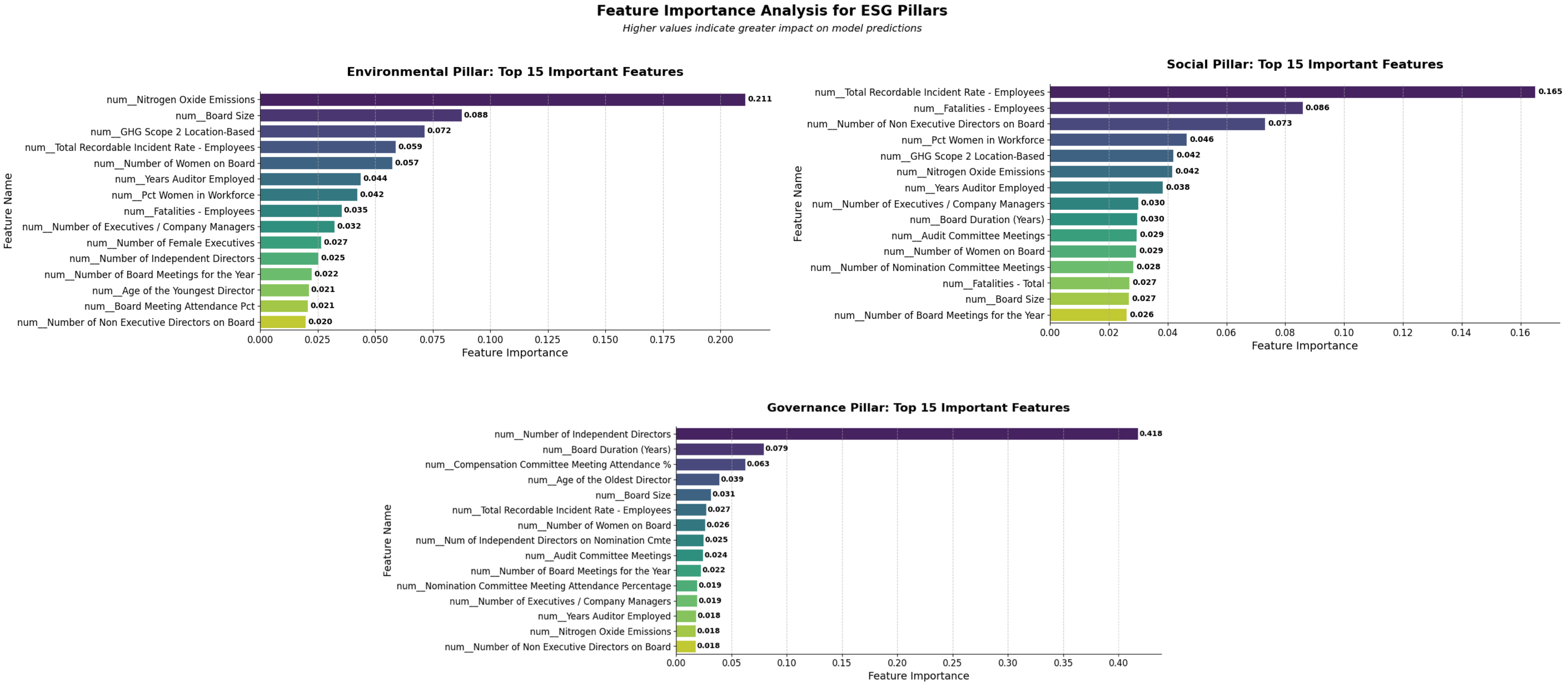
Points on the red dashed line represent perfect predictions

Model Performance between Two Layer Model and Direct Prediction of ESG Score

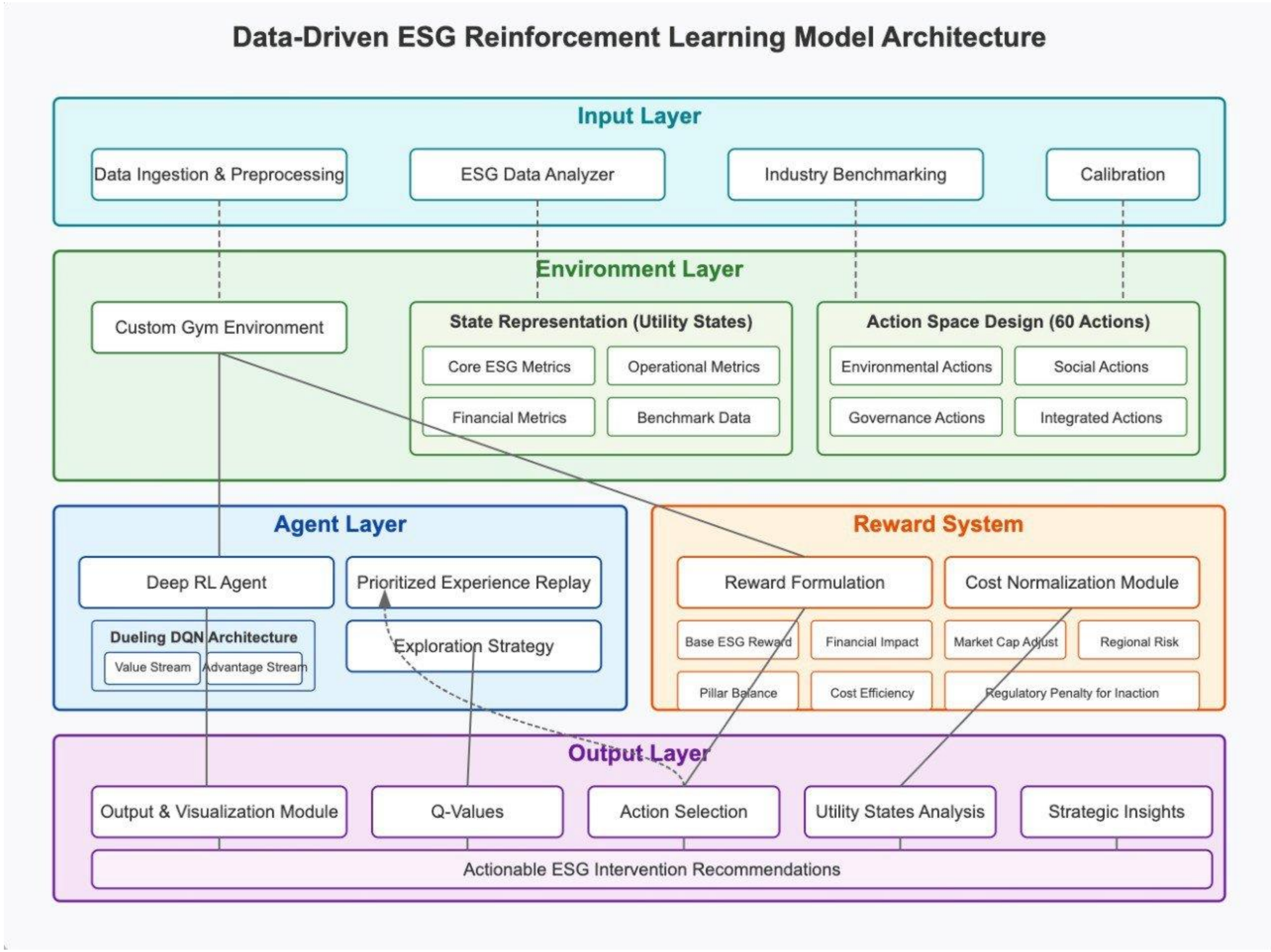


Note: Lower values are better for MSE, RMSE, and MAE. Higher values are better for R-squared and Adjusted R-squared.

Feature Importance Analysis for ESG Pillars



Reinforcement Learning Model Architecture



Action States

```
# GHG Scope 2 Reduction Actions
30: {'name': 'Scope 2 Reduction: Purchase Voluntary RECs (25% of Consumption)',
     'effects': {'GHG Scope 2 Location-Based': -0.25, 'Renewable Energy Use': 0.25, 'BESG Environmental Pillar Score': 0.05},
     'cost': 10, 'pillar': 'environmental', 'initiative_type': 'renewable_procurement_market'},
31: {'name': 'Scope 2 Reduction: Purchase Compliance RECs (25% of Consumption)',
     'effects': {'GHG Scope 2 Location-Based': -0.25, 'Renewable Energy Use': 0.25, 'BESG Environmental Pillar Score': 0.05},
     'cost': 45, 'pillar': 'environmental', 'initiative_type': 'renewable_procurement_market'},
32: {'name': 'Scope 2 Reduction: Enter Utility Green Tariff (100% of Consumption)',
     'effects': {'GHG Scope 2 Location-Based': -1.0, 'Renewable Energy Use': 1.0, 'BESG Environmental Pillar Score': 0.15},
     'cost': 30, 'pillar': 'environmental', 'initiative_type': 'renewable_procurement_utility'},
33: {'name': 'Scope 2 Reduction: Sign Long-Term PPA (50% of Consumption)',
     'effects': {'GHG Scope 2 Location-Based': -0.50, 'Renewable Energy Use': 0.50, 'BESG Environmental Pillar Score': 0.18},
     'cost': 70, 'pillar': 'environmental', 'initiative_type': 'renewable_procurement_ppa'},
34: {'name': 'Scope 2 Reduction: Install On-site Solar PV (20% of Consumption)',
     'effects': {'GHG Scope 2 Location-Based': -0.20, 'Renewable Energy Use': 0.20, 'BESG Environmental Pillar Score': 0.15},
     'cost': 80, 'pillar': 'environmental', 'initiative_type': 'renewable_generation_onsite'},
# Energy Efficiency Actions
35: {'name': 'Energy Efficiency: LED Lighting Retrofit',
     'effects': {'GHG Scope 2 Location-Based': -0.08, 'BESG Environmental Pillar Score': 0.07},
     'cost': 20, 'pillar': 'environmental', 'initiative_type': 'energy_efficiency_lighting'},
36: {'name': 'Energy Efficiency: HVAC System Upgrade',
     'effects': {'GHG Scope 2 Location-Based': -0.12, 'BESG Environmental Pillar Score': 0.10},
     'cost': 55, 'pillar': 'environmental', 'initiative_type': 'energy_efficiency_hvac'},
37: {'name': 'Energy Efficiency: Building Insulation Improvement',
     'effects': {'GHG Scope 2 Location-Based': -0.05, 'BESG Environmental Pillar Score': 0.05},
     'cost': 30, 'pillar': 'environmental', 'initiative_type': 'energy_efficiency_envelope'},
38: {'name': 'Energy Efficiency: Implement Energy Management System (EMS)',
     'effects': {'GHG Scope 2 Location-Based': -0.10, 'BESG Environmental Pillar Score': 0.08},
     'cost': 40, 'pillar': 'environmental', 'initiative_type': 'energy_efficiency_monitoring'},
39: {'name': 'Energy Efficiency: Industrial Process Optimization',
     'effects': {'GHG Scope 2 Location-Based': -0.15, 'BESG Environmental Pillar Score': 0.12}, # Assumes Scope 2 impact
     'cost': 60, 'pillar': 'environmental', 'initiative_type': 'energy_efficiency_process'},
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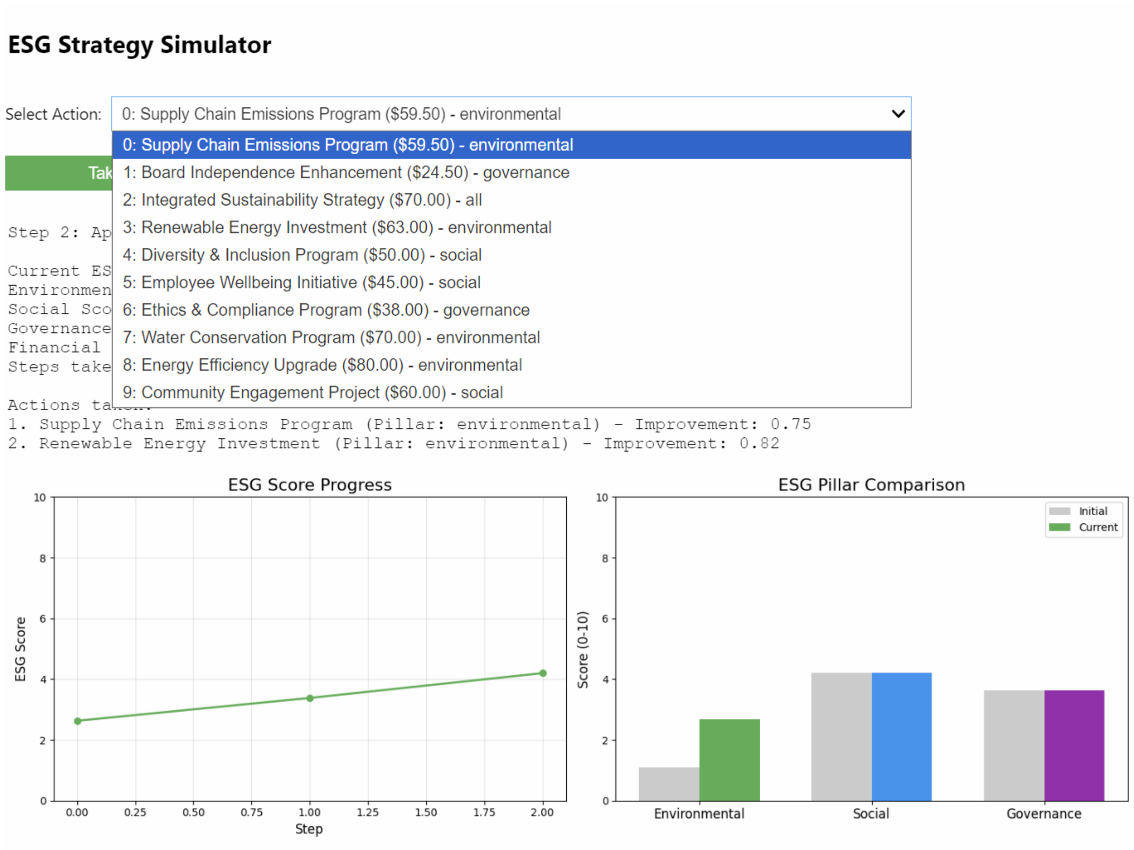
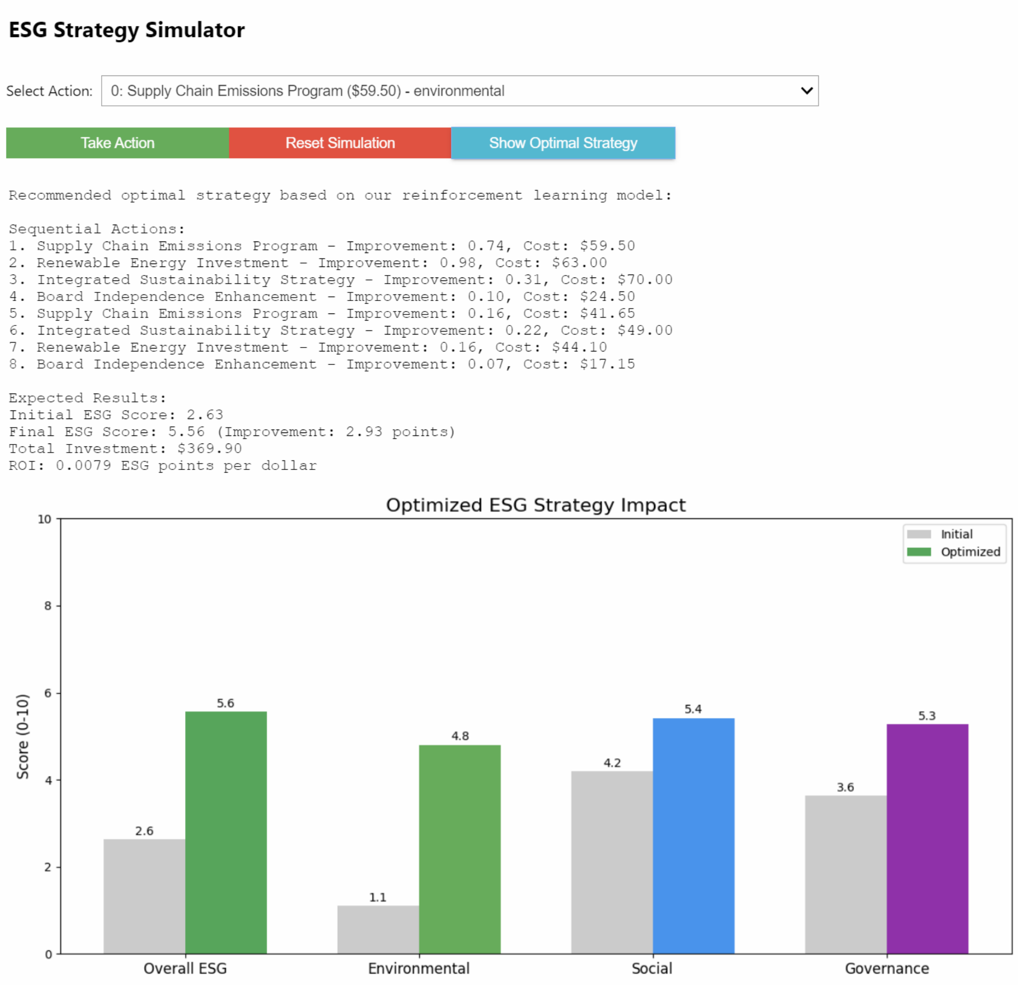
ESG Strategy Simulator





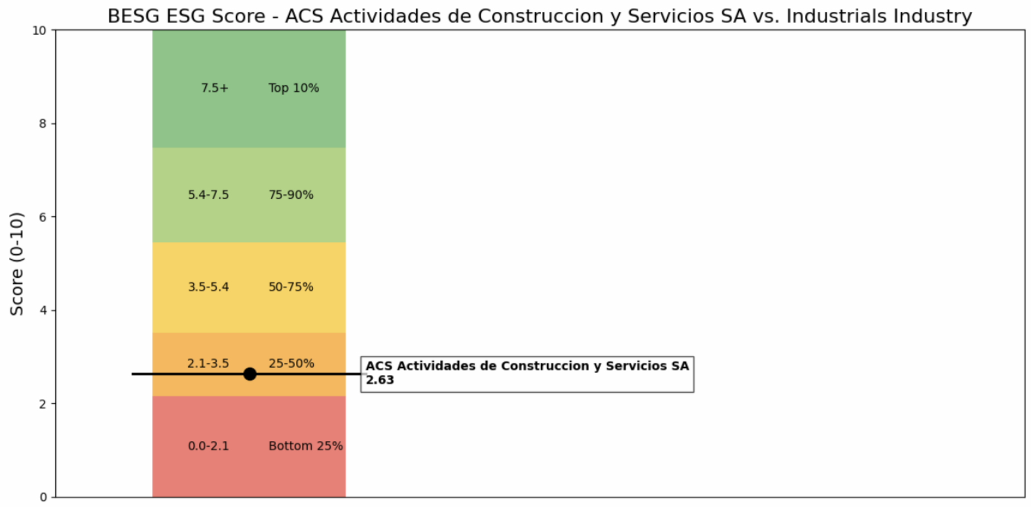
ESG Industry Benchmark Comparison

ESG Industry Benchmark Comparison

Company: ACS Actividades de Construccion y Servicios SA   Metric: BESG ESG Score

View:

Initial vs. Industry | Optimized vs. Indus... | Before & After



Industry Benchmark Comparison: BESG ESG Score

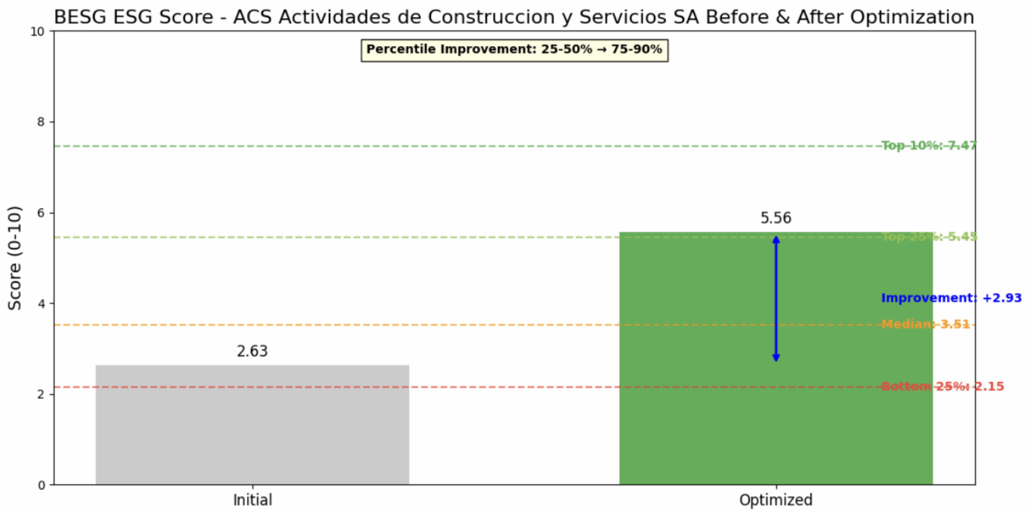
Benchmark	Value	Initial Position	Optimized Position
Bottom 25% Threshold	2.15	✓ Above	✓ Above
Industry Median (50%)	3.51	✗ Below	✓ Above
Top 25% Threshold	5.45	✗ Below	✓ Above
Top 10% Threshold	7.47	✗ Below	✗ Below
Company Score	-	**2.63 (25-50%)**	**5.56 (75-90%)**

ESG Industry Benchmark Comparison

Company: ACS Actividades de Construccion y Servicios SA   Metric: BESG ESG Score

View:

Initial vs. Industry | Optimized vs. Indus... | Before & After



Industry Benchmark Comparison: BESG ESG Score

Benchmark	Value	Initial Position	Optimized Position
Bottom 25% Threshold	2.15	✓ Above	✓ Above
Industry Median (50%)	3.51	✗ Below	✓ Above
Top 25% Threshold	5.45	✗ Below	✓ Above
Top 10% Threshold	7.47	✗ Below	✗ Below
Company Score	-	**2.63 (25-50%)**	**5.56 (75-90%)**