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Helpless Rich Data: The Effect of Financial Openness with Dimensionality Reduction

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Abstract: The literature on financial openness is rich, yet the selection of a suitable financial index remains a challenge. In this paper, Principal Component Analysis (PCA) and Factor Analysis (FA) are utilized to reduce the dimensionality of five publicly available financial openness indices. The results of the estimation are unexpected: PCA suggests a negative impact of financial openness on economic growth, while FA yields inconsistent results. Importantly, the negative impact of the institutional component on economic growth is statistically significant. These findings highlight the urgent need for proper institutional readiness to fully realize the benefits of financial openness.

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1. Introduction

One of the oldest controversial issues in economics is the effect of financial openness on economic growth. Despite its age, it appears to be a never-ending debate. Theoretically, capital market liberalization can lower the cost of capital, allowing perfect international capital mobility to cause factor price equalization and, finally, accelerate economic growth. In contrast with the firm theoretical argument, the empirical results regarding the effect of financial openness are still inconclusive. For example, Bekaert et al. (2005) show that equity market liberalization allows foreign investors to participate in the market lead, resulting in a 1% increase in real GDP per capita. Moreover, Bekaert et al. (2011) find that financial openness positively affects economic growth through capital stock growth and total factor productivity growth. In particular, because the effect on total factor productivity growth is larger than on capital stock growth, financial openness can lead to considerable GDP growth even with a relatively modest increase in investment.

In contrast, Rodrik (1998) demonstrates that certain countries without restrictions on payments for capital transactions have better economic performance, such as high economic growth or more investment. Particularly, among 23 countries that have maintained openness since 1973, some achieved high economic growth, whereas others underperformed. This implies that the correlation between openness on the capital account and economic performance is not necessarily positive. In line with this, Edison et al. (2002) showed that using new measures of international financial integration, the null hypothesis that international financial integration is unrelated to economic growth is not rejected. Koirala et al. (2024)

found no significant association between financial development and financial openness, while financial openness weakens the effectiveness of monetary policy using data from 100 countries from 1980 to 2018. This implies that financial openness has no positive effect but lowers the effectiveness of the monetary policy, which can be a significant tool to control an economy.

The argument regarding financial openness has been vague and more controversial since the Global Finance Crisis and the Great Recession of 2007–2009. This is due to the fact that most developing countries were negatively impacted by the financial crisis, which reignited the debate regarding the effect of financial openness. Meanwhile, some major economic institutions, such as the IMF (2012), have changed their view regarding financial openness in the sense that the benefit of financial openness outweighs the risk if countries reach a certain level or threshold. This implies that a developing or less-developed country needs appropriate policies and/or plans when rapid capital flow surges or disruptive outflows occur. In other words, "Capital Flow Management" may be a proper policy tool for some countries. In addition to conflicting views, the index for financial openness exacerbates the conflicting views. In general, financial openness indices can be categorized into de facto or de jure. De facto is an indicator based on economic outcomes such as foreign direct investment, Total Export/Import, and/or Foreign Financial Assets/Liabilities. In contrast, de jure is an indicator based on a country's legal system on the economy, such as tariffs and/or other legal restrictions. Since each index has limitations, there is no clear guidance for the choice of the indices. At the same time, Gräbner et al. (2021) estimate a standard growth regression specification with different economic openness indices and show that different economic openness categories can affect economic growth differently. In other words, the choice of the index matters and has a critical effect on the estimation results, so the effect of financial openness is not robust in the selection of indices.

Due to this reason, this paper employs dimensional reduction techniques such as Principles Component Analysis (PCA) and Factor Analysis (FA) to avoid the issue of the selection of indices. Even though many indices exist in de jure and de facto, only five are publicly available. Among the five indices, four indices are *de jure*, including the Chinn–Ito Index (KAOPEN, Chinn & Ito, 2006, 2008), the Wang–Jahan Capital Account Openness Index (KANEW, Jahan & Wang, 2016), Schindler's index (KA, Schindler, 2009), and the Heritage Economic Freedom Index (IFHeritage)[1], and one index is *de facto*, (Lane & Milesi-Ferretti, 2003, 2007, 2017), known as LMF.

In addition to the impact of choice in financial openness variables, this paper employs the idea of Wang et al. (2023) that countries can be divided into stable or transitioning countries in terms of World Bank Categorization since the effect of financial openness on economic growth varies across the different levels of economies. They utilize the World Development Indicator (WDI) to categorize countries into four income groups. In accordance with this, this paper divides countries into either stable or transitioning countries. Because Wang et al. (2023) chose one specific financial openness index from *de jure* and de facto, as mentioned above, their research is also subject to criticism regarding the selection of a suitable financial openness index. Using PCA and FA with five indices, this paper extracts two principal components (or factors) and employs them to estimate the effect of financial openness at different levels of economies. The baseline model estimation results are counter-intuitive in that the economic component (or factor) has a positive or insignificant effect, while the institutional component (or factor) has a negative effect. This result implies that financial openness without institutional restructuring cannot have the expected effect. This result is consistent with the IMF's (2012) view that countries reach a certain level or threshold to benefit from financial openness. Consistent with Rajan's (2005) conclusion, technological change, market liberalization, and institutional

change all expand access to credit and risk-sharing opportunities. At the same time, however, this progress creates perverse behavior in investors due to the incentive structure aligned with the progress, so financial development makes financial markets riskier as a reflex of the development.

In this context, this paper contributes to this debate by employing Principal Component Analysis (PCA) and Factor Analysis (FA) to reduce the dimensionality of five publicly available financial openness indices and provide insights into the relationship between financial openness and economic growth at the different levels of economies by overcoming the selection of a suitable financial index.

The main contributions are as follows: First, for the dimensionality reduction, the paper employs financial openness data from 181 countries to produce more results. (See Appendix A) Compared with other studies, our analysis includes most of the world's countries. Thus, the analysis in this paper draws a more general conclusion regarding the effect of financial openness on economic growth.

Second, in addition to the number of countries, our analysis covers more recent periods from 1987 to 2016. This data period includes the period after the Great Recession (or Sub-Prime Mortgage Crisis) so that the paper can reveal how this event changed the effect of financial openness on economic growth. Moreover, this paper shows that the aftermath of the Great Recession differs between countries, depending on the stages of economies. Consistent with Kose and Ohnsorge (2020), this paper reveals that the effect varies between countries.

Third, the data's inclusion of more countries and longer time periods enables this paper to examine the aftermath of the Great Recession. The effect of financial openness varies between countries; the spillover effect of the Great Recession is also different between countries. This implies that when a negative shock hits an economy, a country can draw on sizable policy buffers, enabling it to be more resilient. Particularly, this paper shows that regardless of their financial institutional developments, every country needs to prepare an appropriate monetary policy or fiscal rule.

In the rest of the paper, Section 2 briefly introduces a different type of financial openness indices and explains the pros and cons of each index employed in this paper. Section 3 describes the dimensionality reduction techniques and explains what components (or factors) are associated with financial openness indices. Section 4 introduces the empirical model and the control variables employed to estimate the effect of financial openness. Section 5 summarizes some of this paper's findings.

2. Indices for Financial Openness

Generally, all indices for financial openness can be categorized into either *de facto* or *de jure*. One important feature of de jure is that the IMF's Annual Report on Exchange Arrangement and Exchange Restrictions (AREAER) plays an important role. The AREAER has tracked the exchange rate and trade regime of one hundred and eighty-nine countries and three territories since 1950. In particular, AREAER measures six restriction categories: (i) overall openness, (ii) openness of capital outflow, (iii) openness of capital inflow, (iv) financial market openness, (v) resident openness, and (vi) non-resident openness.[2] If any restrictions are in place, the standard indicator takes a value of zero, suggesting that a country is a closed economy. Based on the AREAER, de jure can be categorized into three scenarios: (i) de jure indices are based on AREAER Categorical Restrictions, (ii) the indices are based on the actual text of AREAER, and (iii) the indices are not based on AREAER.

For example, the Chinn–Ito index (KAOPEN, Chinn and Ito (2006, 2008)) and Wang–Jahan Capital Account Openness Index (KANEW, Jahan and Wang (2016)) are AREAER-based de jure indices, while Schindler's index (KA, Schindler (2009)) is an AREAER text-

based index. However, the Heritage Economic Freedom Index (IFHeritage)[3] is a non-AREAER-based index. In contrast, Lane and Milesi-Ferretti (2003, 2007, 2017), known as LMF, is a de facto index. In addition to these indices, a combined (or hybrid) indicator for financial openness is also available. However, due to its hybrid property, it does not belong to any of the categories mentioned above.

While there are numerous financial openness indices, there is a lack of clear guidance. On the one hand, only five financial openness indices are publicly available, so there is no need to pay attention to developing criteria; on the other hand, it is not easy to choose the proper indicator due to the limitations of each indicator. For example, one problem of some de facto is taking a reference point such as GDP so that the variation in the index comes from the variation in the reference variable, not from the openness variable itself (Fujii, 2019). For *de jure*, these cannot reflect the actual legal system in effect, and the disaggregated index cannot reflect the actual degree of financial integration (Schindler, 2009). Moreover, Gräbner et al. (2021) show how different categories of economic openness and indices can have different effects on economic growth. Hence, the choice of the index matters and has a critical effect on the estimation results. In terms of robustness, it is challenging to measure the actual effect of financial openness. Therefore, this situation justifies employing the "dimensionality reduction" technique rather than choosing one specific index in each category, which is a better decision to see the effect of financial openness.

As noted above, although many financial openness indices exist in the literature, KAOPEN, KA, KANEW, LMF, and IF_Heritage are the only ones that are publicly available. Intuitively, more robust results can be available if more indices for financial openness are included. As shown in Gräbner et al. (2021), however, there is a stronger association among indices within each category, but weaker associations exist across different categories. Therefore, the results can be robust even though relatively fewer indices are included in the analysis. At the same time, Table 1 shows the unbalanced data structure among indices due to the different numbers of observations. This could possibly be another reason why the results are not robust enough to be considered in the selection of indices. Due to the unbalanced structure, it is quite persuasive to employ the dimensionality reduction technique despite the weakness of the technique decreasing the number of observations.

Table 1. Descriptive statistics for financial openness indices.

Measure	# of Country	# of Obs.	Period	Mean	Std. Dev.	Min.	Max	Type
KAOPEN	181	6958	1970–2016	0.0055	1.5363	−1.9043	2.3599	*de jure*
KA	100	2200	1995–2017	0.3757	0.3403	0	1	*de jure*
KANEW	162	2464	1996–2013	0.5529	0.3459	0	1	*de jure*
LMF	174	6099	1970–2011	−0.3569	1.4644	−32.97	17.207	*de facto*
IF_Heritage	166	3300	1995–2019	59.7572	10.7934	15.6	90.5	*de jure*

Note: This table is the descriptive statistics of each financial openness index. Appendix A provides details on the availability of financial openness indices. #—represents number.

3. Dimensionality Reduction

3.1. Overall Results

Roughly, PCA and FA are employed to identify a common pattern among variables. The identified pattern is used to extract the underlying (latent) variables or principal components in the data so that a relatively small number of variables can summarize large amounts of information from many variables. For example, Stock and Watson (2002) employed Principal Component Analysis to translate a large number of time series variables using a small number of indices and showed that only six components can explain 215 time series data points. Therefore, the dimensionality reduction technique may be very helpful in a data-rich environment when there are no clear guidelines for the selection of data.

As mentioned above, many different financial openness variables exist in both *de jure* and *de facto*. Even though some indices are within the same conceptual dimension, the result varies with the selection of the index (Gräbner et al., 2021). In this case, it seems reasonable to employ the reduction technique rather than choosing one specific variable if there is no theoretical foundation for the choice. This is because this situation belongs to *the curse of dimensionality*, which is that the high dimensionality of data is due to a rich data environment that provides less meaningful information for the accuracy of the estimation.[4] To address this issue, several dimension reduction techniques, such as PCA, FA, t–distributed stochastic neighbor embedding (t–SNE), Random Projection, or linear discriminant analysis, are utilized in the literature. This paper utilizes FA and PCA techniques since these techniques are relatively easy to implement and effective in analyzing high-dimensional data.

Even though PCA and FA share commonalities such as dimensionality reduction, linear transformation, mathematical foundation, etc., they are different in several aspects. Regarding the objective, FA identifies latent variables that underlie the observed variable, while PCA identifies principal components that capture the maximum variance in the data. Thus, the observed variables in FA have a unique variance, which can be explained by the underlying latent variables. However, the observed variables in PCA can be modified into principal components that are orthogonal or independent among components.

Moreover, PCA can combine many variables into a single component or a few components by the optimal weighted contribution of each variable so that PCA explains the total variance among variables. In contrast, FA constructs a latent variable from other associated variables so that FA explains the common variance among variables. Therefore, the main purpose of PCA is to reduce the dimensions of data by creating orthogonal principal components, while FA aims to identify unknown underlying latent variables in data. Due to this reason, the application of each technique is different. In general, however, PCA is recognized as a particular version of FA.

According to Kim (2008), FA is more appropriate for explaining the correlation among variables to generate underlying (or latent) variables, while PCA is better for summarizing the data with a small number of variables for dimensionality reduction. Even though Gräbner et al. (2021) show that there is a strong association within a category, as noted earlier, it does not imply a rigorous theoretical foundation for the underlying variable. Since there is no clear theoretical foundation for the existence of underlying variables among financial openness variables, PCA is a more appropriate approach. Conversely, however, the structure of data is an unbalanced panel dataset in the sense that each country has a missing value. This suggests that the assumption of FA that underlying factors influence variables have errors is correct. Considering several factors in dimensionality reduction, it is unclear what technique is more appropriate to reduce the dimensionality of financial openness variables. This is because both are the case in financial openness. Therefore, this paper employs PCA and FA to estimate the effect of financial openness on economic growth.

Table 2 shows the results of PCA. Five components are extracted from five financial openness variables (KAOPEN, KANEW, KA, IFHeritage, and LMF). Panel A in Table 2 shows how much each component can explain the total variance. Generally, eigenvalues show the amount of variability of the corresponding eigenvector. For example, component 1 can explain 63.43% of the total variance, while component 2 can explain 19.92%. Therefore, 83.55% of the total variance can be explained by both components. According to the Guttman–Kaiser Criterion (Guttman, 1954; Kaiser, 1960), components are acceptable only when the eigenvalue is higher than or equal to a unit. (Component 2 is very close to a unit.) This is because the higher eigenvalue stands for more explanatory power for the variance.

Table 2. Eigenvalue of Principle Component Analysis.

Panel A: Overall Countries				
Component	Eigenvalue	Difference	Proportion	Cumulative
Component 1	3.1713	2.1752	0.6343	0.6343
Component 2	0.9961	0.4081	0.1992	0.8335
Component 3	0.5879	0.3915	0.1176	0.9511
Component 4	0.1964	0.1482	0.0393	0.9904
Component 5	0.0482		0.0096	1.0000
Panel B: Stable Countries				
Component	Eigenvalue	Difference	Proportion	Cumulative
Component 1	3.3511	2.4218	0.6702	0.6702
Component 2	0.9293	0.3803	0.1859	0.8561
Component 3	0.5490	0.4291	0.1098	0.9659
Component 4	0.1199	0.0691	0.0240	0.9898
Component 5	0.0508		0.0102	1.0000
Panel C: Transitioning Countries				
Component	Eigenvalue	Difference	Proportion	Cumulative
Component 1	2.9005	1.8305	0.5801	0.5801
Component 2	1.0699	0.3933	0.2140	0.7941
Component 3	0.6766	0.3688	0.1353	0.9294
Component 4	0.3079	0.2629	0.0616	0.9910
Component 5	0.0450		0.0090	1.0000

Note: This table provides the eigenvalue of each component of overall countries and at different levels of economies. According to the Guttman–Kaiser criterion (Guttman, 1954; Kaiser, 1960), an eigenvalue of a component greater than one should be chosen. Thus, a component's eigenvalue greater than one is chosen. Total Number of Observations: Overall—1387, Stable—804, and Transitioning—583. Pearson Correlation Coefficient, ρ = 0.9511 (Overall), 1.0000 (Stable), and 1.0000 (Transitioning).

In PCA, eigenvectors in Table 3 determine the contribution of the data to generate principal components and the association of principal components with the data. Because the eigenvector consists of the weight of each variable, it shows how much each variable contributes and in what direction. In general, the larger the absolute coefficient value, the more influential it is on a particular principal component. Therefore, it is possible to identify which component is closer to the original variables. For example, the eigenvector of the second component with LMF shows 0.9372, so LMF follows the direction of component 2. In other words, component 2 is more closely related to LMF than any other component. Table 6 also confirms that component 1 is more associated with de jure indices, whereas component 2 is more associated with *de facto*. Therefore, component 1 can be defined as a *de jure* component, whereas component 1 can be defined as a *de factor* component.

In contrast with PCA, Panel A in Table 4 reveals that factor 1 explains 98.75% of common variance so that five indices can be merged into one factor. At the same time, the second factor has an eigenvalue of less than a unit. Therefore, it is possible to conclude that factor 1 is the only variable for data reduction. However, the factor loading calculation in Table 5 shows that all four *de jure* indices are more closely related to factor 1, while no factors successfully capture LMF. This is because the uniqueness of LMF is 0.8912. Note that factor loading is an indicator that shows the relative importance of a variable in a factor so that values represent the strength of the relationship between unobserved factors and variables, and uniqueness is the variance, which is unique to the variable and not shared with factors. In interpretation, variables with a higher value of factor loading on a particular factor can be seen as having a strong association with that factor. Conversely, the lower value of factor loading implies the lower uniqueness of a variable so that a factor inadequately captures a variable. Therefore, it is safe to conclude that factor 1 is more related to *de jure*, while the second factor is associated with *de facto* or LMF. This is because factor 2 is more associated with IF_Heritage and LMF than any other variables. Moreover, Table 6 also confirms that factor 1 is more related to *de jure*, while factor 2 is

related to IF_Heritage and LMF. This implies that financial openness variables do not have consistent underlying variables, so the choice of the financial index matters in the effect of financial openness. This is also consistent with the finding in Quinn et al. (2011) that IF_Heritage is linked in Factor Analysis to unique dynamics in an uninterpretable manner; it also supports their argument that creating a composite financial openness measure from PCA is preferred if the underlying indicators are crude. Because the factor loading of factor 2 has a higher value of factor loading to capture LMF, however, this paper employs factor 2 as a *de facto* factor. Therefore, factor 1 and factor 2 are employed to estimate the effect of financial openness as PCA.

Table 3. Eigenvector of Principle Component Analysis.

Panel A: Overall Countries						
Variables	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5	Unexplained
KAOPEN	0.5191	−0.0601	−0.0413	0.8457	−0.1004	0
KA	−0.5212	0.1870	0.2840	0.4251	0.6573	0
IF_Heritage	0.3959	0.2245	0.8709	−0.1853	−0.0064	0
KA New	0.5303	−0.1806	−0.2447	−0.2617	0.7468	0
LMF	0.1447	0.9372	−0.3151	−0.0366	0.0079	0
Panel B: Stable Countries						
Variables	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5	Unexplained
KAOPEN	0.5193	−0.0713	−0.1083	0.8422	−0.0656	0
KA	−0.5106	0.2280	0.2489	0.4148	0.6710	0
IF_Heritage	0.4004	0.1441	0.8970	−0.1196	−0.0025	0
KA New	0.5174	−0.1862	−0.2401	−0.3081	0.7383	0
LMF	0.2039	0.9421	−0.2531	−0.0802	−0.0210	0
Panel C: Transitioning Countries						
Variables	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5	Unexplained
KAOPEN	0.5170	−0.0403	0.0470	0.8469	−0.1074	0
KA	−0.5368	0.1625	0.3155	0.4007	0.6522	0
IF_Heritage	0.3609	0.3835	0.8112	−0.2517	−0.0362	0
KA New	0.5564	−0.1634	−0.2117	0.2407	0.7490	0
LMF	0.0678	0.8934	−0.4421	0.0294	0.0290	0

Notes: Eigenvectors determine the contribution of the data to generate principal components and the association of principal components with the data. Because the eigenvector consists of the weight of each variable, it shows how much each variable contributes and in what direction each variable contributes. In general, the larger the absolute coefficient value, the more influential it is on a particular principal component.

Table 4. Eigenvalue of Factor Analysis.

Panel A: Overall Countries				
Component	Eigenvalue	Difference	Proportion	Cumulative
Factor 1	2.9507	2.1752	0.9875	0.9875
Factor 2	0.2386	0.4081	0.0798	1.0674
Panel B: Stable Countries				
Component	Eigenvalue	Difference	Proportion	Cumulative
Factor 1	3.1437	2.9285	0.9885	0.9885
Factor 2	0.2152	0.2509	0.0677	1.0562
Panel C: Transitioning Countries				
Component	Eigenvalue	Difference	Proportion	Cumulative
Factor 1	2.6717	2.3793	0.9586	0.9586
Factor 2	0.2925	0.2566	0.1049	1.0635

Note: A variable with a higher value of factor loading on a particular factor can be seen as a strong association with that factor. Total Number of Observations: 1387 (Overall), 804 (Stable), and 583 (Transitioning). LR Test: Independent vs. Saturated (Full): $\chi^2(10) = 5594.29$ ($p > \chi^2 = 0.0000$: Overall), $\chi^2(10) = 3659.10$ ($p > \chi^2 = 0.0000$: Stable).

Table 5. Factor loading of Factor Analysis.

Category	Variable	KAOPEN	KA	IF_Heritage	KA New	LMF
Overall Countries	Factor 1	0.8811	−0.9397	0.5799	0.9602	0.1820
	Factor 2	0.1224	0.1911	0.2952	−0.1557	0.2751
	Uniqueness	0.2807	0.0805	0.5766	0.0538	0.8912
Stable Countries	Factor 1	0.9337	−0.9447	0.6182	0.9585	0.2803
	Factor 2	0.0920	0.1982	0.2434	−0.1384	0.2984
	Uniqueness	0.1197	0.0683	0.5586	0.0621	0.8324
Transitioning Countries	Factor 1	0.7977	−0.9313	0.4744	0.9684	0.0722
	Factor 2	0.1560	0.2011	0.3588	−0.1322	0.2854
	Uniqueness	0.3290	0.0815	0.6462	0.0441	0.8991

Note: Factor loading is known as an indicator that shows the relative importance of a variable in a factor so that values represent the strength of the relationship between unobserved factors and variables, and uniqueness is the variance, which is unique to the variable and not shared with factors. The calculation shows that all four de jure indices are more closely related to factor 1, while no factors successfully capture LMF.

Table 6. Coefficient of correlation.

Panel A: Overall Countries					
Variables	KAOPEN	KA	IF_Heritage	KA New	LMF
Component 1	0.9243	−0.9281	0.7050	0.9444	0.2576
Component 2	−0.060	0.1867	0.2241	−0.1803	0.9354
Factor 1	0.9029	−0.9629	0.5942	0.984	0.1865
Factor 2	0.1958	0.3058	0.4724	−0.2492	0.4403
Panel B: Stable Countries					
Variables	KAOPEN	KA	IF_Heritage	KA New	LMF
Component 1	0.9506	−0.9348	0.7330	0.9471	0.3733
Component 2	−0.0687	0.2198	0.1389	−0.1795	0.9081
Factor 1	0.9540	−0.9651	0.6316	0.9793	0.2863
Factor 2	0.1395	0.3006	0.3692	−0.2100	0.4525
Panel C: Transitioning Countries					
Variables	KAOPEN	KA	IF_Heritage	KA New	LMF
Component 1	0.8806	−0.9142	0.6147	0.9476	0.1155
Component 2	−0.0417	0.1681	0.3966	−0.1690	0.9242
Factor 1	−0.8172	−0.9540	0.4860	0.9921	0.0739
Factor 2	0.2553	0.3291	0.5873	−0.2163	0.4671

Notes: This table provides a coefficient of correlation between factors (or components) and an original variable and shows that they are highly correlated. This implies that factors (or components) effectively capture underlying data structures.

3.2. Countries at Different Stages

According to Kose et al. (2009), different threshold conditions, such as financial market development, institutional quality, governance, macroeconomic policies, and trade integration, complicate the effect of financial openness so that the conditions mitigate the effect of financial openness. In addition, Kose et al. (2011) show that at a low level of financial and institutional development, Foreign Direct Investment (FDI) and portfolio equity are beneficial and safer than debt flow and conclude that the effect of financial openness can vary across countries due to the dependency of the effect on the maturity of an economy. Based on this idea, Wang et al. (2023) employ the World Development Indicator (WDI) provided by the World Bank, which categorizes countries into four income groups: Low Income, Lower Middle Income, Upper Middle Income, and High Income. This categorization is calculated based on GNI per capita in USD, converted from local currency using the Atlas method.[5,6] Since there is an inconsistency in WDI between pre-1987 and post-1987, the indices are adjusted according to the new categorization of the WDI. The inconsistency in the WDI is that there are three different income levels pre-1987 (Low,

Middle, and High Income), while there are four types of different income levels post-1987. Since the new categorization of the WDI is applicable only to post-1987, for example, LMF is trimmed accordingly. After trimming, the time interval of LMF is from 1987 to 2011. Note that LMF is available from 1970 to 2011. However, KA is available from 1995 to 2017, so the data should not be trimmed. After trimming, countries in the data fall into the category of either stable or transitioning countries. Here, stable countries are those who have stayed at the same income level since 1987. In other words, a country can be regarded as stable even if there is a change in the income level during the time period of the data. Inversely, transitioning countries are those who transit from one level to another, so the income level in 1987 should differ from the income level in the last year of each dataset.

Based on this categorization, identical dimensionality reduction techniques are applied to each dataset. As shown in Tables 2–6, the differences in the estimates are negligible in terms of magnitude. Apart from magnitude, the estimation results are generally consistent with those for all countries. As noted above, factors 1 and 2 and principal components 1 and 2 are employed to estimate the countries at different stages of income levels.

4. Estimation

4.1. Overview of the Estimation Procedure

As noted earlier, this paper employs five financial openness indicators from 181 countries from 1987 to 2010. Thus, the dataset has very high dimensions (or a large number of observations) compared to the traditional panel dataset. This can create *the curse of dimensionality*, so those five indicators are reduced by PCA or FA.

As discussed below, this paper follows the standard specification known as the dynamic panel, which has a shorter time period but more entities. However, this dynamic panel model can create a bias known as Nickell's (1981) bias. This paper employs system GMM estimation to avoid possible bias. According to Wang et al. (2023), 181 countries have different stages of economies, so they can have different effects of financial openness on economic growth. Thus, the dataset is divided into stable and transitioning countries based on the WDI and estimates the effect of financial openness at the different stages of economies.

4.2. Empirical Models

The main hypothesis of the paper is how financial openness affects economic growth, using either principal components or factors extracted from PCA or FA. The model employs the set of control variables that affect economic growth, following the standard specification used in the existing literature.

$$\Delta y_{i,t} = cons. + \Delta y_{i,t-1} + \beta 1 F_{i,t} + \beta 2 X_{i,t} + \lambda_i + \epsilon_{i,t} \quad (1)$$

where $y_{i,t}$ is the economic growth in a country i and year t, defined by the change in the GDP per capita adjusted by Purchasing Power Parity (PPP). $F_{i,t}$ is either the *principal component or factor* from financial openness indices based on the dimensionality reduction. $X_{i,t}$ consists of the set of control variables, including (i) capital service, (ii) total factor productivity, (iii) domestic credit, and (iv) trade openness. In addition, λ is the unobserved country-specific effect.

This equation is typically known as the dynamic panel model, so the dynamic panel regression can provide biased results if the data have a shorter time period (t) but more individuals (n). This is known as Nickell's (1981) bias in dynamic panel models. For this reason, Arellano and Bond (1991) suggested that the Generalized Methods of Moments (GMMs) should be used to handle this issue in dynamic panel models, particularly the first-differenced GMM estimator, to eliminate the bias. However, a potential weakness of

the first-difference GMM estimator was shown in Arellano and Bover (1995), Blundell and Bond (1998), and Bond et al. (2001). These studies showed that if the lagged variables are close to random walk, the lagged levels are a poor instrument for first-difference variables. Moreover, Roodman (2009) argued that the first-difference transformation magnifies gaps in an unbalanced panel so that the first-difference at t and $t + 1$ is missing if the value at t is missing. Due to the random walk issue in the lagged level and amplifying missing data in the unbalanced panel, the alternative GMM estimator, known as System GMM, was proposed.

The advantage of System GMM is that it is suitable for addressing the endogeneity issue without any external instrument variables. Instead, it requires the lagged dependent variables and the difference in endogenous independent variables in two time periods as instrument variables. Additionally, it also requires no correlation between instrument variables and error terms and the absence of the second-order autocorrelation in residual to generate consistent results. These conditions are tested by the Arellano and Bond (1991) AR (1) (Autoregressive 1) and AR (2) test and the Sargan–Hansen Test (or Sargan J test).

Table 8 shows the condition that no serial correlation at an order higher than one is tested by the Arellano and Bond (1991) AR (1) and AR (2) tests. The test for AR (1) results in rejecting the null hypothesis regarding the absence of the first-order serial correlation in residuals. However, the test for AR (2) cannot reject the null hypothesis of the absence of the second-order correlation in residuals. Thus, the serial correlation requirements for System GMM are satisfied and justify employing System GMM.

As noted above, the System GMM does not require any external instrument variables. Instead, internal instrument variables are required to deal with the endogeneity issue. Due to internal instrument variables, the estimator requires an overidentification test to ensure that the model has more instruments than necessary for the estimation. The test for overidentification is implemented using the Sargan–Hansen test or Sargan's J test. The results in Table 8 show that there are no rejections of the null hypothesis of the validity of overidentification except for PCA estimation for stable countries.[7] Therefore, the overidentification condition requirement for System GMM is also satisfied and justifies employing *System* GMM.

4.3. Control Variables

Due to asymmetric information, credit rationing is an unavoidable feature in the banking industry (Stiglitz & Weiss, 1981). The bank charges the interest rate to avoid the adverse selection effect or affect the incentive effect of borrowers in order to reduce the riskiness of a loan. With asymmetric information, it is not easy for banks to identify either good or bad borrowers. Therefore, the banks employ various screening tools such as credit scores, the number of loans, history of credit, and so on. This suggests that by using more effective screening tools, the bank can approve more loans, as it can better identify *lemon* borrowers. Since the proper allocation of loans can increase the efficiency of the financial markets and, finally, lead to economic growth, it is important to measure how many loans are approved to gauge how financial markets are close to the perfect market. Based on this idea, this paper employs *domestic credit to the private sector provided by the* World Bank.[8] Domestic credit to the private sector (or credit to the public) refers to financial resources provided to the private sector, such as loans, purchases of non-equity securities, trade credits, and other accounts receivable that establish a claim for repayment. Thus, this variable is a proxy variable for measuring the efficiency of the financial market.

The fundamental theoretical framework to explain long-run economic growth is the Solow–Swan model. (Solow, 1956; Swan, 1956). This framework explains long-run economic growth through capital accumulation, technological progress, and population

growth. Despite the property that continuous capital accumulation encourages economic growth temporarily, capital accumulation is one of the key components in the framework. Due to this property of the Solow–Swan model, Mankiw et al. (1992) modified the model by adding human capital and described the international variation in the cross-country data very well. This suggests that physical capital and human capital are important determinants of economic growth. Rather than employing capital stock, this paper employs capital service provided by Penn World Table (PWT).[9] Capital service measures the capital stock by estimating the user cost of capital and comparing the implicit rental price of capital and the level of capital service normalized relative to the United States. This is because high-income countries invest more in less durable assets (e.g., computers) and less in more durable assets, while low-income countries perform the inverse. These differences stem from the relatively higher cost of less durable assets in developing countries or less developed countries. As a result, these countries place less emphasis on less durable assets, ultimately underestimating the importance of physical capital. This suggests that employing capital stock could negatively impact the effect of capital on economic growth. Therefore, capital service seems to be a more relevant variable to capture the effect of capital accumulation on economic growth.

In addition to the capital variable, technological progress in the Solow–Swan model is one of the most important determinants of long-run economic growth. Due to its importance and exogeneity, Solow (1957) segregated variations in output per capita attributable to technical changes from variations due to changes in capital per capita. This is known as the *Solow Residual* or total factor productivity (TFP).[10] The TFP is generally calculated by dividing the output by the weighted average of input factors such as labor and capital and measures the efficiency of the economy. Likewise, PWT computed the TFP on the basis of average hours worked for countries and capital estimates.

The one implication of endogenous growth theory is that economic policies that encourage openness, competition, and R&D will support long-run economic growth. From this point of view, trade openness is one of the important factors in promoting economic growth if trade openness encourages the diffusion of knowledge and/or innovation through competition. In contrast with the implication, Young's (1991) learning-by-doing model showed that a country under free trade with less initial technology experiences technological progress and/or economic growth less than or equal to a country under autarky with the same level of technology in the sense that the effect of trade openness could not lead to economic growth by technological progress and/or innovation. Counter-intuitively, Yanikkaya (2003) showed that trade barriers are positively associated with economic growth. This suggests that trade openness could not be a way to promote economic growth, so other characteristics of countries related to trade openness can affect economic growth. However, it is clear that trade openness affects economic growth irrespective of whether it has a positive or negative effect. Therefore, this paper employs trade openness as the sum of exports and imports of goods and services measured as a share of the GDP, which is provided by the World Bank.[11]

Table 7 shows the descriptive statistics of control variables. The data cover 181 countries from 1971 to 2016. However, some countries do not observe every period, so the total number of observations of each control variable is different. In other words, the dataset is unbalanced panel data. Methodologically, due to this challenge, *listwise deletion* is adopted so that observations with missing values in any variables will be excluded from the statistical analysis. *Listwise deletion* drops a case from the analysis if it has a missing value in at least one of the specified variables. In contrast, *pairwise deletion* does not drop the case from the analysis even if it has a missing value in a specified variable. Because *pairwise deletion* allows using a missing value, it is possible to have biased results due to

the different subsets of variables.[12] Even though *listwise deletion* is more wasteful, listwise deletion is employed in the analysis to have more unbiased results.

Table 7. Descriptive statistics of control variables.

Measure	# of Observations	Mean	Std. Dev.	Min.	Max
Economic Growth	7108	3.7534	6.3437	−64.0471	149.973
Capital Service	5347	0.0353	0.11380	0	1.3379
TFP	4503	0.7249	0.4174	0.1054	5.7396
Domestic Credit	6165	39.0653	37.6957	0.1859	312.019
Trade	6631	78.2974	48.0492	0.0209	442.62

Notes: The data cover 181 countries from 1971 to 2016. However, some countries do not observe every period, so the total number of observations of each control variable is different. #—represents number.

5. Results

Columns (a) and (b) in Table 8 show the overall countries' results of PCA and FA. One surprising result is that there is no critical difference in the results except for the financial openness variables. Particularly, the significance and sign of coefficients of control variables in each reduction methodology are almost identical between them. The only difference is the difference between component 2 and factor 2.

Table 8. PCA and FA estimation results.

Category	Overall Countries		Stable Countries		Transitioning Countries	
Variables	(a) PCA	(b) FA	(c) PCA	(d) FA	(e) PCA	(f) FA
Financial Openness						
Component 1	−0.7620		−0.8739 **		−1.1639 **	
	(0.5840)		(0.4458)		(0.5188)	
Component 2	−0.6575		−1.6111		−0.0163	
	(0.5138)		(1.0298)		(0.3662)	
Factor 1		−0.6263		1.6585		−1.8914 **
		(1.0040)		(1.2161)		(0.7904)
Factor 2		0.6691		0.4260		0.3499
		(1.1130)		(1.0036)		(1.1937)
Control Variables						
Growth Lag	0.1824 ***	0.1996 ***	0.1471 ***	0.2285 ***	0.3380 ***	0.2551 ***
	(0.0524)	(0.0538)	(0.0406)	(0.0498)	(0.0504)	(0.0362)
Capital Service	11.2195 ***	11.0595 ***	11.4870 ***	11.3271 ***	9.1789 *	13.1303 ***
	(3.2478)	(3.3386)	(3.2785)	(3.3436)	(5.5321)	(3.6726)
TFP	12.4478 ***	13.0570 ***	6.1496 ***	11.1489 ***	4.0671	7.8918 ***
	(3.0079)	(1.7335)	(2.0666)	(2.1038)	(5.6527)	(2.6058)
Domestic Credit	−0.0667 ***	−0.0719 ***	−0.0572 ***	−0.0809 ***	−0.0481 ***	−0.0774 ***
	(0.0143)	(0.0154)	(0.0119)	(0.01862)	(0.0134)	(0.0148)
Trade	0.0705 ***	0.0824 ***	0.0782 ***	0.0785 ***	0.0543 **	0.0274 ***
	(0.0154)	(0.0154)	(0.0240)	(0.0148)	(0.0240)	(0.0091)
Constant	−7.4130 ***	−8.4694 ***	−4.6493 *	−7.0278 ***	−1.3767	0.2181
	(2.6263)	(1.8720)	(3.127)	(2.3678)	(3.8127)	(1.5221)
Model Statistics						
AR(1)	−5.51 ***	−5.35 ***	−3.87 ***	−4.06 ***	−3.76 ***	−3.73 ***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
AR(2)	−0.97	−0.80	−1.21	−0.72	0.49	0.30
	[0.330]	[0.426]	[0.227]	[0.475]	[0.624]	[0.766]
Sargan–Hansen	11.23	13.89	16.96 *	12.04	14.49	15.24
	[0.253]	[0.178]	[0.075]	[0.282]	[0.152]	[0.172]
# of Obs.	1089	1089	655	655	434	434

Note: Standard error in parentheses. *p*-value in square brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Arellano and Bond (1991) AR(1) and AR(2) tests require the condition that no serial correlation at an order higher than one. The Sargan–Hansen test requires an overidentification test to ensure that the model has more instruments than necessary for the estimation.

Among control variables, trade openness shows a positive effect on economic growth and supports the traditional argument that trade helps a country develop its economy. Although this is consistent with the argument, its magnitude is very low. In other words, its effect is less than a percentage (for PCA, 0.0705% increased by 1% increase in trade openness.), so its effect is not critical. Possibly, this could be the reason why there is controversy regarding its effect on trade. Because most of the countries in the world are less developed or developing countries, these countries are the majority in the data. As known, low-income countries depend more on agriculture-based economies such as agriculture, forestry, and fishing sectors. In contrast, developed countries rely more on manufactured goods such as electronics and IT equipment (UNCTAD, 2018). Therefore, the benefit from the trade could be less in either less-developed or developing countries due to the exposure to price volatility of agricultural products. This is the possible explanation for why the effect of trade openness is weakly positive. In other words, the positive effects from developed countries outweigh the negative effects from less-developed or developing countries due to the difference in industrial structure. However, these effects are nearly balanced, resulting in only a weak positive effect. In this vein, the estimation results in the other four columns for stable and transitioning countries support this argument that stable countries have relatively larger positive magnitudes than transition countries, while both countries have smaller magnitudes.

For domestic credit, its effect is negative on economic growth. This result is consistent with Gozgor (2015), with only seven out of fifty-eight countries, including developed and developing countries, having statistically significant Granger causality between domestic credit and economic growth. This implies that higher domestic credit causes the financial institution to have more financial costs, such as screening costs or processing costs, so the increase in domestic credit cannot lower the cost and, finally, discourages economic growth. At the same time, this suggests the presence of asymmetric information regardless of the quantity of domestic credit. In terms of magnitude, transitioning countries have a relatively weaker effect than stable countries. A possible explanation for the difference in the magnitude is that stable countries are relatively more financially developed countries. This implies that stable countries can be exposed to more advanced financial technologies or tools, which allow financial institutions to utilize the leverage more effectively. Inversely, this also implies that the financial institutions in stable countries can take riskier actions, such as leverage, due to moral hazards under asymmetric information. Considering the fact that leverage is more common in stable countries, the results showing that transitioning countries have a weak effect are acceptable. Regarding the magnitude of trade openness, however, the effect of domestic credit on economic growth is not critical.

In contrast with domestic credit, capital service shows different results and supports the argument in Mankiw et al. (1992) model that physical and human capital are critical factors in encouraging economic growth. As mentioned above, capital service is a variable to show the utilization of capital stock in each country relative to the United States. (Note that the United States has a unit value.) As predicted in Mankiw et al. (1992), capital service is a significant and critical factor in determining economic growth. Particularly, capital service is the most critical variable for economic growth in terms of magnitude. This is also consistent with the prediction of the AK Growth Model, which suggests that a country continues to achieve economic growth due to increasing returns in the scale of capital. In defense of the AK Growth Model, McGrattan (1998) showed that high investments are associated with a period of high growth rates in OECD countries and three Asian non-OECD countries. The estimation results also defended the argument of the AK model and were consistent with her results. In sum, the estimation results support "*capital deepening*"

in the AK model or some of the endogenous growth models, which shows that deepening leads to better productivity, resulting in growth in the overall output.

Regardless of the economic growth models, either in the Solow–Swan model or the endogenous growth models, TFP is the most critical factor for economic growth, so it is generally required for long-run economic growth. In this point of view, the estimation results are consistent with the theoretical argument. One surprising result is that even though its importance is larger than capital service theoretically, its magnitude is less than that of capital service, so TFP is the second critical factor in encouraging economic growth. This is a somewhat counter-intuitive result since capital accumulation could have a temporary effect while TFP has a permanent and long-run effect.

According to Schefold (1976), however, technological progress is in different forms, such as saving labor, savings of raw materials, mechanization, and inventions. It is well known that modern technology progress is more closely tied to mechanization and new inventions rather than saving labor or raw materials. Since less-developed or developing countries tend to rely on labor-intensive industries like agriculture, the transition to modern technology may involve significant costs, such as reequipping, relocating, and industrialization (Solo, 1969). Because these technological transformations require capital accumulation as the prerequisite condition, capital service itself can be a more critical factor than TFP. Moreover, the estimation results show that the magnitude of the coefficients of TFP in transitioning countries is lower than those of the stable countries, which supports the argument for the existence of the technological transformation cost.

This is also particularly true for some developing countries, such as the *Four Asian Tigers* (or *Four Asian Dragons*). In this vein, Krugman (1994) made a specific comment on this case: *"Asian growth, like that of the Soviet Union in its high-growth era, seems to be driven by extraordinary growth in inputs like labor and capital rather than gains in efficiency"* (p. 70). As mentioned above, the majority of the data consists of either developing countries or less developed countries. Therefore, this possibly accounts for the reason why capital service has a larger effect on economic growth than TFP.

According to Melo et al. (2001), there are eleven variables that characterize the initial conditions of developing or transitioning countries to a market economy such as development, resources, initial macroeconomic distortion, income level, urbanization, industrialization, and so on. They found that initial conditions are crucial for both economic performance and the pace of economic liberalization. By developing a linkage system model, they demonstrated how initial conditions, policies, and performances are interconnected. The results show that the growth lag (or initial condition) has a positive effect on current economic growth so that it has an inertia effect once an economy takes off from a development pathway as the plane takes off from the runway, as shown in Melo et al. (2001). In addition, the magnitude of the lag of growth in transitioning countries is larger than that of stable countries.

This suggests that transition countries rely more on the previous economic conditions. Finally, the most surprising variables are the components or factors for financial openness. In the case of PCA, both components are negative, and this is counter-intuitive and contradicts the existing literature that financial openness has a positive effect on economic growth. A possible explanation is, as noted in Quinn et al. (2011), that the benefit of financial openness has declined over time due to the inclusion of the recent financial crisis. For example, Bekaert et al. (2005), and Quinn and Toyoda (2008) employ data from 1980 to 1997 and from 1950 to 1999, respectively, while this paper employs data from 1987 to 2010s.[13] This paper covers a more recent period and includes more financial crises than the existing literature, so it is acceptable that both components are negative. In contrast with PCA, the FA results show inconsistent results that the signs of factors differ across the model.

Possibly, the finding in Quinn et al. (2011) that IF_Heritage in FA has an uninterpretable unique dynamic is a reason to generate inconsistent results. In line with this, the FA results support the argument in (Quinn et al., 2011), as noted earlier, that PCA is preferred to extract a composite financial openness measure.

In terms of magnitude, transitioning countries have a higher magnitude in component 1 and factor 1, while stable countries have a higher magnitude in component 2 and factor 2. This result is consistent with the results in Quinn et al. (2011) that the estimated coefficient of financial openness for non-OECD countries is larger than for OECD countries, showing *"Diminishing Returns to Liberalization"*. This paper is not limited to a category of OECD and non-OECD but extends the category, including more developed, developing, and less developed countries. Hence, the results in this paper not only support the results of Quinn et al. (2011) but also generalize the existing results. However, component 2 and factor 2 show an inverse pattern that stable countries have a larger magnitude than transitioning countries. These results imply that stable countries are more exposed to economic risks while transitioning countries are more exposed to institutional risk because component 1 and factor 1 are closer to de jure, while component 2 and factor 2 are closer to de facto. As noted in the literature regarding financial development, developed countries generally have significantly different and resilient finance institutional systems compared to developing or less-developed countries in terms of depth, accessibility, or efficiency. Therefore, transitioning countries can have a more severe financial crisis than stable countries when adverse shocks hit the economy. Inversely, however, the aftermath of a financial crisis should be greater in stable countries than in transitioning countries. As noted in Kose and Ohnsorge (2020), this is because, ironically, transitioning countries generally could have strong economic growth before the financial crisis so that transitioning countries can draw on sizable policy buffers, enabling them to be more resilient. In addition, developing and less-developed countries go through several financial crises, such as the 1997–1998 Asian Crisis, so they can adopt inflation-targeting monetary policies or fiscal rules regardless of their financial institutional developments.

In terms of statistical significance, all financial openness variables in the FA estimations are statistically insignificant, while the first components in stable and transitioning countries are statistically significant. In line with this, the signs of the FA estimations are inconsistent, while the PCA estimations are consistent across the different models. These estimation results support Quinn et al. (2011) argument as to why PCA is preferred. The results imply that the institutional components of financial openness matter in economic growth, affecting growth negatively. This is because only institutional components or factors are statistically significant. At the same time, this also justifies the dominance of negative effects during the Global Financial Crisis and Great Recession of 2007–2009 and particularly supports the reason why some major economic institutions, such as the IMF, have changed their views regarding financial openness. Moreover, this result is consistent with a theoretical argument that capital controls are always helpful in preventing the volatility of the external account, reducing the possibility of a financial crisis, and, finally, improving welfare gains (Coulibaly, 2023). Therefore, the most important aspect of financial openness is not economic aspects but institutional aspects, so it is not possible for a country to enjoy the fruit of financial openness without proper institutional readiness. From this point of view, the controls on inflows that Brazil penalizes for short-term capital inflow after the Global Financial Crisis are acceptable responses if they are not mature enough to absorb the negative effect of the financial crisis due to financial openness.[14]

6. Discussion: Lesson from History (Financial Crisis in East Asia)

Successful economic growth in East Asia has amazed academia and professions and spurred the investigation of what economic policies and factors contributed to the success of East Asian Economies, particularly the Four Tigers (or Dragons). From early 1960 to late 1990, East Asian Economies achieved a high economic growth rate of more than three percent, and this result is still modest compared to the Four Tigers, who achieved exceptionally higher economic growth of more than seven percent. Note that the Four Tigers are Hong Kong, the Republic of Korea, Singapore, and Taiwan. Even though there were some controversial issues about which economic factor was the main factor for them to achieve successful economic growth, it was well known that export-oriented international trade policies, lower taxes, and aggressive government intervention are the most acceptable arguments among academia and professions.

Even with economic success, in 1997, East Asian Economies were suddenly shaken by financial turmoil. As a result, the Four Tigers experienced a sharp contraction in their GDP and the economic deregulation and liberalization of financial markets. Before the crisis, some Asian countries such as Indonesia, Malaysia, and the Republic of Korea liberalized capital imports with a fixed exchange rate, encouraging financial institutions such as commercial banks or non-bank financial institutions to borrow funds from foreign financial institutions. Particularly, the prosperousness of economic growth in Asian economies created optimism about their economies, and this optimism augmented capital imports under the open capital account with fixed exchange rates.

When optimism shifted to fear due to worsening economic conditions, foreign investors reacted quickly, engaging in herd behavior by withdrawing their loans, which led to rapid capital outflows. For example, the vacancy rate of buildings in Thailand due to the heated construction boom and Hanbo Steel and six other *Chaebols*[15] in South Korea going bankrupt due to the overinvestment in the manufacturing capacity were triggered by the herd behavior of recovering their loans. This herd behavior caused Asian countries to have a financial crisis in 1996 and 1997, damaging important economic fundamentals to sustain economic growth and stability. Regardless of the fear of foreign investors, the fundamental reason behind the crisis was capital inflow and outflow.

According to Aliber and Kindleberger (2015), the history of financial (or banking) crises over the last forty years shows that financial crises are associated with currency crises. For example, the surge in the price of real estate and stocks and securities is caused by the increase in the supply of credit due to the increase in cross-border capital inflows. This increase leads to an appreciation of the local currencies and also leads to an economic boom. At the same time, possibly, the central bank raised the interest rate to lessen inflationary pressure due to the boom, attracting more cross-border capital inflow. Once grounded or non-grounded expectations of economic situations are changed, however, the decline in cross-border inflows starts, which triggers a depreciation of the local currencies and a decline in stocks and securities, and, finally, changes the ability of the indebted countries to pay interest and principal payments. This also accelerates capital outflow, exacerbates the economy, and, finally, damages important economic fundamentals. Therefore, it is required to have a proper risk management system to handle capital inflow and outflow independently of the confidence of foreign investors.[16]

This history is consistent with the implication of this paper that it is not possible for a country to enjoy the fruit of financial openness without a proper institutional system that can defend the economy from the economic pessimism of foreign investors or the attacks of global macro hedge funds. In particular, the capital inflow created economic booms in the economy, as mentioned in the literature, which indicates that financial openness has a

positive effect. However, capital outflow showed that it could create either a financial crisis or economic turmoil, as the institutional aspect of financial openness has a negative effect.

7. Conclusions

This paper employs the dimensionality reduction technique to investigate the effect of financial openness on economic growth. This is because there are variations in financial openness indices in either *de jure* or *de facto,* and the selection of indices matters to the results (Gräbner et al., 2021). Using five publicly available financial openness indices (four are *de jure*, and one is *de facto*), the results show counter-intuitive results: financial openness does not encourage economic growth. This implies that without proper legal or institutional readiness, the dark side of financial openness, such as financial crisis, outweighs the bright side of financial openness, such as knowledge diffusion. In other words, a country wanting to enjoy the fruit of financial openness should have a mature institutional or legal system. Also, this is consistent with the current change in the stance of the IMF (2012), which was one of strong support for either liberalization or globalization. A theoretical argument in Coulibaly (2023) states that capital controls can reduce the possibility of a financial crisis and improve welfare gains.

Because only five financial openness indices are available publicly, this paper has limitations in that it does not include many financial openness indices in the dimensionality reduction technique. Thus, future research should include more indices in the technique to provide a clearer understanding of the relationship between financial openness and economic growth.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A Financial Openness Indices Availability

Table A1. Financial Openness Indices Availability.

No.	Country	KAOPEN	KA	IF_Heritage	KA NEW	LMF
1	Afghanistan	1971–1994 and 2000	1995–2016	N/A	N/A	2002–2011
2	Albania	1995–2016	N/A	1995–2016	1996–2013	1993–2011
3	Algeria	1971–2016	N/A	1995–2016	2010–2013	1971–2011
4	Angola	1993–2016	1995–2016	1995–2000 and 2006–2016	1996–2013	1985–2011
5	Antigua and Barbuda	1985–2009	N/A	N/A	1996–2005	1977–2011
6	Argentina	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
7	Armenia	1996–2016	N/A	1996–2016	1996–2013	1996–2011
8	Aruba	1992–2016	N/A	N/A	N/A	1991–2011
9	Australia	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
10	Austria	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
11	Azerbaijan	1996–2016	N/A	1996–2016	1996–2013	1995–2011
12	Bahamas, The	1977–2016	N/A	1995–2016	1996–2013	N/A
13	Bahrain	1976–2016	1995–2016	1995–2016	1996–2013	1971–2011
14	Bangladesh	1976–2016	1995–2016	1995–2016	2001–2013	1973–2011
15	Barbados	1974–2016	1995–2016	1996–2016	1996–1998 and 2005–2014	N/A
16	Belarus	1996–2016	N/A	1995–2016	2002–2013	1994–2011
17	Belgium	1971–2016	N/A	1996–2016	1997–2014	1971–2011
18	Belize	1985–2016	N/A	1995–2016	1996–2013	1976–2011
19	Benin	1979–2016	N/A	1996–2016	1996–2013	1971–2011
20	Bhutan	1985–2016	N/A	2009–2016	1996–2013	1983–2011
21	Bolivia	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
22	Bosnia and Herzegovina	1999–2016	N/A	1998–2016	N/A	1998–2011
23	Botswana	1972–2016	N/A	1995–2016	1996–2013	1974–2011
24	Brazil	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
25	Bulgaria	1994–2016	1995–2016	1995–2016	1996–2013	1991–2011
26	Burkina Faso	1988–2016	1995–2016	1996–2016	1996–2013	1974–2011
27	Burundi	1971–2016	1995–2016	1997–2000 and 2006–2016	2010–2013	1971–2011
28	Cambodia	1973–1974 and 1995–2016	N/A	1997–2016	2013	1993–2011
29	Cameroon	1971–2016	N/A	1995–2016	N/A	1971–2011
30	Canada	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
31	Cape Verde	1982–2016	N/A	N/A	N/A	1981–2011
32	Central African Republic	1971–2016	N/A	2002–2016	1996–1998 and 2008–2013	1971–2011
33	Chad	1971–2016	1995–2016	1997–2016	2008–2013	1971–2011
34	Chile	1971–2016	N/A	1995–2016	1996–2013	1971–2011
35	China	1984–2016	1995–2016	1995–2016	1996–2013	1981–2011
36	Colombia	1971–2016	1995–2016	1995-2016	2002–2013	1971–2011
37	Comoros	1981–2016	N/A	2009–2016	2011–2013	1979–2011
38	Congo, Dem. Rep	1971–2012	N/A	N/A	1996–2013	1971–2011
39	Congo, Rep.	1971–2016	N/A	1996–2016	2008–2013	1971–2011
40	Costa Rica	1971–2016	1995–2016	1995–2016	2006–2013	1971–2011
41	Cote d'Ivoire	1971–2016	1995–2016	N/A	2000–2013	1971–2011
42	Croatia	1996–2016	N/A	1996–2016	1996–2000 and 2003–2013	1996–2011
43	Cyprus	1971–2016	1995–2016	1996–2016	1996–2013	1973–2011
44	Czech Republic	1996–2016	1995–2016	1995–2016	1996–2013	1993–2011
45	Denmark	1971–2016	1995–2016	1996–2016	1996–2013	1971–2011
46	Djibouti	1982–2016	N/A	1997–2016	1996–2013	1977–2011
47	Dominica	1982–2016	N/A	2009–2016	N/A	1977–2011
48	Dominican Republic	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
49	Ecuador	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
50	Egypt, Arab Rep	1971–2016	1995–2016	1995–2016	1999–2013	1971–2011

Table A1. *Cont.*

No.	Country	KAOPEN	KA	IF_Heritage	KA NEW	LMF
51	El Salvador	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
52	Equatorial Guinea	1973–2016	N/A	1999–2016	2008–2013	1971–1977 and 1985–2011
53	Eritrea	1998–2016	N/A	2009–2016	N/A	1995–2011
54	Estonia	1996–2016	N/A	1995–2016	1998–2013	1992–2011
55	Ethiopia	1971–2016	1995–2016	1995–2016	2009–2013	1971–2011
56	Fiji	1975–2016	N/A	1995–2016	1996–2013	1977–2011
57	Finland	1971–2016	1995–2016	1996–2016	1996–2013	1971–2011
58	France	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
59	Gabon	1971–2016	N/A	1995–2016	2003–2013	1971–2011
60	Gambia, The	1971–2016	N/A	1997–2016	N/A	1971–2011
61	Georgia	1996–2016	1995–2016	1996–2016	1996–2013	1995–2011
62	Germany	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
63	Ghana	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
64	Greece	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
65	Grenada	1979–2016	N/A	N/A	2008–2013	1971–2011
66	Guatemala	1971–2016	1995-2016	1995–2016	1996–2013	1971–2011
67	Guinea	1971–2016	N/A	1995–2016	1996–1998	1971–2011
68	Guinea-Bissau	1981–2016	N/A	1999–2016	2010–2013	1980–2011
69	Guyana	1971–2016	N/A	1995–2016	1996–2013	1971–2011
70	Haiti	1971–1976 and 1984–2016	N/A	1995–2016	2003–2013	1971–2011
71	Honduras	1971–2016	N/A	1995–2016	1996–2013	1971–2011
72	Hong Kong, China	1971–2016	1995–2016	1995–2016	1996–2013	1980–2011
73	Hungary	1986–2016	1995–2016	1995–2016	1996–2013	1982–2011
74	Iceland	1971–2016	1995–2016	1997–2016	1996–2013	1971–2011
75	India	1971–2016	1995–2016	1995–2016	2004–2013	1971–2011
76	Indonesia	1971–2016	1995–2016	1995–2016	1996–1998 and 2008–2013	1971–2011
77	Iran, Islamic Rep.	1971–2016	1995–2016	1996–2016	2003–2013	1971–2011
78	Iraq	1971–1994 and 2000–2002	N/A	1996–2002	2008–2013	2005–2011
79	Ireland	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
80	Israel	1971–2016	1995–2016	1995–2016	1996–2016	1971–2011
81	Italy	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
82	Jamaica	1971–2016	1995–2016	1995–2016	2009–2013	1971–2011
83	Japan	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
84	Jordan	1971–2016	N/A	1995–2016	1996–2013	1971–2011
85	Kazakhstan	1996–2016	1995–2016	1998–2016	1996–2013	1994–2011
86	Kenya	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
87	Kiribati	1990–2005	N/A	2009–2016	N/A	1988–2011
88	Korea, Rep.	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
89	Kuwait	1971–2016	1995–2016	1996–2016	1996–2013	1974–2011
90	Kyrgyz Republic	1997–2016	1995–2016	1998–2016	1999–2013	1993–2011
91	Lao PDR	1971–1975 and 1981–2016	N/A	1996–2016	2003–2013	1977–2011
92	Latvia	1996–2016	1995–2016	1996–2016	1996–2013	1992–2011
93	Lebanon	1971–2016	1995–2016	1996–2016	1996–2013	1971–2011
94	Lesotho	1972–2016	N/A	1996–2016	N/A	1975–2011
95	Liberia	1971–2016	N/A	2009–2016	1996–2013	1971–2011
96	Libya	1971–1972 and 1977–2016	N/A	1996–2012	N/A	1972–2011
97	Lithuania	1996–2016	N/A	1996–2016	1996–2013	1992–2011
98	Macedonia, FYR	1997–2016	N/A	2003–2016	2002–2016	1993–2011
99	Madagascar	1971–2016	N/A	1995–2016	2008–2013	1971–2011
100	Malawi	1971–2016	N/A	1995–2016	1996–2013	1971–2011
101	Malaysia	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
102	Maldives	1982–2016	N/A	2009–2016	1999–2013	1978–2011
103	Mali	1971–2016	N/A	1995–2016	1998–2013	1971–2011
104	Malta	1972–2016	1995–2016	1995–2016	1996–2013	1971–2011
105	Marshall Islands	1996–2016	N/A	N/A	N/A	N/A
106	Mauritania	1971–2016	N/A	1996–2016	2007–2013	1971–2011

Table A1. *Cont.*

No.	Country	KAOPEN	KA	IF_Heritage	KA NEW	LMF
107	Mauritius	1972–2016	1995–2016	1999–2016	1996–2013	1971–2011
108	Mexico	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
109	Micronesia, Fed. Sts.	1996–2016	N/A	2009–2016	N/A	N/A
110	Moldova	1996–2016	1995–2016	1995–2016	1996–2013	1994–2011
111	Mongolia	1995–2016	N/A	1995–2016	2008–2013	1992–2011
112	Morocco	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
113	Mozambique	1988–2016	N/A	1995–2016	1996–2013	1980–2011
114	Myanmar	1971–2016	1995–2016	N/A	1996–1997	1971–2011
115	Namibia	1994–2016	N/A	1997–2016	2011–2013	1989–2011
116	Nepal	1971–2016	N/A	1996–2016	2007–2013	1971–2011
117	Netherlands	1971–1974 and 1981–2016	1995–2016	1996–2016	1996–2013	1971–2011
118	New Zealand	1971–2016	1995–2016	1996–2016	1996–2013	1971–2011
119	Nicaragua	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
120	Niger	1971–2016	N/A	1996–2016	1996–2013	1971–2011
121	Nigeria	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
122	Norway	1971–2016	1995–2016	1996–2016	1996–2013	1971–2011
123	Oman	1977–2016	1995-2016	1995–2016	1996–2013	1973–2011
124	Pakistan	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
125	PaN/Ama	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
126	Papua New Guinea	1979–2016	N/A	1996–2001 and 2009–2016	1999–2013	1973–2011
127	Paraguay	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
128	Peru	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
129	Philippines	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
130	Poland	1986–2016	1995–2016	1995–2016	1996–2013	1975–2011
131	Portugal	1971–2016	1995–2016	1995–2016	1996–2013	1972–2011
132	Qatar	1976–2016	1995–2016	1999–2016	1996–2013	1971–2011
133	Romania	1976–2016	1995–2016	1995–2016	1996–2013	1990–2011
134	Russian Federation	1996–2016	1995–2016	1995–2016	1996–2013	1993–2011
135	Rwanda	1971–2016	N/A	1997–2016	1996–2013	1993–2011
136	Sao Tome and Principe	1981–2016	N/A	2009–2016	N/A	1987–2011
137	Samoa	1975–2016	N/A	1996–2001 and 2009–2016	1996–2013	N/A
138	San Marino	1996–2016	N/A	N/A	N/A	N/A
139	Saudi Arabia	1971–2016	1995–2016	1996–2016	1996–2013	1971–2011
140	Senegal	1971–2016	N/A	1996–2016	1996–2013	1971–2011
141	Seychelles	1981–2016	N/A	2009–2016	1996–2013	1977–2011
142	Sierra Leone	1971–2016	N/A	1995–2000 and 2003–2016	2008–2013	1971–2011
143	Singapore	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
144	Slovak Republic	1996–2016	N/A	1995–2016	1996–2001 and 2005–2013	1993–2011
145	Slovenia	1996–2016	1995–2016	1996–2016	1996–2013	1992–2011
146	Solomon Islands	1982–2016	N/A	2009–2016	1996–2013	1977–2011
147	Somalia	1971–1994 and 2000–2007	N/A	N/A	N/A	N/A
148	South Africa	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
149	Spain	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
150	Sri Lanka	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
151	St. Kitts and Nevis	1988–2016	N/A	N/A	1996–1998 and 2002–2013	1983–2011
152	St. Lucia	1983–2016	N/A	N/A	N/A	1976–2011
153	St. Vincent and the Grenadines	1983–2016	N/A	N/A	2008–2013	1976–2011
154	Sudan	1971–2007 and 2009–2016	N/A	1995–2000	1996–2013	1971–2011
155	Suriname	1971–1974 and 1982–2016	N/A	1996–2016	2006–2013	1976–2011
156	Swaziland	1973–2016	1995–2016	N/A	1996–2013	1971–2011
157	Sweden	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
158	Switzerland	1996–2016	1995–2016	1996–2016	1996–2013	1971–2011

Table A1. *Cont.*

No.	Country	KAOPEN	KA	IF_Heritage	KA NEW	LMF
159	Syrian Arab Republic	1971–2016	N/A	1996–2012	2008–2012	1971–2011
160	Tajikistan	1997–2016	N/A	1998–2016	1996–2013	1997–2011
161	Tanzania	1971–2016	1995–2016	1995–2016	1996–1998 and 2005–2013	1971–2011
162	Thailand	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
163	Togo	1971–2016	1995–2016	1999–2016	1996–2013	1971–2011
164	Tonga	1989–2016	N/A	2009–2016	1996–2013	1980–2011
165	Trinidad and Tobago	1971–2016	N/A	1996–2016	1996–2013	1971–2011
166	Tunisia	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
167	Turkey	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
168	Turkmenistan	1996–2016	N/A	1998–2016	N/A	1993–2011
169	Uganda	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
170	Ukraine	1996–2016	1995–2016	1995–2016	1996–2013	1994–2011
171	United Arab Emirates	1976–2016	1995–2016	1996–2016	1996–2013	1973–2011
172	United Kingdom	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
173	United States	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
174	Uruguay	1971–2016	1995–2016	1995–2016	2000–2013	1971–2011
175	Uzbekistan	1996–2016	1995–2016	1998–2016	2010–2013	1992–2011
176	Vanuatu	1985–2000	N/A	2009–2016	N/A	1973–2011
177	Venezuela, RB	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
178	Vietnam	1971–1974 and 1980–2016	1995–2016	1995–2016	1996–2013	1995–2011
179	Yemen, Rep.	1995–2000 and 2002–2016	1995–2016	1995–2015	1996–2005	1990–2011
180	Zambia	1971–2016	1995–2016	1995–2016	1996–2013	1971–2011
181	Zimbabwe	1984–2016	N/A	1995–2016	1996–2013	1976–2011

Notes

1 https://indexdotnet.azurewebsites.net/index/download (accessed on 12 January 2024).
2 Available at https://www.elibrary-areaer.imf.org/Pages/Home.aspx (accessed on 12 January 2024).
3 See note 1.
4 The curse of dimensionality generally refers to the problem or issue of data analysis such that sparsity of data, the complexity of computation, overfitting, challenging in the visualization of high dimensional data, or less meaningful data information emerge as the dimension of dataset increases. This term was first coined by Bellman (1957).
5 The thresholds are updated annually at the beginning of the World Bank's fiscal year, July 1st. Available at https://datacatalog.worldbank.org/dataset/world-development-indicators (accessed on 12 January 2024).
6 The Atlas method is a method that smooths exchange rate fluctuation by a three-year moving average using a price-adjusted conversion factor. For measuring inflation, the current methodology uses the change in SDR deflator complied from inflation measures represented in the IMF's Special Drawing Rights.
7 This test is rejected by 10 percent of the significance level. Generally, 5 percent and 1 percent are usual. Conservatively, it would be statistically insignificant.
8 Available at https://data.worldbank.org/indicator/FS.AST.PRVT.GD.ZS (accessed on 12 January 2024).
9 Available at https://www.rug.nl/ggdc/productivity/pwt/?lang=en (accessed on 12 January 2024).
10 In Solow (1957), *Solow Residual* was not coined. However, it is widely used in the literature.
11 Available at https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS (accessed on 12 January 2024).
12 In general, most statistical packages employ listwise deletion as the default method except for some analyses such as descriptive statistics, Factor Analysis, or regression.
13 Most of the data are available up to 2016. However, data from some countries is not available up to 2016.
14 This is known as Brazilian *Imposto Sobre Operacoes Financeiras* (IOF).
15 These are Korean-specific conglomerates that are generally controlled by a family
16 Regarding the risk management, financial crisis literature emphasizes *lender-of-last-resort*, providing additional liquidity to financial institutions or countries to handle financial crisis. Even though this is an acceptable solution, it cannot be a fundamental solution to reduce any possibility of the negative effect of financial openness. This is because it can create the *moral hazard* behavior such as *too big to fail*.

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