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Impact of Blockchain Technology on Maritime Transport in the Shipping Industry*

Sang-phil Byun[a], Jeong-Hun Oh[b]

[a]UNIDO ITPO Korea. South Korea
[b]Graduate School of International Studies, Korea University. South Korea

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Abstract

Purpose - The purpose of this paper is to assess the empirical evidence that shows blockchain technology has been a significant contributor to the growth of maritime transport in the shipping industry.
Design/methodology/approach - Employing a generalized linear model using data from 2010 to 2019, this paper presents empirical evidence to demonstrate the positive impact of the adoption of blockchain technology on the maritime transport industry.
Findings - Results from Granger causality tests confirm that there is a positive unidirectional causality from blockchain technology to maritime transport. This paper also demonstrates the positive effects of information technology (IT) and GDP growth on maritime transport. On the other hand, maritime transport is negatively influenced by the tax burden.
Research implications or Originality - The results of this paper suggest a potential sustainable development strategy for the maritime transport industry involving the redirection of economic resources toward blockchain technology. Adopting other forms of IT and reducing the tax burden are also useful strategies for the development of the industry.

Keywords: Blockchain Technology, GLM, Maritime Transport, Shipping Industry
JEL Classifications: C30, C82, F14

Ⅰ. Introduction

Over the past decade, blockchain technology and other forms of information technology (IT) have been important drivers of the fourth industrial revolution, which has fundamentally changed not only daily living but also the way business is conducted (World Bank, 2020). This has been the case for the shipping industry, with Loklindt et al. (2018), Belu (2019), Filom (2020), Peronja et al. (2020), and Pu and Lam (2020) reporting that blockchain technology has been employed to expedite the information, physical, and financial flows associated with marine transport. This is because blockchain technology offers decentralization, transparency, and immutability, leading to higher levels of efficiency within the industry. Furthermore, smart contracts based on blockchain technology facilitate contract negotiations without the need for

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[a] First Author. Email: bsphil0126@gmail.com
[b] Corresponding Author. Email: ojh@korea.ac.kr

intermediary intervention, significantly reducing time and costs in maritime transport (Belu, 2019; Peronja et al., 2020).

Although there have been a large number of case studies and theoretical studies on the role of blockchain technology in the maritime transport, there has been a lack of empirical research on this topic. Therefore, the main objective of this paper is to assess the empirical evidence for the positive impact of blockchain technology on the maritime transport industry. The most noteworthy finding of this paper is that blockchain technology has a positive impact on the seaborne trade volume. Using a generalized linear model (GLM) with data from 2010 to 2019, this paper reveals a positive relationship between blockchain technology and seaborne trade. Furthermore, results of the Granger causality test reveal that the causality from blockchain technology to seaborne trade is unidirectional. Empirical results from the GLM indicate that expenditure on IT and the GDP growth also have a positive impact on seaborne trade. In contrast, a higher tax burden has a negative relationship with seaborne trade.

The rest of this paper is structured as follows. Chapter II provides a literature review, while chapter III explains the research methodology. Chapter IV summarizes the empirical findings, and concluding remarks are provided in chapter V.

II. Literature Review

Numerous studies have investigated the contribution of blockchain technology to trade.[1) The World Trade Organization (WTO, 2018) reported that blockchain technology can move international trade toward digitization, while the European Parliamentary Research Service (EPRS, 2020) summarized the potential impacts of blockchain technology on international trade. Jugovic et al. (2019), Chang et al. (2019), Saberi et al. (2019), and Kim (2020) have also analyzed the possible advantages of applying blockchain technology to international trade. They argue that blockchain technology has streamlined transaction processes, leading to more rapid, stable, and efficient international trade.

Other research has focused on the impacts of blockchain technology on maritime transport. Loklindt et al. (2018) suggested that blockchain technology can be adapted for the exchange of shipping documents, while Filom (2020) reported that maritime transport can employ blockchain features to provide trust, speed, decentralization, and privacy. Pu and Lam (2020) also conducted a systematic analysis of blockchain applications in the maritime industry and found that companies can use these applications to improve their competitiveness. Furthermore, according to Belu (2019) and Peronja et al. (2020), smart contracts based on blockchain technology can reduce the time and costs involved in contract negotiation in the maritime transport industry for current shipments and bills of lading.

To date, however, no empirical research on this topic has been conducted except for Siddik et al. (2020), who reported a positive relationship between blockchain technology and international trade. The main contribution of this paper is to assess the impacts of blockchain technology on maritime transport in the shipping industry using the empirical analysis of a GLM. As shown in previous studies such as Loklindt et al. (2018), Belu (2019), Filom (2020), Peronja

1) Because the literature on the determinants of trade is too extensive, we have limited our discussion to blockchain. Please refer to Matuszczak (2019) and Kwame & Omolemo (2020) for a more detailed review of the determinants of trade. Please refer to Hwa & Kim (2019) and Song (2020) for the detailed review on the blockchain technology and trade.

et al. (2020), and Pu and Lam (2020), the maritime transport industry has been one of the largest adopters of blockchain technology for trade.[2] Another contribution of this paper is that it uses most recent data from 2010 to 2019 for its analysis.

Ⅲ. Research Methodology

3.1 Empirical Model

The objective of this paper is to provide insights into the application of blockchain technology in maritime transport by ascertaining its impact on seaborne trade volume through empirical analysis. In the present study, a GLM is adopted to identify the relationship.[3] The GLM equation is as follows:

$$STt = \beta0 + \beta1\ BTt + \beta2\ ITt + \beta3\ GDPt + \beta4\ INFt + \beta5\ BFt + \beta6\ FFt + \mu t \quad (1)$$

where STt refers to the log of the seaborne trade volume at time t, and BTt denotes the bitcoin circulation volume at time t.[4] ITt denotes the log of IT expenditure,[5] GDPt represents the annual GDP growth rate, INFt is the inflation rate, BFt denotes business freedom, and FFt represents fiscal freedom, which is an indicator of the tax burden. $\beta0-6$ represent the coefficients attached to the independent variables, and μt represents the error term.

The dependent variable and the main independent variable are seaborne trade volume and bitcoin circulation, respectively. It is expected that there will be a direct relationship between the two. Other independent variables are used to examine the link between seaborne trade volume and bitcoin circulation. Zhu (2007) reported that IT has served as one of the drivers of the rapid growth in trade in the 1990s. Hence, expenditure on IT is expected to have a positive relationship with seaborne trade. Valentine et al. (2013) also found a positive relationship between GDP growth and maritime trade volume, while Stockman (1981) confirmed that inflation has a negative relationship with international trade. Therefore, both of these variables are included in the model. Business freedom is measured using an index for the effectiveness of government regulations on a scale of 0 to 100. Abasimi et al (2018) confirmed a positive relationship between business freedom and trade. Fiscal freedom was measured using the tax burden imposed by the government. Keen and Syed (2006) found that a high level of tax

2) The most popular blockchain-based platforms for trade such as Maersk and IBM's CargoX, and dKagro have been applied to the maritime transport industry. Please refer to Peronja et al. (2020) for details.

3) Due to the insufficient time periods in the blockchain data, conventional time series analysis using a vector autoregressive model (VAR) or a vector error correction model (VECM) is not accessible to describe the relationship among our variables. Hence, as Siddik et al. (2020), we use a GLM, which allows the model to be related to the dependent variable through a link function and the magnitude of the variance to be a function of its predicted value. Please refer to Nelder and Wedderburn (1972) for detailed information on the GLM.

4) People may argue if BT directly represents the blockchain technology level. Unfortunately, there does not exist time series data which directly measure blockchain technology usage level. As Crosby et al (2016) points out, bitcoin is a standard example of the usage of blockchain technology. Hence, we use bitcoin circulation data in order to measure blockchain technology as other empirical studies did on it. Please refer to Siddik et al (2020) for details.

5) IT has been employed in trade to improve efficiency for several decades (Zhu, 2007). Since blockchain represents only a minor proportion of this IT, it has been overlooked to include BTt and ITt as separate independent variables in the model.

hurts trade activity. The summary of the applied variables is presented in ⟨Appendix 1⟩.

3.2 Data Analysis

Time-series data from 2010 to 2019 are employed for the empirical analysis. Data for seaborne trade and bitcoin circulation are obtained from UNCTAD and blockchain.com, respectively. The data for expenditure on IT are taken from gartner.com. Both GDP and inflation data are acquired from the World Bank (2020). Finally, data for business and fiscal freedom are attained from the Heritage Foundation (2021). The summary of the descriptive statistics is presented in ⟨Table 1⟩.

Table 1. Descriptive Statistics for the Variables in the Model

Variable	Mean	Std. Dev	Min.	Max.
STt	9.193	0.095	9.036	9.313
BTt	13.291	4.334	5.000	18.130
ITt	8.180	0.040	8.130	8.247
GDPt	2.961	0.551	2.365	4.303
INFt	2.652	1.042	1.434	4.822
BFt	64.600	0.481	63.500	65.000
FFt	77.360	0.675	75.800	78.000

Correlation analysis is conducted to identify any dependencies among the variables. ⟨Table 2⟩ shows that all of the correlation coefficients between the variables were lower than 0.7, indicating a low level of correlation. In addition, the variables have variance inflation factors (VIFs) ranging from 2.33 to 7.27 with a mean of 5.08, suggesting that there are no serious multicollinearity issues in the model. The VIF test results are presented in ⟨Appendix 2⟩.

Table 2. Correlation Analysis

	STt	BTt	ITt	GDPt	INFt	BFt	FFt
STt	1.0000						
BTt	0.9842	1.0000					
ITt	0.4142	0.3576	1.0000				
GDPt	-0.5249	-0.6230	-0.4976	1.0000			
INFt	-0.7063	-0.7506	0.1658	0.2960	1.0000		
BFt	-0.5386	-0.5552	-0.2513	0.5161	0.4494	1.0000	
FFt	0.6290	0.7447	0.1821	-0.7784	-0.6393	-0.3320	1.0000

IV. Empirical Findings

In the analysis process for this study, stationarity and cointegration tests are conducted first, followed by GLM estimation and a Granger causality test.

In the first step of the estimation process, a unit root test is conducted following Elliott et al. (1996). This paper employs three different regression models in order to test the unit root of the time-series data as follows:

$$\Delta Yt = \Delta Yt\text{-}1 + \varepsilon t \quad (2)$$

$$\Delta Yt = \alpha + \Delta Yt\text{-}1 + \varepsilon t \quad (3)$$

$$\Delta Yt = \alpha + \Delta Yt\text{-}1 + \beta T + \varepsilon t \quad (4)$$

Where Y is the time series variable, t is the current year, t-1 is the previous year, α is the intercept, Δ is the coefficient of the lagged Y, T is the trend, β is the coefficient of the trend, and εt is the error term. Time-series data are non-stationary when the null hypothesis fails to be rejected, indicating that the time-series data have a unit root.

Table 3. Unit Root Test Results

Variable	Model	Level	Variable	Model	Level
	1st	-1.449***		1st	-3.918
STt	2nd	-0.973***	INFt	2nd	-1.834***
	3rd	-0.790***		3rd	-2.924***
	1st	-2.667***		1st	-1.391***
BTt	2nd	-6.310	BFt	2nd	-0.596***
	3rd	-2.251***		3rd	0.213***
	1st	-2.815***		1st	-2.436***
ITt	2nd	-4.285***	FFt	2nd	-1.739***
	3rd	-1.978***		3rd	-4.956***
	1st	-3.403			
GDPt	2nd	-2.256***			
	3rd	-1.131***			

Note: *** denotes that the test statistics are significant at the 1% level

As ⟨Table 3⟩ shows, the results of the unit root test reveal that all the variables, except BCt in (2) and GDPt and INFt in (1), strongly reject the null hypothesis at the 1% level of significance, indicating that they are stationary.

In the second step of the estimation process, a Johansen cointegration test is employed to identify whether the time-series data are cointegrated or not (Johansen, 1991). The maximum eigenvalue, trace statistics, and critical values are presented in ⟨Table 4⟩.

Table 4. Johansen Cointegration Test Results

Ho	Eigenvalue	λmax	5% c.v.	λtrace	5% c.v.
r=0	-	12.3244	14.07	14.6118	15.41
r=1	0.78574	2.2874	3.76	2.2874	3.76
r=2	0.24868	-	-	-	-

According to 〈Table 4〉, the estimated values of λtrace and λmax are lower than the 5% critical values when r is 0 or 1, indicating there is no cointegration in the model at the 5% level of significance. This shows that the GLM can be used to estimate the long-term impact of blockchain technology on maritime transport.

As a result of the GLM analysis, 〈Table 5〉 shows that there is a positive relationship between blockchain technology adoption and the seaborne trade volume. This empirical evidence endorses the results from Loklindt et al. (2018), Belu (2019), Filom (2020), and (Peronja et al., 2020). Maritime transportation projects based on blockchain technology such as Tradelens, CargoX, and dKagro have illustrated that blockchain technology-based platforms can reduce transaction costs by eliminating complex processes from seaborne trade (IBM, 2018).

The GLM results confirm that spending on IT also positively affects seaborne trade. This is in agreement with Zhu (2007), who found that the use of IT can contribute to the growth of maritime transport. Furthermore, this study confirms that the annual GDP growth rate has a positive relationship with seaborne trade. Several empirical studies, including Tang (2006) and Matuszczak (2019), have also demonstrated evidence for this. Higher GDP growth for a country raises the per capita income, which increases investment in trade. The present study also finds that the tax burden has a negative association with seaborne trade. Keen and Syed (2006) confirmed that a higher tax rate has a negative impact on the seaborne trade. On the other hand, the inflation rate and business freedom fail to exhibit a significant relationship with seaborne trade.

Table 5. GLM Estimation Results

Variables	Coefficient	Std. Error	z-Statistic	Prob.
BTt	0.025***	0.001	44.07	0.000
ITt	0.226***	0.039	5.86	0.000
GDPt	0.020***	0.004	4.54	0.000
INFt	0.000	0.002	0.02	0.983
BFt	0.001	0.003	0.35	0.727
FFt	-0.019***	0.004	-4.82	0.000
Cons	21827.33	0.449	18.57	0.000

Note: *** denotes that the test statistics are significant at the 1% level

In the final step of the estimation process, the Granger causality test results presented in 〈Table 6〉 reveal the presence of Granger causality from blockchain technology to seaborne trade at the 5% level of significance. However, there was no strong evidence that seaborne trade directly affected blockchain technology. This indicates that there is a unidirectional relationship between blockchain technology and seaborne trade, which suggests that the digitalization of maritime transport by adopting blockchain technology has a positive impact on seaborne trade.

Table 6. Granger Causality Test Results

Direction of Causality	χ2	df	Prob. > χ
STt BTt	1.0790	2	0.617
BTt STt	7.7939	2	0.018 **

Note: ** denotes that the test statistics are significant at the 5% level

V. Conclusions

Maritime transport is a vital component of trade that has contributed to the growth of the global economy. Despite this, this industry faces challenges due to the complexity of the maritime transport system, the lack of consistent international regulations, and the presence of multiple security issues (Filom, 2020). In recent years, blockchain technology has been adopted to solve these issues due to its numerous advantages, thus promoting the development of maritime transport (Pu & Lam, 2020).

By employing GLM with data from 2010 to 2019, this paper provides empirical evidence for the positive impact of blockchain technology adoption on maritime transport. This paper also demonstrates the positive effects of IT and GDP growth on maritime transport. On the other hand, it is revealed that maritime transport is negatively influenced by a heavy tax burden.

The results of this paper can be used to design a sustainable development strategy for maritime transport that involves redirecting economic resources toward blockchain technology. Other useful strategies for this industry could include adopting other forms of IT and reducing the tax burden.

The lack of previous empirical research motivated the exploration of the relationship between blockchain technology and maritime transport in the present study. However, blockchain technology is still in its nascent stages and, as mentioned in chapter III, there is a lack of suitable statistical methodologies due to limited data availability and the complicated nature of the links between blockchain technology and the maritime industry. Hence, it would be useful to extend the findings of this paper by conducting other empirical studies with different datasets and novel empirical models.

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Appendix 1. List of variables, measurements, and data sources

Variables	Measurements	Unit	Expected sign	Source
STt	The log of seaborne trading volume	Metric tons in millions		UNCTAD
BTt	Bitcoin trading volume	BTC	+	Blockchain.com
ITt	The log of IT spending	In billion U.S. dollars	+	Gartner.com
GDPt	Annual growth rate of GDP	%	+	World Bank
INFt	Inflation rate	%	-	World Bank
BFt	The index of business freedom	0 ~ 100	+	Heritage Foundation
FFt	The index of fiscal freedom	0 ~ 100	-	Heritage Foundation

Appendix 2. VIF test results

Variable	VIF	1/VIF
BTt	6.20	0.161263
ITt	2.53	0.396008
GDPt	6.35	0.157483
INFt	5.79	0.172698
BFt	2.33	0.429831
FFt	7.27	0.137527
Mean VIF	5.08	