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Assessing the Impact of Global Sustainability Competitiveness on Logistics Performance: A Regression Study

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Abstract *– Logistics performance is impacted by global competitiveness. However, global competitiveness must be sustainable to truly be considered competitive. Therefore, there is a need to assess logistics performance in terms of a metric that encompasses both competitiveness and sustainability. This was proposed to be done through the Global Sustainability Competitiveness Index (GSCI). The objective of this study was to determine whether the GSCI, particularly through its sub-indices of natural capital, resource intensity, social capital, intellectual capital, and governance, has a significant impact on logistics performance (measured through the Logistics Performance Index or LPI). Data from 122 countries for the years 2016, 2018, and 2023 were analyzed through panel data regression analysis, and it was found that the GSCI sub-indices of social capital, intellectual capital, and governance had a positive and statistically significant impact to logistics performance. Therefore, if countries wish to improve on their logistics performance, they may look into improvement of these three factors.*

Keywords*: logistics performance index, LPI, global sustainability competitiveness index, GSCI, social capital, intellectual capital, governance, panel data regression*

I. INTRODUCTION

One of the most significant lessons from the pandemic is that supply chain reliability and resilience are critical. It was clearly observed during lockdowns the necessity of efficient and effective logistics systems, in the distribution of essential goods and medicines for instance. Poor logistics performance brought about very serious and very real consequences to stakeholders.

Even when the pandemic has officially ended, there is a need to ensure high levels of logistics performance as it has the potential not only to mitigate risks, but also to promote higher productivity which is especially critical as nations work towards recovery from the negative impacts of the pandemic.

National performance and productivity can be gauged on a global scale using several metrics, one of the most popular being the Global Competitiveness Index (GCI). Several studies have established a link between global competitiveness and logistics performance, more specifically that several pillars of the GCI have a significant impact on logistics performance (measured through the Logistics Performance Index or LPI). This implies that

improving upon certain pillars of global competitiveness (based on the GCI framework) would enable nations to improve on their logistics performance.

However, an organization called SolAbility argues that "what is not sustainable is not competitive, and what is not competitive is not sustainable". That is, the organization believes that sustainability and competitiveness need to co-exist. Sustainability is defined by the United Nations as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" [1]. While a healthy economic system is essential to achieving sustainability, the concept goes beyond merely economics and finance. The social and environmental aspects should equally be considered in order to promote competitiveness that is truly sustainable. A metric that encompasses both sustainability and competitiveness is the Global Sustainability Competitiveness Index (GSCI).

This study aims to explore the potential linkage between GSCI (as opposed to GCI) and LPI.

II. REVIEW OF RELATED LITERATURE

2.1 The Logistics Performance Index (LPI)

The Logistics Performance Index (LPI) is a benchmarking tool developed by the World Bank Group. The LPI aims to assess the logistics performance of a country and to identify areas for improvement in order to enhance trade and economic competitiveness [2]. In the latest assessment done by the World Bank Group, the LPI analyzes countries through six indicators:

- Customs: the efficiency of customs and border management clearance;
- Infrastructure: the quality of trade- and transport-related infrastructure;
- Cost: the ease of arranging competitively priced international shipments;
- Services: the competence and quality of logistics services;
- Reliability: the ability to track and trace consignments; and
- Timeliness: the frequency with which shipments reach consignees within the scheduled or expected delivery time.

The LPI is measured on a scale of 1 (low) to 5 (high) with weights assigned to each of the indicators. Countries with higher LPI scores are generally considered to have more efficient and reliable logistics systems.

LPI scores are considered an important metric in the economic performance or potential of a country. Improvements in any of the components of the LPI can lead to significant growth in a country's trade flows [3,4]. The LPI also has a positive relationship with net exports globally and drives world trade [5]. Another study by Civelek et al. [6] shows that the mediator effect of LPI is statistically significant on the relation between Global Competitiveness Index (GCI) and Gross Domestic Product (GDP). This suggests that the logistics ability of a country influences its competitiveness and prosperity.

Indeed, it is important to understand the drivers of logistics performance. Having a high LPI score entails having resilient supply chains that can better adapt to disruptions and uncertainties.

2.2 Global Competitiveness Index (GCI)

The Global Competitiveness Index (GCI) developed and published by the World Economic Forum measures a country's competitiveness, which are computed based on the following 12 indicators or pillars: public institutions, security and social cohesion, environment, infrastructure, human capital, public health, social protection, education and skills, labour market, financial conditions, competition, innovation, and future orientation of business [7].

The GCI is a "progress score" on a 0-to-100 scale, where 100 represents an ideal state wherein an issue ceases to be a constraint to productivity growth [8]. The GCI is a comprehensive metric that helps countries improve their competitiveness, which in turn translates to higher economic growth. That being said, the GCI mainly focuses on productivity and economics.

2.3 Studies that discuss the relationship between the Global Competitiveness Index (GCI) and Logistics Performance

The 12 pillars of the GCI each have their own factors, making the GCI one of the most comprehensive indices. Because of this, GCI has been used in studies to better understand how countries can improve their competitiveness. One of the areas wherein GCI has been used is in determining its relationship or effect on logistics performance.

The study of Ekici, et al. [9] checks which of the pillars or indicators of GCI are significant in improving logistics performance. The results show that governments should focus on technological readiness, higher education and training, innovation, market size, and infrastructure to facilitate improvement in the logistics performance of their countries. The same is true based on the study of Erkan [10] where the results demonstrate that the quality of railroad infrastructure and port infrastructure are major determinants of the logistics performance of countries. This implies that if a country wants to increase its logistics performance, it should primarily improve the quality of railroad and port infrastructure. Another study of Ekici, et al. [11] shows the most important GCI pillars that affect the logistics performance of a country to be business sophistication, financial market development, infrastructure and good market efficiency, and higher education and training.

Ekici, et al. [12] also performed a case study focusing on the GCI of Turkey, and analyzed its logistics performance to develop the basic strategies to be adopted by the government to achieve a targeted LPI level for the country. Among the many factors relating to logistics performance, it was found that fixed broadband internet availability is the most important target area for improvement related to sustainable logistics policy.

The research of Çemberci et al. [13] measured the moderating effect of GCI on each dimension of the LPI. As a result of the analysis, the moderating effects on three of the six dimensions have been found to be statistically significant. If a country targets to be on top in terms of the GCI, it needs to make important improvements in the following dimensions of

logistics services: international transportation, tracking and tracing, and timeliness.

As shown in this section, there have been numerous studies that establish a link between global competitiveness through the GCI to logistics performance and vice versa.

2.4 The Global Sustainability Competitiveness Index (GSCI)

The Global Sustainability Competitiveness Index (GSCI) is published by SolAbility and measures the competitiveness and sustainability of countries, based on 190 quantitative indicators derived from international organizations (e.g., World Bank, IMF, UN) [14]. National performance is often measured through metrics such as the Gross Domestic Product (GDP) or the Global Competitiveness Index (GCI), which are primarily focused on economic parameters. There needs to be a way to measure national performance beyond economics, a method that provides a more holistic picture of the strengths and weaknesses of each country as well as their future direction and potential. The GSCI measures national development and success beyond pure financial or economic outcomes. According to SolAbility, the GSCI "serves as a comprehensive alternative in terms of assessing country-specific and issue-specific risks for both operators and investors, and to validate or verify progress for countries" [14].

GSCI scores range from 0 to 100, where 100 is the highest score and indicates that a country is doing exceptionally well in terms of social, environmental, and economic development. In its most recent report, the 190 quantitative indicators used for the GSCI are grouped into six sub-indices: natural capital, resource intensity and efficiency, social capital, intellectual capital, economic sustainability, and governance efficiency. This is shown in Figure 1.

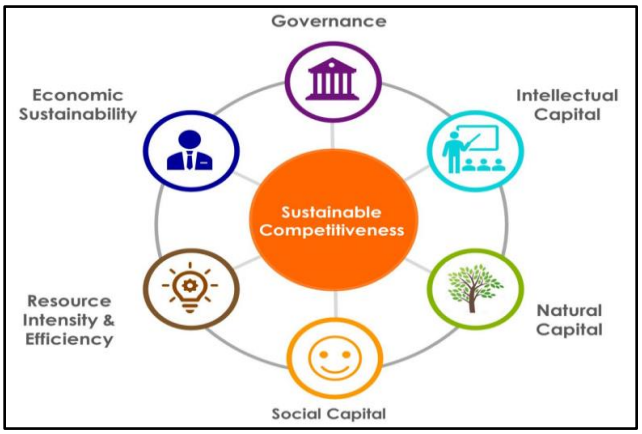

Figure 1. The Sustainable Competitiveness Model

Natural capital pertains to a country's "given natural environment, including the availability of resources, and the level of the depletion of those resources." Intellectual capital refers to "the capability of a nation to generate wealth and jobs through innovation and value-added industries in the globalized markets." Economic sustainability pertains to the ability of a nation to "generate wealth through sustainable economic development." Governance efficiency pertains to the "results of core state areas and investments, including infrastructure, market and employment structure, and the provision of a framework for sustained and

sustainable wealth generation." Resource intensity refers to "the efficiency of using available resources as a measurement of operational competitiveness in a resource-constrained world." Finally, social capital encompasses "health, security, freedom, equality, and life satisfaction within a country." Among these sub-indices, economic sustainability is relatively new; it was introduced to the model in 2022 [14].

2.5 Statistical Tools Utilized in Related Studies

The study by Yildiz [15] aimed to identify the relationship between logistics performance (through the LPI and its sub-indices) and global competitiveness (through the GCI and its pillars) using Structural Equation Modelling (SEM). SEM is an analytical tool that is able to combine regression, correlation, and factor analyses simultaneously [16]. This tool is especially useful when several dependent variables need to be simultaneously analyzed. The study of Ekici, et al. [9] also utilized the SEM methodology, particularly covariance-based SEM, in order to conduct multivariate exploratory and confirmatory regression analyses.

There have also been several studies that utilized panel data regression analysis in order to analyze the relationship between logistics performance and global competitiveness. In the study by Serdar, Erkan, and Sudi [17], panel data regression models were used to evaluate the effect of several economic factors such as GDP per capita and percentage of commercial service imports to logistics performance. In the study of Wong and Tang [18], the objective was to estimate logistics performance using panel data, which is a combination of cross-sectional and time-series data. In particular, since the time component was small (between 2 to 4 years), the proponents ruled out the use of dynamic or non-stationary panel data methods. The study ultimately utilized the Fixed Effects (FE) model to conduct a regression analysis with logistics performance as the dependent variable and the GCI pillars of corruption perception, political stability, infrastructure, technology, supply of labour and education as the independent or explanatory variables.

III. THE PROBLEM, HYPOTHESIS, AND METHODOLOGY OF THIS STUDY

3.1 Problem

Several studies have been conducted to determine the link between logistics performance and global competitiveness through the Global Competitiveness Index (GCI). However, as the organization SolAbility argues, "What is not sustainable is not competitive; what is not competitive is not sustainable" [14]. Few studies (if any) have explored the link between logistics performance to both competitiveness and sustainability. Therefore, there exists a research gap in terms of identifying the relationship between logistics performance and global sustainability competitiveness (as measured through the Global Sustainability Competitiveness Index or GSCI).

Main Problem: Does the GSCI (through its sub-indices) have a significant impact on the LPI?

3.2 Hypothesis

The hypothesis of this study is that there is a factor or a set of factors related to global sustainability competitiveness that significantly influence logistics performance. The null and alternative hypotheses are as follows:

H_0: The GSCI sub-indices do not have a significant impact on the LPI
H_1: At least one GSCI sub-index has a significant impact on the LPI

3.3 Methodology

The following methodology was adopted for this study:

3.3.1 Data Gathering

The quantitative data used in this study were primarily the Logistics Performance Index (LPI) gathered from the World Bank Group database, and the Global Sustainability Competitiveness Index (GSCI) gathered from SolAbility published reports.

The World Bank Group began publishing the LPI in 2007, and has published LPI data bi-annually since 2010. However, due to the pandemic, there were no LPI reports published in 2020 and 2022. As for the GSCI indices, SolAbility began publishing these reports in 2012. However, earlier publicly available reports show overall GSCI scores only and do not specify the scores for each GSCI sub-index. Additionally, there have been significant changes in the sub-indices over the years. For instance, the sub-index Economic Sustainability was only included in 2022.

In order to balance out the availability of LPI data as well as the completeness of GSCI data, the years included in the study were 2016, 2018 and 2023, which coincide with the three most recent published LPI reports wherein GSCI sub-index scores are also available. Moreover, there are only five (out of the current six) GSCI sub-indices that are common and that can be used for these three years (i.e., economic sustainability was excluded). Finally, the countries that did not have complete data for all three years were excluded from the study. A total of 64 countries were excluded due to this reason, bringing the total number of countries included in the study to be 122.

The following data were gathered for the 122 countries included in the study for the years 2016, 2018, and 2023:

- Logistics Performance Index Scores (lpioverall)
- Global Sustainability Index – Natural Capital Sub-Index Scores (natcap)
- Global Sustainability Index – Resource Intensity Sub-Index Scores (resint)
- Global Sustainability Index – Social Capital Sub-Index Scores (soccap)
- Global Sustainability Index – Intellectual Capital Sub-Index Scores (intcap)
- Global Sustainability Index – Governance Sub-Index Scores (gov)

3.3.2 Descriptive Statistics

A quantitative summary of the variables included in the study was provided to better understand their characteristics.

3.3.3 Selection of Statistical Tool and Checking for Assumptions

Given that there was only one dependent variable to be examined in the study (LPI) as opposed to several dependent variables simultaneously being examined, a panel data regression model was utilized.

There are three basic panel data models that can be used depending on cross-sectional and/or time-specific effects. These are:

a) Pooled Ordinary Least Squares (OLS)
b) Fixed Effects
c) Random Effects

The Pooled OLS method is effective in cases wherein the individual effect (e.g., cross-sectional or time specific effect) does not exist. If the previous statement holds true in the context of this study, it implies that the individual circumstances of each country (e.g., policies, culture) do not play a factor in the analysis.

There are five core assumptions that must be met for panel data regression, or more specifically, for OLS to be used:

1) Linearity
2) Exogeneity
3) Homoskedasticity and Non-autocorrelation
4) Independent and Non-Stochastic
5) No Multicollinearity

More specifically, if either assumption 2 (exogeneity) or 3 (homoskedasticity or non-autocorrelation) are not met, then the Pooled OLS model would be an inefficient and biased model. A supplementary test for endogeneity must be conducted to identify whether Fixed Effects or Random Effects is the more appropriate model [19].

3.3.4 Generation of Initial Regression Model

Once the final panel data regression model has been selected (i.e., Pooled OLS, Fixed Effects, or Random Effects), initial panel data regression analysis was conducted in order to determine the relationships between and among the different factors. In particular, LPI scores (lpioverall) were established as the dependent variable, while the GSCI sub-indices of natural capital (natcap), resource intensity (resint), social capital (soccap), intellectual capital (intcap), and governance (gov) were set as the independent variables or factors. The output of the analysis is an initial regression model which presented the GSCI sub-indices that have a statistically significant relationship to the LPI.

3.3.5 Revision of Regression Model and Discussion of the Significant Factors

The initial regression model was further refined to include only the GSCI sub-indices that were statistically significant, with the objective of increasing the overall R-squared of the model. This is an application of backward stepwise regression which is helpful in examining the relationship between a dependent variable and independent variables. First, all independent variables are included in the regression analysis. Subsequently, subsets of the independent

variables are included in the regression analysis to improve the model (which can be quantified through the R-squared) [20].

Given this refined panel data regression model, the implications of each significant factor were discussed.

IV. CASE STUDY AND ITS RELATED SCOPE AND LIMITATIONS

The objective of this study is to examine logistics performance and global sustainability competitiveness not only across countries but also over time. A main limitation in terms of the data that can be utilized is due to the fact that LPI reports are not published annually. At the same time, published GSCI reports from 2017 did not include the scores for each sub-index. Therefore, a relatively limited amount of data can be used. However, a rule of thumb in terms of required sample size is 10 per explanatory or predictor variable [19]. Since the study utilized 122 countries with 3 years' worth of data per country, bringing the total sample size to 366, the sample size is adequate for 5 explanatory variables.

This research was primarily conducted to examine the GSCI sub-indices that have an impact on logistics performance (through the LPI) in its entirety. Therefore, the characteristics and relationships of each sub-index of the LPI were not explored.

V. RESULTS AND DISCUSSION

5.1 Descriptive Statistics

Figure 2 provides a summary of the data included in the study. There was a total of 122 countries included with 3 years' worth of data per country. Thus, a balanced panel was utilized. It can be observed in Figure 2 that the "between" standard deviations (i.e., between and among different countries) are relatively larger than those "within" (i.e., each individual country over time).

For LPI (lpioverall), the mean score is 2.99 out of 5.00, wherein the highest is 4.3000 and the lowest is 1.5983. For the GSCI sub-indices of natural capital (natcap), resource intensity (resint), social capital (soccap), intellectual capital (intcap) and governance (gov), the maximum possible score is 100. From Figure 2, it can be observed that the mean sub-index scores range from 23.05 to 71.02 for natcap, 18.89 to 65.55 for resint, 24.80 to 65.76 for soccap, 11.28 to 79.73 for intcap, and 24.70 to 75.97 for gov.

Variable		Mean	Std. dev.	Min	Max	Observations	
lpiove~l	overall	2.993936	.6047001	1.598322	4.3	N =	366
	between		.5915597	1.976146	4.175804	n =	122
	within		.1328038	2.527637	3.396876	T =	3
natcap	overall	46.12172	10.08171	23.04678	71.01739	N =	366
	between		9.461796	26.27862	64.35339	n =	122
	within		3.550476	35.62179	56.1767	T =	3
resint	overall	44.03591	8.362321	18.89466	65.5543	N =	366
	between		6.753533	29.16181	58.15566	n =	122
	within		4.956623	30.20395	56.99471	T =	3
soccap	overall	43.83119	9.385915	24.8	65.76272	N =	366
	between		8.797202	26.90452	62.14367	n =	122
	within		3.33597	34.62528	53.67068	T =	3
intcap	overall	42.3278	13.3783	11.27778	79.72782	N =	366
	between		12.97349	17.42445	76.71687	n =	122
	within		3.404381	32.53598	53.34117	T =	3
gov	overall	50.24615	10.23298	24.7	75.97208	N =	366
	between		9.059055	28.79348	66.47062	n =	122
	within		4.805945	39.02643	69.0549	T =	3

Figure 2. Descriptive Statistics of the Dependent and Independent Variables

5.2 Checking for Assumptions and Selection of Panel Data Regression Model

In order to utilize panel data regression, the following assumptions must be met: linearity, independent and non-stochastic independent variables, and no multicollinearity among independent variables. To test for linearity for multiple independent variables, the residuals were plotted against fitted values. From the residuals vs. fitted plot in Figure 3, it can be seen that the linearity assumption is met.

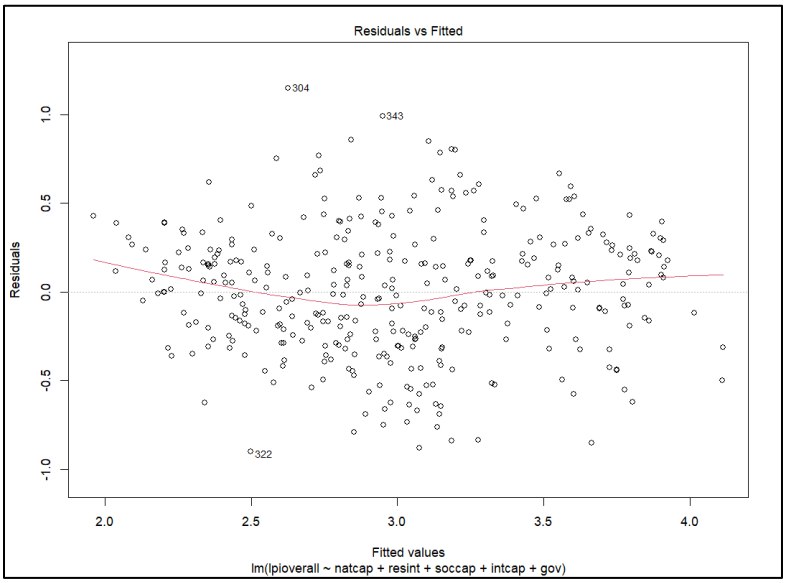

Figure 3. Residuals vs. Fitted Plot

The independent variables in the study (i.e., GSCI sub-index scores) can be considered independent and non-stochastic as they are by nature "fixed in repeated samples" [20]. To test for multicollinearity, the variance inflation factors (VIF) of each independent variable was observed. According to Daoud [22], VIF values greater than 5 imply multicollinearity. The VIFs for the independent variables for the study are summarized in Table 1. As can be observed, there were no VIF values that exceed the threshold of 5.

Table 1. Variance Inflation Factors of the Independent Variables

Variable	VIF
natcap	1.0107
resint	1.0010
soccap	1.4912
intcap	1.0027
gov	2.0559

Figure 3 can also be used to examine homoskedasticity. Since there are portions in the plot wherein the vertical spread of the residuals varies with respect to the fitted values, it cannot be said for certain that the variance is constant (i.e., heteroskedastic). With this, the panel data regression model utilized should incorporate a "robust" setting that would address this heteroskedasticity.

In terms of autocorrelation, the Durbin-Watson test was utilized. The Durbin-Watson test establishes the null hypothesis that there is no correlation among residuals. The result of the Durbin-Watson test is shown in Figure 4. Since the p-value is significantly low, it can be said that the residuals are autocorrelated. This is not surprising as we are dealing with data for the same individuals (i.e., countries) over time.

```
durbinWatsonTest(LPI_regress)
lag Autocorrelation D-W Statistic p-value
  1       0.4347344      1.129479       0
Alternative hypothesis: rho != 0
```

Figure 4. Durbin-Watson Test for Autocorrelation Results

Since assumption 3 was not met, the Pooled OLS model is not appropriate. With this, the Hausman test for endogeneity was employed with the objective of identifying whether a Fixed Effects model or a Random Effects model is more appropriate to use. For the Hausman test, the null hypothesis is that individual characteristics are not correlated with the regressors (i.e., Random Effects is more efficient to use). The results of the Hausman test are displayed in Figure 5. A significantly low Prob > chi2 implies that the null hypothesis is rejected, therefore, the Fixed Effects model is more appropriate for the study.

	Coefficients (b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) Std. err.
natcap	.0023926	.0005918	.0018008	.0017801
resint	-.0030437	-.000018	-.0030256	.0009011
soccap	.0046204	.0134963	-.0088758	.0015676
intcap	-.001904	.01407	-.015974	.0019167
gov	.0041541	.0055709	-.0014169	.0006795

b = Consistent under H0 and Ha; obtained from **xtreg**.
B = Inconsistent under Ha, efficient under H0; obtained from **xtreg**.

Test of H0: Difference in coefficients not systematic

chi2(**5**) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= **81.46**
Prob > chi2 = **0.0000**

Figure 5. Hausman Test for Endogeneity Results

5.3 Generation of Initial Regression Model

The results of the initial fixed effects panel data regression analysis are displayed in Figure 6. Based on these results, it can be observed that the sub-indices research intensity (resint), social capital (soccap), and governance (gov) have a statistically significant relationship to the logistics performance index (lpioverall) at a significance level of 0.10. Meanwhile, the sub-indices natural capital (natcap) and intellectual capital (intcap) do not appear to be significant factors to the LPI.

Fixed-effects (within) regression — Number of obs = **366**
Group variable: **country** — Number of groups = **122**

R-squared:
Within = **0.0725**
Between = **0.3186**
Overall = **0.2575**

Obs per group:
min = **3**
avg = **3.0**
max = **3**

F(**5, 121**) = **4.60**
corr(u_i, Xb) = **0.4215** — Prob > F = **0.0007**

(Std. err. adjusted for **122** clusters in **country**)

lpioverall	Coefficient	Robust std. err.	t	P>|t|	[95% conf.	interval]
natcap	.0023926	.0024744	0.97	0.336	-.0025062	.0072914
resint	-.0030437	.001602	-1.90	0.060	-.0062153	.0001279
soccap	.0046204	.0024111	1.92	0.058	-.0001531	.0093939
intcap	-.001904	.0021775	-0.87	0.384	-.0062148	.0024069
gov	.0041541	.0018123	2.29	0.024	.0005662	.0077419
_cons	2.686962	.2145478	12.52	0.000	2.262208	3.111716
sigma_u	.55857197					
sigma_e	.15805966					
rho	.92586371	(fraction of variance due to u_i)				

Figure 6. Initial Fixed Effects Panel Data Regression Model

5.4 Revision of Regression Model

Excluding the two GSCI sub-indices that were not statistically significant based on the initial regression model (natural capital and intellectual capital), a revised regression model was generated and is displayed in Figure 7. The results show that the remaining three sub-indices were still statistically significant to the logistics performance index (lpioverall) at a significance level of 0.10. Additionally, the R-squared of this revised model is better than the initial model at 0.4515.

Fixed-effects (within) regression — Number of obs = 366
Group variable: **country** — Number of groups = 122

R-squared:
Within = **0.0659**
Between = **0.5263**
Overall = **0.4515**

Obs per group:
min = **3**
avg = **3.0**
max = **3**

F(**3, 121**) = **6.89**
corr(u_i, Xb) = **0.5984** — Prob > F = **0.0003**

(Std. err. adjusted for **122** clusters in **country**)

lpioverall	Coefficient	Robust std. err.	t	P>|t|	[95% conf.	interval]
resint	-.0032258	.0016874	-1.91	0.058	-.0065665	.0001149
soccap	.0050418	.0024178	2.09	0.039	.000255	.0098286
gov	.0036643	.0017936	2.04	0.043	.0001135	.0072151
_cons	2.730884	.143272	19.06	0.000	2.447239	3.014529
sigma_u	.53702086					
sigma_e	.15795677					
rho	.92037339	(fraction of variance due to u_i)				

Figure 7. Revised Fixed Effects Panel Data Regression Model

5.5 Discussion of the Significant Factors

5.5.1 Resource Intensity

Based on the revised panel data regression model, resource intensity has a negative and statistically significant relationship to the LPI. Resource intensity pertains to the ability of a nation to manage its available natural capital, human capital, and financial capital efficiently. Its key drivers include the resource management of energy (fossil, electricity, renewables), water (water per capita, water withdrawals rate, water productivity), and raw material (resources per capita, resources per GDP, resource balance).

A major objective under this sub-index is the achievement of a true circular economy that promotes the reuse of resources, which ultimately reduces the use of raw materials as well as CO2 emissions [23]. This sub-index is a combination of two general factors – the "intensity" component, which is based on per capita resource consumption, and the "efficiency" component, which is based on per unit of value generated. In terms of the intensity component, less developed countries that have generally less resources available receive high scores. On the efficiency component, more highly developed economies receive higher scores [24]. Since the regression model incorporated all countries regardless of development level, there may

have been a "cancelling" effect due to these two factors that are to a certain extent inversely related. The top performers in terms of this sub-index are lower middle- to low- income countries such as Papua New Guinea, Congo, Sierra Leone and Malawi. Lower income countries also generally have lower LPI scores (average of 3.5138 for high income countries vs. average 2.6205 for upper middle-, lower middle- and low- income countries). This is one possible explanation for the negative coefficient of the resource intensity factor.

Another possible explanation for the negative relationship between resource intensity and LPI is that countries are not sustainably utilizing their resources in their pursuit of improved logistics performance. This insight is somewhat corroborated by the fact that some of the top LPI performers such as Germany (No. 4), Belgium (No. 8), and Japan (No. 14) had relatively lower scores for resource intensity (Germany-No. 43, Belgium-No. 75, Japan-No. 92).

5.5.2 Social Capital

Social capital includes the health, security, freedom, equality, and life satisfaction within a country, facilitating development. According to SolAbility, it represents the "sum of social stability and well-being of the entire population" [25]. The key elements and drivers in the social capital sub-index are health (healthcare availability, child mortality, family planning), equality (income equality, resource equality, and gender equality), crime (theft, violent crime, prison population), freedom (press freedom, human rights, violent conflicts), and satisfaction (individual happiness, suicide rate, public service satisfaction). It is interesting to observe that social capital is a significant factor to the logistics performance of a country, particularly with a positive relationship. In a general sense, it is not difficult to imagine how better healthcare for citizens, less human rights violations, or high public service satisfaction would enable better economic performance. Through this study, it can be established with statistical significance that investing in the improvement of a nation's social capital can improve its logistics performance.

5.5.3 Governance

Governance, or governance efficiency, reflects "the performance of a country's regulatory framework and infrastructure environment to facilitate sustainable competitiveness" [26]. Its key elements and drivers include the following: government cohesion (public services, educational budget, and military spending), infrastructure (investments, roads and rail, and transmission), business environment (ease of doing business, business registration, and sector developments), corruption (corruption index, bribery prevalence, and red tape), and financial stability (austerity, exposure to financial shocks, and financial regulation). The governance sub-index has a positive and statistically significant impact on LPI, which implies that better governance aids in improving logistics performance. The governance sub-index has a very wide scope, and it affects or is closely related to other sub-indices such as social capital and intellectual capital as well. Better governance in terms of a low corruption index or a high rating in terms of ease of doing business would definitely enable better logistics performance, and this conjecture is backed up by the positive and statistically significant relationship between the governance sub-index and LPI.

5.5.4 Qualitative Examination of Select Countries

Two countries were selected in order to examine their current policies, initiatives, or contexts in order to better appreciate their performance in terms of the LPI and the significant factors of resource intensity, social capital, and governance. The countries selected were Sweden, one of the top performers across all metrics (i.e., LPI, resource intensity, social capital, governance), and Sudan, one of the poorest performers. Their LPI, resource intensity, social capital, and governance ranks in 2023 are listed in Table 2. Their income category (i.e., high, upper middle, lower middle, or low) as published by the World Bank have also been included.

Table 2. LPI, Resource Intensity, Social Capital, and Governance Ranks of Sweden and Sudan in 2023

Country	Income Category	LPI Rank	Resource Intensity Rank	Social Capital Rank	Governance Rank
Sweden	High	7	3	6	5
Sudan	Low	115	145	173	166

A top-performing country such as Sweden has well established and well communicated strategies. In their published strategy for trade, investment, and global competitiveness for 2024 [27], some key topics include "free, sustainable and rules-based world trade with fewer trade barriers", "improved Team Sweden cooperation for greater impact", "an image of Sweden that communicates partnership", "strengthening Sweden's position globally as a prioritised partner for green and digital transition", and "increased coordination and better synergies between trade policy, trade promotion and development cooperation." These are all indicative of the country's efforts to improve competitiveness in a sustainable manner. In the published strategy, the importance of proper performance measurement, monitoring and evaluation was also highlighted.

As for Sudan which generally fared low in terms of the relevant metrics, the competitiveness and sustainability conditions are not good. Sudan has been experiencing conflict since April 2023. According to a report published by the UN Office for the Coordination of Humanitarian Affairs (OCHA) on Sudan [28], it was reported that Sudan's economy contracted by 12% in 2023. Furthermore, the country's human capital as well as industrial, education, and health facilities have been negatively affected by the continued armed conflict. This can explain the country's poor performance in terms of logistics performance, global competitiveness, and sustainability.

VI. SUMMARY, CONCLUSION AND RECOMMENDATION

Logistics performance is impacted by global competitiveness; several studies have already established this relationship. However, as SolAbility advocates, competitiveness must go hand in hand with sustainability, that is, "what is not sustainable is not competitive" and vice versa. Currently, there are a small number of studies that examine the relationship between

sustainable competitiveness and logistics performance. The objective of this study was to add to the body of research relating sustainable competitiveness (through the global sustainability competitiveness index or GSCI) and logistics performance (through the logistics performance index or LPI). In particular, the study aimed to identify if the GSCI through its sub-indices (i.e., natural capital, resource intensity, social capital, intellectual capital, and governance) has a significant impact on logistics performance by conducting panel data regression analysis. By identifying the significant factors (if any), the sustainable competitiveness drivers that contribute to better national logistics performance can be better understood.

LPI scores were obtained from reports published by the World Bank Group while GSCI sub-index scores were obtained from reports published by SolAbility. LPI and GSCI data for the years 2016, 2018, and 2023 for 122 countries were utilized in this study. The results of the fixed effects panel data regression analysis show that the GSCI sub-indices of resource intensity, social capital, and governance significantly impact logistics performance. This implies that logistics performance can be impacted by changes in these sustainable competitiveness factors. Select countries were also examined to assess their performance against their current contexts.

One recommendation for future studies is to validate the results of this study once new GSCI and LPI data become available. Moreover, future studies can look into the relationship between global sustainability competitiveness and logistics performance by clustering regions (e.g., North America, South Asia, Middle East and North Africa, etc.) or income groups (e.g., high income, low income, lower middle income, upper middle income), as there may be similar behaviors within each region and/or income group that are significantly different across other regions and/or income groups. Analyses can also be made within each region and/or income group where each country's scores are on a more comparable basis. Finally, it would be interesting to compare and contrast the GSCI factors alongside the GCI factors that significantly impact logistics performance in order to observe the similarities and differences in these factors, and to analyze which set of factors (GSCI or GCI) have a higher explanatory power for logistics performance.

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