ERINA Discussion Paper No.2106

Tracking Regional Integration in Northeast Asia:

A composite index approach

Cyn-Young PARK
Racquel CLAVERIA

December 2021

Niigata, Japan
ECONOMIC RESEARCH INSTITUTE FOR NORTHEAST ASIA

Manuscript received in October 2019

Tracking Regional Integration in Northeast Asia: A composite index approach

Cyn-Young PARK and Racquel CLAVERIA[1]

Abstract

In this paper, we employed a composite index approach in assessing regional integration in Asia and the Pacific, with special focus on Northeast Asia. Findings suggest that the pace of integration in Northeast Asia is broadly trending upward over the 2006 – 2016 sample period, catching up to the level of most integrated region in Southeast Asia. Of the six dimensions featured in the composite index, we find that trade and investment and movement of people are the main drivers of regional integration, while the money and finance dimension was the weakest link. An in-depth analysis of Northeast Asia indicates that infrastructure and connectivity as well as institutional and social integration drive the subregion's integration with entire Asia. By contrast, integration within the subregion is lowest in terms of institutional and social integration, suggesting the dearth of formal integration mechanisms in Northeast Asia. Finally, country-level analysis for the subregion suggests that higher-income economies (such as People's Republic of China, Japan, and Republic of Korea) show in general a broader regional integration compared to more narrowly-based subregional integration in Democratic People's Republic of Korea and Mongolia.

Keywords

international migration, labor mobility, regional economic integration

JEL Classification

F22, O15

Cyn-Young PARK (cypark@adb.org) is Director of the Regional Cooperation and Integration Division (ERCI) in the Economic Research and Regional Cooperation Department (ERCD) of the Asian Development Bank (ADB).

Racquel CLAVERIA (rclaveria.consultant@adb.org) is a consultant in ERCD.

1 Introduction

Since the 1980s, a multitude of initiatives in Asia and around the world have aimed to promote economic openness, recognizing the positive effects of international cooperation and integration on economic growth and social outcomes. In particular, the process of regional economic integration, bringing neighboring countries together in the pursuit of common goals, can facilitate regional trade and investment, develop cross-border infrastructure, improve mobility, strengthen provision of regional public goods, and provide a legal and institutional basis for international policy cooperation.

The benefits have been well documented, particularly those driven by increased market size, exploitation of economies of scale, enhanced competition, increased investment, and technical transfers. Many studies suggest a positive relationship between trade openness and economic growth[2], and likewise, a numerous set of Asian economies has spearheaded regional integration as a development strategy.

Yet, even as they benefit from regional integration, low-income developing countries may fear the risks of full integration or lack the capacity to participate in large-scale regional integration initiatives. And of course, economic openness will naturally produce winners and losers. Economic subordination of underdeveloped countries, marginalization of socioeconomically vulnerable groups, and loss of sociocultural diversity are related concerns. Economic openness and liberalization, especially on financial markets and capital flows, may also invite financial contagion and risk widening inequality between countries, particularly in smaller nations, and within countries, in more vulnerable communities.

In Northeast Asia as well, the subject of this paper, economies of diverse background have approached regional integration with varying strategies. To fully understand the drivers of regional integration and optimize strategies, policy makers need mechanisms to monitor and evaluate the progress of regional integration on set goals. Against this backdrop, the Asian Development Bank (ADB) introduced the Asia-Pacific Regional Cooperation and Integration Index (ARCII) to capture the degree of regional integration and its multidimensionality in the region (ADB 2017) [3]. The ARCII employs 26 socioeconomic indicators categorized into six different dimensions to measure the diversity of regional cooperation and integration efforts: (i) trade and investment, (ii) money and finance, (iii) regional value chains, (iv) infrastructure and connectivity, (v) movement of people, and (vi) institutional and social integration.

---

[2] Such as Dollar 1992; Dollar and Kraay 2004; Edwards 1992, 1993; Frankel and Romer 1999; Harrison 1996; Harrison and Hanson 1999; and Sachs and Warner 1995.

[3] In 2017, the Asia Economic Integration Report of the Asian Development Bank unveiled the ARCII for 2013 using the methodology of Huh and Park (2017, 2018). A panel approach was later employed to extend the ARCII over 2006–2016 to monitor evolution of the index and identify the different drivers of regional integration over time (Park and Claveria 2018). The single year and panel ARCII series both cover 48 Asian economies, classified by subregion according to the ADB.

This paper extends the ARCII to focus on the Northeast Asian subregion: here expanded to include the People's Republic of China (PRC), the Democratic People's Republic of Korea (DPRK), Japan, Mongolia, the Republic of Korea, and the Russian Federation. In particular, the paper applies the ARCII to analyze the extent of integration of Northeast Asia with Asia generally and within the subregion. It also expands the country coverage of ARCII[4].

Despite differing stages of development, degrees of openness, and systems of political governance among its economies, Northeast Asia appears to hold great potential for reaping the benefits of integration due to its resource complementarities. Japan and the Republic of Korea have ample capital and technology, the PRC and DPRK are rich in labor and market potential, and Mongolia and the Russian Federation abound in natural resources. The opportunity for mutually beneficial cooperation and integration within the subregion is therefore enormous. Using the extended ARCII, this paper reviews regional integration trends in Asia, deepens the comparative analysis of regional integration within and beyond Northeast Asia, and shares insights of country level progress of regional integration.

Section 1 of the paper presents the key regional integration trends derived from the expanded ARCII country coverage. Section 2 shows the results of constructing ARCII at the intrasubregional level. Section 3 discusses regional integration trends in Northeast Asia in greater detail and section 4 concludes with policy implications.

2 Key Regional Integration Trends in Asia and the Pacific

2.1. Asia-Pacific Regional Integration Index: Construction and Interpretation

The ARCII, as noted, is based on 26 indicators designed to reveal multiple aspects of regional integration in six dimensions: trade and investment integration, money and finance integration, regional value chains, infrastructure and connectivity, movement of people, and institutional and social integration (Appendix 2 lists the 26 ARCII indicators). Index construction entails two steps: first, six dimensional subindexes are compiled as weighted averages of basic indicators; second, the overall index as a weighted average of the dimensional subindexes is compiled. In each step, the weights are determined based on panel principal component analysis (PCA) (Appendix 3 reviews ARCII methodology)[5].

PCA is a mathematical procedure that transforms a larger set of potentially correlated variables into a smaller set of uncorrelated variables called principal components. The analysis identifies a linear combination of the variables that explains the maximum variance of these variables. After removing the first maximum variance, it goes on finding a second linear combination which explains the maximum proportion of the remaining variance, and so on. This procedure results in orthogonal (uncorrelated) factors. As such, the first principal component accounts for the

[4] Appendix 1 presents the full country coverage of ARCII for this paper.

[5] See Huh and Park (2017, 2018) and Park and Claveria (2018) for more detailed discussion.

most variability that can be extracted from the data, with each succeeding component accounting for as much of the remaining variability as possible.

The ARCII is aggregated using weights obtained from a two-stage panel PCA. In the first stage, panel PCA is employed to apportion a weight to each indicator to construct the six dimensional subindexes. In the second stage, panel PCA is applied again to weight the subindexes to compile the overall index.

Table 1 shows the weights for each indicator and dimension of the ARCII. Taking into account all available information from 50 Asian countries for 2006–2016, the highest weight (0.189) was allocated to Dimension VI (institutional and social integration), followed by Dimension I (trade and investment) and Dimension V (movement of people), both assigned with weight of 0.179. Meanwhile, the lowest weight (0.122) was apportioned to Dimension II (money and finance). The PCA based weights would influence the share of each dimension in constructing each principal component (which is a linear combination of the dimensions) that explains the variation of the overall integration patterns in a subsequent manner.

Panel PCA-derived weights are used as reference weights in computing the ARCII for each year in the sample period. Keeping the weights constant over time would be useful in analyzing the evolution of the ARCII for each economy and regional/subregional grouping. It would also allow comparability of the composite index across the years.

2.2. Overall and Dimensional Sub-Indexes over Time

During 2006–2016, as measured by the ARCII, the very modest increase of the ARCII is in line with a common observation that regional integration is gradual (Figure 1). Each of the dimensional subindexes, while stable over time similar to the overall index, varies in magnitude and patterns of movement. Among the subindexes, Dimension I (trade and investment) and V (movement of people) maintained relatively higher scores than the overall index throughout the sample period. This implies the importance of Dimension I and V in the overall regional integration for Asia and the Pacific. Dimension III (regional value chain) and IV (infrastructure and connectivity) broadly tracked the overall index. Dimension II (money and finance) and VI (institutional and social integration) showed relatively lower integration. Dimension II also showed the highest volatility. This sub-index increased sharply in 2008, coinciding with the height of the global financial crisis, and picked up again in 2011 before the crisis drew to a close, stabilizing thereafter. The pattern illustrates that financial market interconnectedness tends to increase during stress periods and to decline during recovery (Chowdhury et al. 2018).

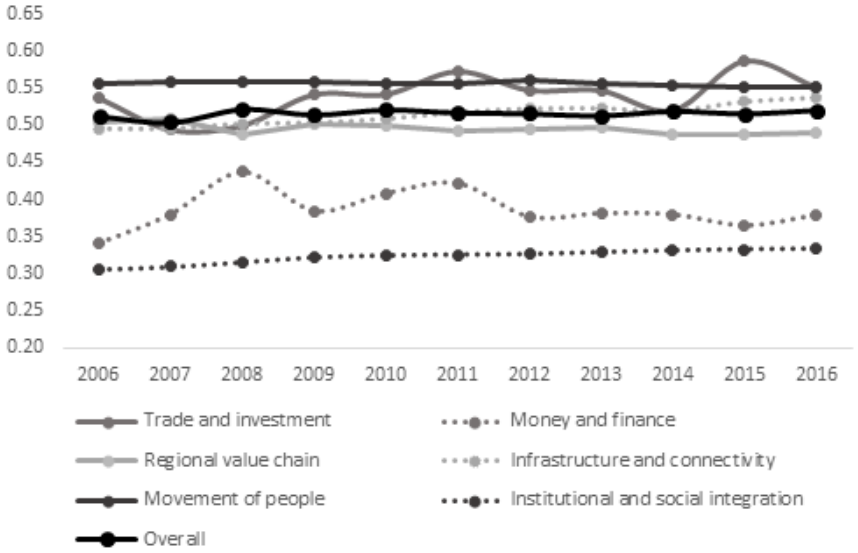
Trade and investment, infrastructure and connectivity, and movement of people appear to be the main drivers of regional integration in Asia (Figure 2). The figure presents the contribution of each dimensional index to the overall composite index, with Dimensions I, VI, and V, respectively, corresponding to those three measures. Money and finance (Dimension II) makes the least contribution to the estimated panel ARCII, which would seem to suggest that money and finance integration is the weakest link in regional integration in Asia.

Table 1: Asia-Pacific Regional Cooperation and Integration Index Panel PCA-Derived Weights

Dimensions and Subdimensions		Weights	
I. Trade and Investment Integration			**0.179**
I-a	Proportion of intraregional goods exports to total goods exports	0.181	
I-b	Proportion of intraregional goods imports to total goods imports	0.188	
I-c	Intraregional trade intensity index	0.218	
I-d	Proportion of intraregional foreign direct investment (FDI) inflows to total FDI inflows	0.208	
I-e	Proportion of intraregional FDI inflows plus outflows to total FDI inflows plus outflows	0.205	
II. Money and Finance Integration			**0.122**
II-a	Proportion of intraregional cross-border equity liabilities to total cross-border equity liabilities	0.243	
II-b	Proportion of intraregional cross-border bond liabilities to total cross-border bond liabilities	0.259	
II-c	Pair-wise dispersion of deposit rates averaged regionally relative to that averaged globally	0.243	
II-d	Pair-wise correlation of equity returns averaged regionally minus that averaged globally	0.256	
III. Regional Value Chain			**0.170**
III-a	Ratio between average trade complementarity index over regional trading partners and average trade complementarity index over all trading partners	0.245	
III-b	Ratio between average trade concentration index over regional trading partners and average trade concentration index over all trading partners	0.230	
III-c	Proportion of intraregional intermediate goods exports to total intraregional goods exports	0.317	
III-d	Proportion of intraregional intermediate goods imports to total intraregional goods imports	0.207	
IV. Infrastructure and Connectivity			**0.161**
IV-a	Ratio between average trade cost over regional trading partners and average trade cost over all trading partners	0.220	
IV-b	Ratio between average liner shipping connectivity index over regional trading partners and average liner shipping connectivity index over all trading partners	0.189	
IV-c	Logistics performance index (overall)	0.302	
IV-d	Doing Business Index (overall)	0.290	
V. Free Movement of People			**0.179**
V-a	Proportion of intraregional outbound migration to total outbound migration	0.247	
V-b	Proportion of intraregional tourists to total tourists (inbound plus outbound)	0.242	
V-c	Proportion of intraregional remittances to total remittances	0.209	
V-d	Proportion of other Asian countries that do not require an entry visa	0.302	
VI. Institutional and Social Integration			**0.189**
VI-a	Proportion of other Asian countries that have signed free trade agreements	0.172	
VI-b	Proportion of other Asian countries that have an embassy	0.199	
VI-c	Proportion of other Asian countries that have signed business investment treaties	0.202	
VI-d	Proportion of other Asian countries that have signed double taxation treaties	0.214	
VI-e	Cultural proximity with other Asian countries relative to that with all other countries	0.213	

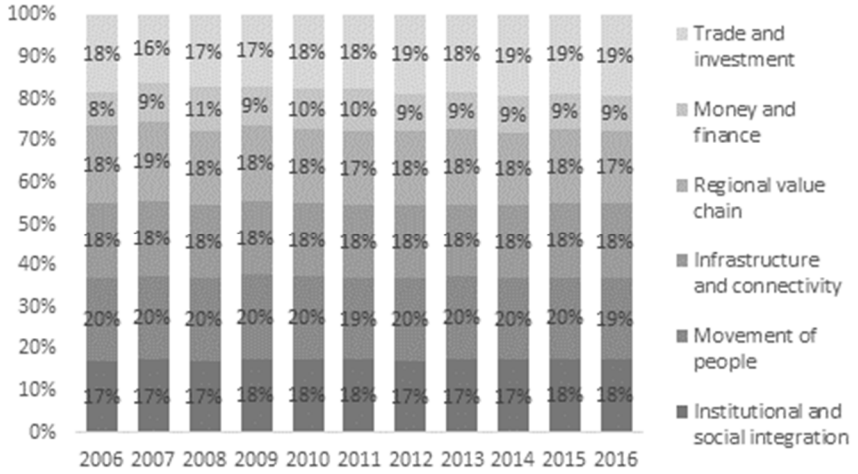
PCA = principal component analysis Source: Authors' calculations.

Figure 1: Overall Asia-Pacific Regional Cooperation Integration Index and Dimensional Subindexes—Asia



Source: Authors' calculations.

Figure 2: Dimensional Contribution to Asia-Pacific Regional Cooperation and Integration Index—Asia



Source: Authors' calculations

2.3 Performance of Asia Subregions[6]

Among the subregions, Southeast Asia showed the highest degree of integration with the entire Asian region, with an average score of 0.586 for the entire sample period (Figure 3). Northeast Asia followed, with a steadily increasing trend. South Asia and Central Asia placed third and fourth throughout the sample period. However, the progress of regional integration was noticeable for Central Asia until 2014, despite starting from a relatively low level.

By dimension, trade and investment and infrastructure and connectivity show visible progress across subregions (Figure 4). In trade and investment integration with the region, Southeast Asia is a leader. Money and finance integration exhibited ups and downs over the sample period across all subregions. In particular, the money and finance sub-index peaked in 2008 for these subregions, reflecting the well-known statistical regularity of higher financial market correlations during crisis periods. Movement of people seems to be most stable over time, reflecting socioeconomic factors including the cultural proximity and general economic and labor market conditions driving labor mobility tend not to change easily.

Variations across different subregions are also noticeable by dimension. Southeast Asia scored highest in regional integration for the dimension of regional value chain until overtaken by Central Asia and Northeast Asia in 2012. Northeast Asia was the forerunner in regional integration for infrastructure and connectivity, with its sub-index rising at an accelerating pace over the sample period. Subregional variations in movement of people and institutional and social integration were particularly large across the sample period. Regional integration as reflected in the movement of people was dominated by Southeast Asia, while particularly weak in Central Asia. Finally, Northeast Asia registered consistently the highest sub-index score in institutional and social integration among other subregions, while the Pacific scored lowest on this front.

2.4. Leaders in Regional Integration

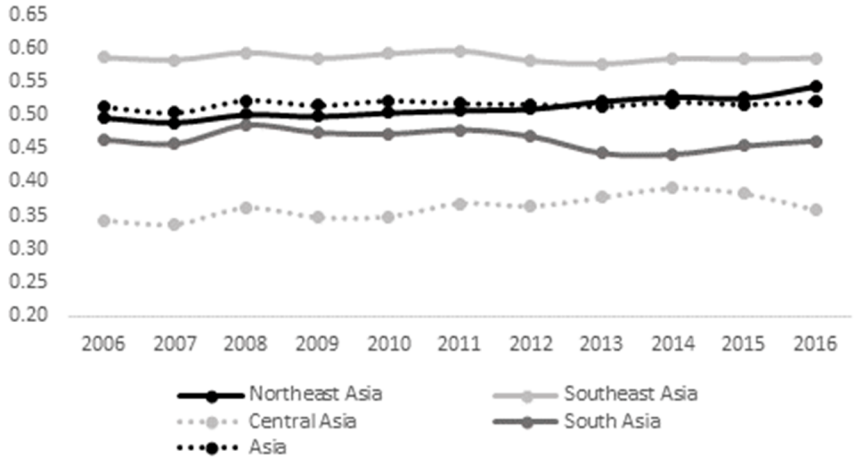
The time-varying ARCII enables examination of the evolution of regional integration of specific economies over time. This allows determination of the leaders in regional integration from 2006 to 2016. Of the 19 economies for which the ARCII could be computed for 2006 and 2016, 14 (more than 70%) progressed in regional integration across the 11-year sample period (Figure 5) [7]. Moreover, four of the top five economies that have advanced most in regional integration are in Northeast Asia, namely Mongolia, the Russian Federation, the PRC, and Japan. Meanwhile, five economies slipped in regional integration from 2006 to 2016: New Zealand, Sri Lanka, Republic of Korea, Indonesia, and Australia.

---

[6] The overall index could not be computed for the Pacific due to lack of data for the money and finance dimension.

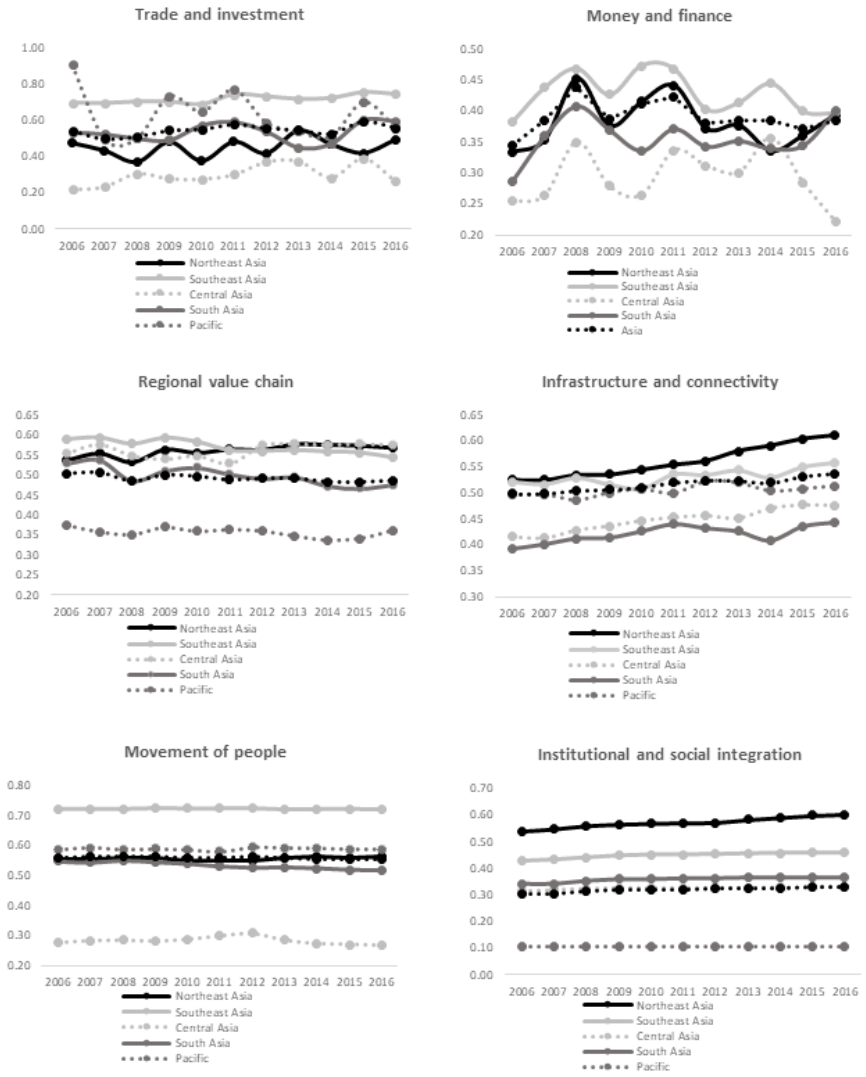
[7] For Mongolia, for which the overall index could not be computed for 2006, the comparative periods are 2007 versus 2016.

Figure 3: Overall Asia and Pacific Regional Cooperation and Integration Index, 2006–2016—Asia Subregions



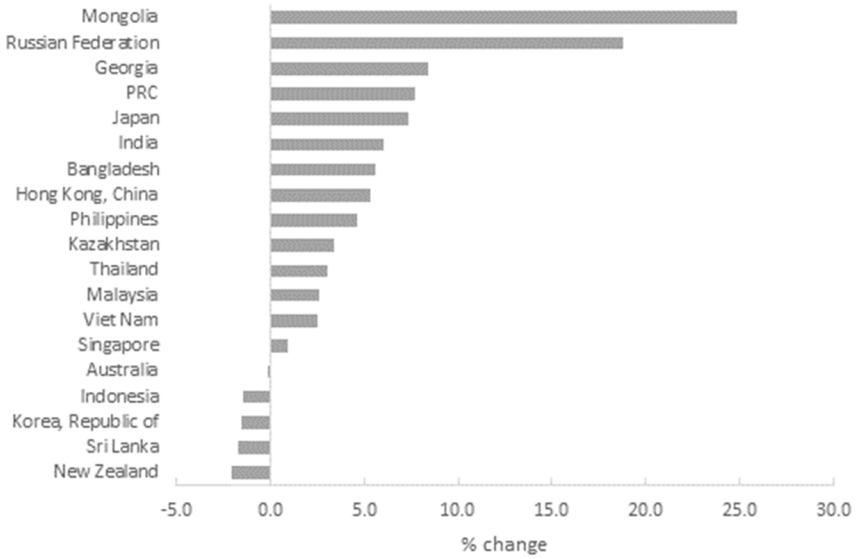
Source: Authors' calculations

Figure 4: Dimensional Sub-Indexes, 2006–2016—Asia Subregions



Source: Authors' calculations.

Figure 5: Asia-Pacific Regional Cooperation and Integration Index, 2016 versus 2006—Selected Asian Economies



Note: For Mongolia for which the overall index cannot be computed for 2006, the comparative periods are 2007 versus 2016.
Source: Authors' calculations

3. Intrasubregional Integration Index

3.1. Construction of Intrasubregional Integration Indexes

The analysis in the preceding section pertained to the integration of each subregion relative to the entire Asian region. That is, the subregional indexes were computed by averaging the scores of the countries in each subregion. Therefore, strictly speaking, the subregional indexes represent a subregion's average regional integration with Asia (intraregional integration). For example, Northeast Asia's integration score would represent the average integration of all countries in Northeast Asia with Asia, rather than integration taking place among the countries of Northeast Asia.

This section computes intrasubregional integration indexes to gauge the extent of integration within each subregion. Specifically, it takes advantage of bilateral data to measure integration among economies within a particular subregion, where the panel data offers sufficient observations to compute the PCA weights for the selected subregion.

Table 2 lists the countries in Northeast Asia, Southeast Asia, and South Asia, respectively, for each of which we were able to compute the overall intrasubregional index and/or dimensional subindexes. Table 3 compares the panel PCA-derived

weights for intra-subregional indexes for the three subregions, with reference to the PCA-derived weights for the entire Asian region. While institutional and social integration received the greatest weight for the whole of Asia, movement of people and trade and investment were apportioned the most weight for Southeast and South Asia, respectively. Meanwhile, institutional and social integration received the lowest weight for Northeast Asia. This could reflect the perceived weaker degree of regionalism (or institution-led integration) relative to regionalization (or market-driven integration) in Northeast Asia. As typically observed in the literature, the simultaneous existence of disparate political and economic systems—ranging from mature-democratic systems (Japan and the Republic of Korea), transition or emerging market economies (the PRC, Mongolia, and the Russian Federation) to socialist systems (the DPRK) has constrained formal integration efforts in the subregion (Pempel 2007 and UNESCAP 2017).

Table 2: Intrasubregional Integration Index—Country Coverage

Northeast Asia	Southeast Asia	South Asia
People's Republic of China	Cambodia	Bangladesh
Japan	Indonesia	India
Republic of Korea	Lao People's Democratic Republic	Maldives
Mongolia	Malaysia	Nepal
Russian Federation	Philippines	Pakistan
Democratic People's Republic of Korea	Singapore	Sri Lanka
	Thailand	
	Vietnam	

Source: Authors' compilation.

Table 3: Panel PCA-derived Weights—Asia Intraregional versus Intrasubregional Integration Indexes

Dimension	Intraregional Integration Index	Intrasubregional Integration Index		
	Asia	Northeast Asia	Southeast Asia	South Asia
Trade and investment	0.179	0.203	0.167	0.139
Money and finance	0.122	0.159	0.170	0.179
Regional value chain	0.170	0.155	0.154	0.155
Infrastructure and connectivity	0.161	0.184	0.175	0.165
Movement of people	0.179	0.163	0.186	0.181
Institutional and social integration	0.189	0.136	0.148	0.179
Sum	1.000	1.000	1.000	1.000

Source: Authors' calculations.

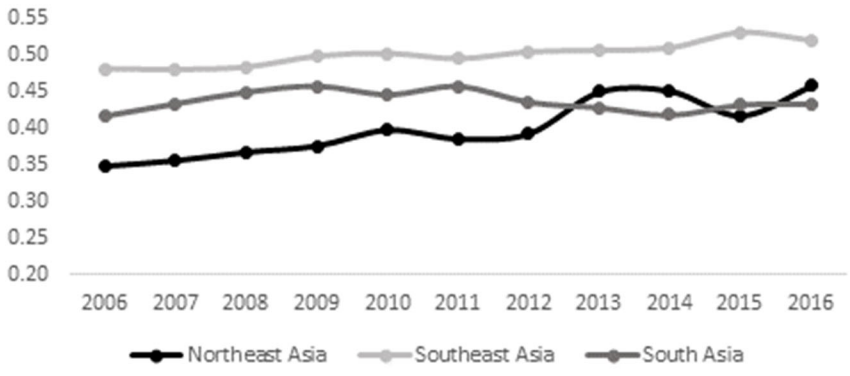
3.2. Overall and Dimensional Intrasubregional Integration Index over Time

Figure 6 shows that Southeast Asia is the most integrated, scoring the highest degree of intrasubregional integration across the sample period. South Asia ranks second, although it was outpaced by Northeast Asia in 2013, 2014, and 2016. In general, intrasubregional dimensional subindexes were most stable for Southeast Asia, suggesting more mature regional integration (Figure 7).

Integration within Northeast Asia made visible advances in money and finance, regional value chain, infrastructure and connectivity, and institutional and social integration. It took the lead in intrasubregional integration in infrastructure and connectivity beginning 2011, after which the sub-index rose steadily until it plateaued in 2014. This could reflect the rapid increase in cross-border connectivity (particularly maritime transport) in the subregion (UNESCAP 2017).

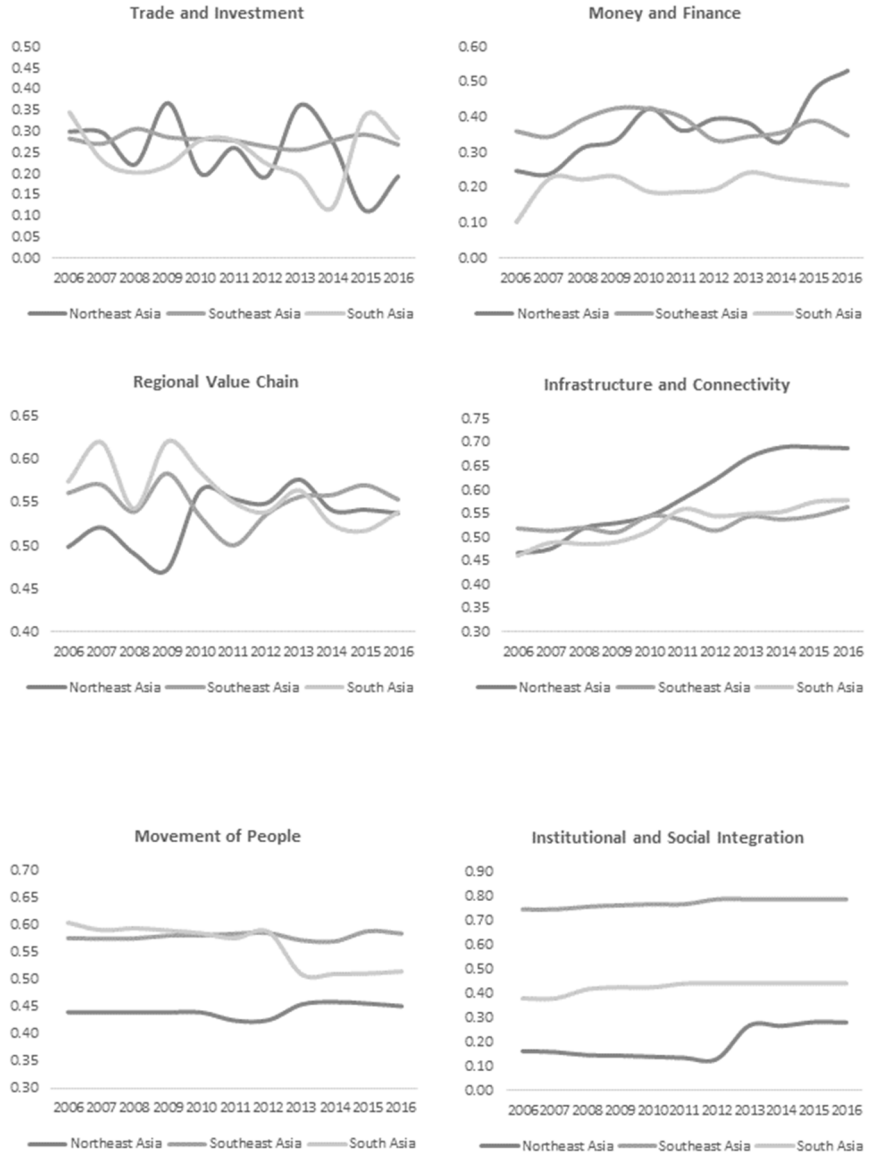
Southeast Asia clearly dominated institutional and social integration, as it institutionalized its integration efforts through the Association of Southeast Asian Nations (ASEAN) and ASEAN Economic Community. South Asia, which has a formal RCI mechanism through the South Asian Association for Regional Cooperation (SAARC), came second. Northeast Asia, however, trailed the other two subregions in institutional and social integration due to lack of a formal, government-led single regional cooperation and integration entity similar to ASEAN in Southeast Asia, SAARC in South Asia, the Eurasian Economic Community in Central Asia, and the Pacific Islands Forum in the Pacific (UNESCAP 2017).

Figure 6: Intrasubregional Integration Indexes, 2006–2010—Northeast Asia, Southeast Asia and South Asia



Source: Authors' calculation

Figure 7: Intrasubregional Integration Indexes, 2006–2010—Northeast Asia, Southeast Asia and South Asia

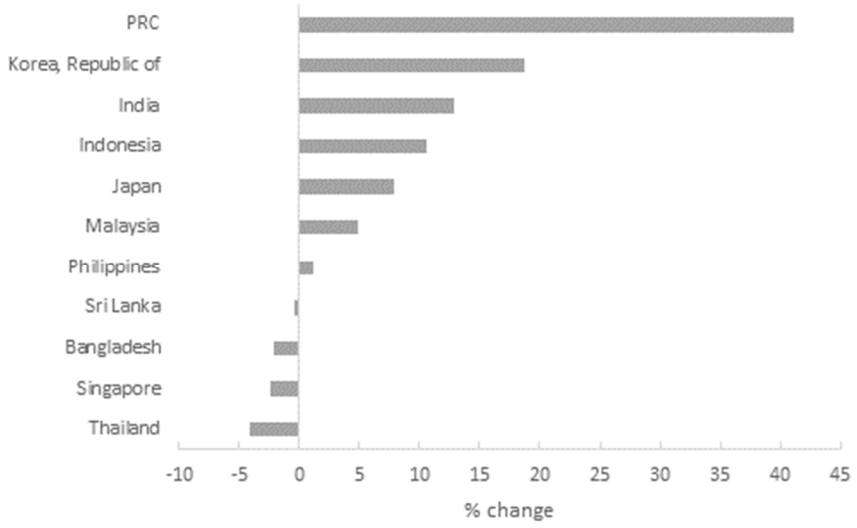


Source: Authors' calculations.

3.3. Leaders in Intrasubregional Integration

The PRC has advanced most in intrasubregional integration, with the index increasing more than 40%. Three out of six Northeast Asian economies (the PRC, Republic of Korea, and Japan) made it into the top five movers in intrasubregional integration, contributing to greater integration within the subregion (Figure 8). Indonesia, Malaysia, and the Philippines also made progress on integration within their own subregion, Southeast Asia.

Figure 8: Intrasubregional Integration Indexes, 2016 versus 2006—Selected Asian Economies

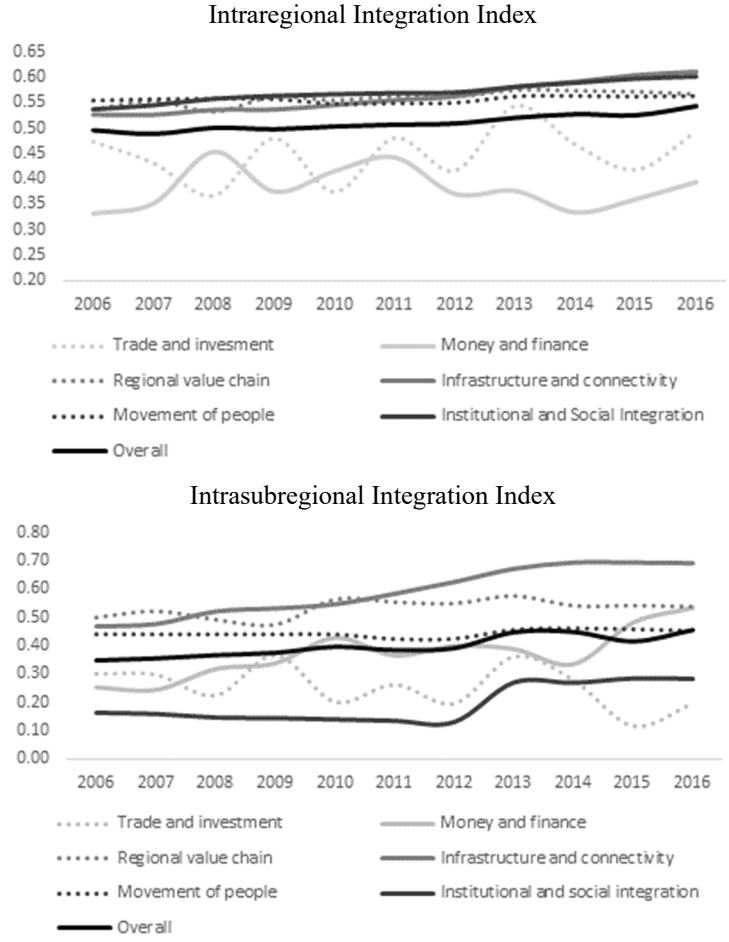


PRC = People's Republic of China.
Source: Authors' calculations.

4 Integration in Northeast Asia

This section looks closer at the integration trends and patterns for Northeast Asia, within and beyond the subregion. Northeast Asia's overall integration with the entire Asian region improved steadily during 2006–2016 (Figure 9). Expanding regional integration in Northeast Asia appears to be driven by infrastructure and connectivity and institutional and social dimensions, closely followed by regional value chain and movement of people. Within Northeast Asia, the pace of economic integration also gathers momentum, especially driven by infrastructure and connectivity as well as institutional and social integration.

Figure 9: Intraregional versus Intrasubregional Overall Index and Dimensional Subindexes—Northeast Asia



Source: Authors' calculations.

First, significant improvements in transport connectivity and logistics (specifically in the PRC, Japan, and the Republic of Korea) have spurred Northeast Asia's intraregional integration in recent years. For instance, the subregion is home to seven of the top-ten container ports in the world. Moreover, improved air transport connectivity in Northeast Asia has led to higher volumes of passenger and cargo transported by air as more low-cost carriers entered the market, flight frequencies significantly increased, and country investment in new and existing airports rose equally over the last decade. Trade and investment integration is also advancing as Northeast Asia increasingly trades with Southeast Asia and the rest of Asia by deep-

ening and expanding its regional production network. Intra-Asian foreign direct investment has also been growing, with Northeast Asia emerging as a major investor in Southeast Asia.

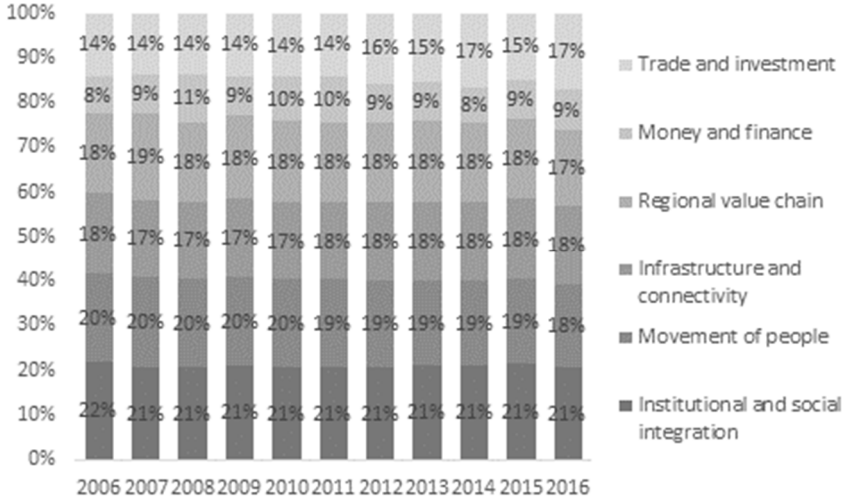
Northeast Asia's high degree of institutional and social integration with Asia could be attributed to the ASEAN+3 process involving the major economies in the subregion (the PRC, Japan, and the Republic of Korea) undertaken in the wake of the 1997 Asian financial crisis. The process has since broadened regionwide cooperation initiatives to include trade, investment, finance, tourism, food, minerals, information and communications technology, energy, environment and sustainable development (UNESCAP 2017). Moreover, "Plus Three" economies have intensified formal regional cooperation efforts with other Asian economies (particularly through free trade agreements) as a continuation of the deregulation and structural reforms that had been pursued in the 1990s.

Conversely, at the subregional level, institutional and social integration scored lowest over the sample period compared to other dimensions. Development gaps and socio-political disparities among Northeast Asia's member economies have limited the subregion's formal integration initiatives that could have steered the creation of an institution-driven intrasubregional regional cooperation and integration entity. Meanwhile, as at the regional level, infrastructure and connectivity led intrasubregional integration in Northeast Asia (Figure 9, lower panel). The said dimension likewise contributed the most to the overall intrasubregional integration index for Northeast Asia (Figure 10, lower panel) on the back of improvements in intrasubregional connectivity. For instance, direct shipping services, transshipment and transport operations through hub ports, and enhanced port development and management have strengthened connectivity among the subregion's coastal economies.

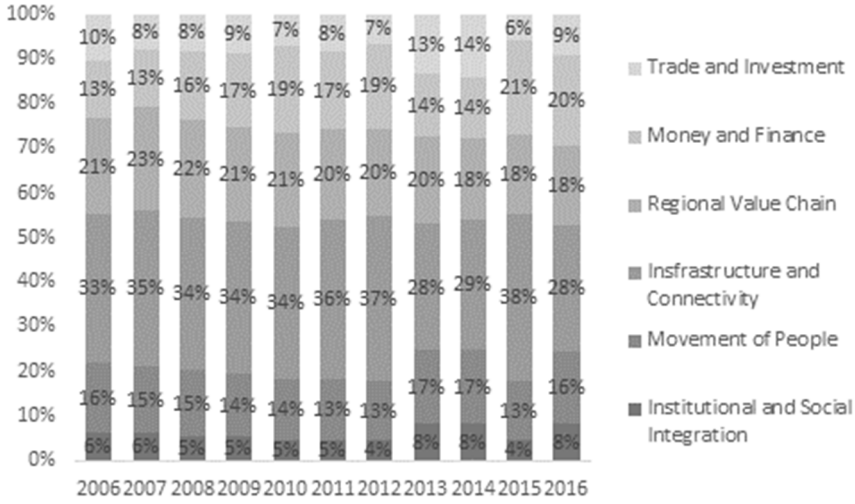
Northeast Asia's subregional trade and investment integration shows a diverging pattern from its broader regional integration. As the Northeast Asian economies continue to geographically expand their trade and investment activities, the subregional level of trade and investment integration is trending down. A similar pattern is reflected in the steady pace of regional value chain integration within Northeast Asia.

Figure 10: Dimensional Contribution to Intraregional and Intrasubregional Integration Index—Northeast Asia

Dimensional Contribution to Intraregional Integration Index



Dimensional Contribution to Intrasubregional Integration Index



Source: Authors' calculations

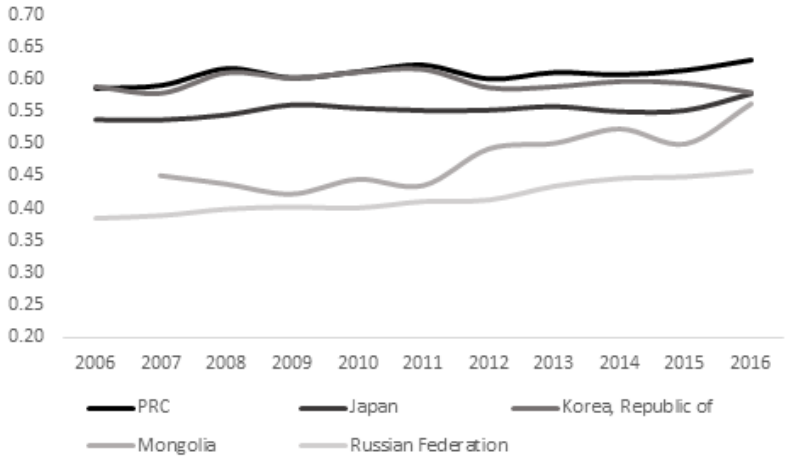
4.1. Performance of Northeast Asian Economies

As shown in Figure 11, the PRC displayed the highest degree of integration with the Asian region, closely followed by the Republic of Korea, then Japan. Mongolia has been steadily gaining ground, while the Russian Federation appears to lag

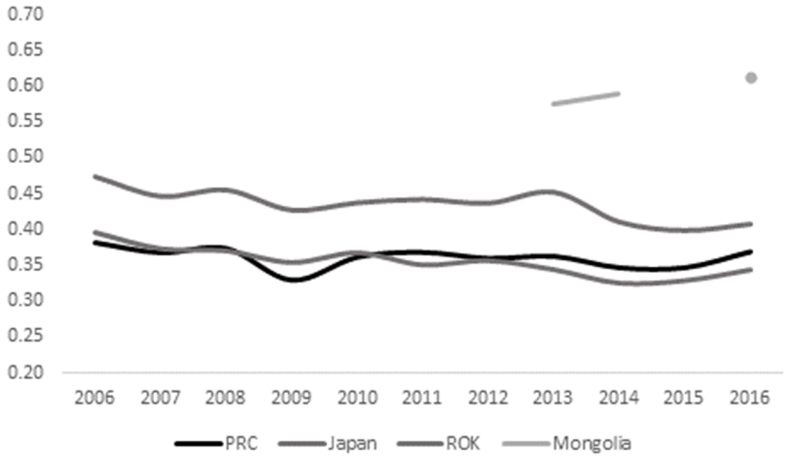
behind other Northeast Asia economies on overall integration with Asia. At the intrasubregional level, the Republic of Korea—with the highest overall intrasubregional index—appears to be the most integrated with Northeast Asia. Japan and the PRC follow and closely track each other. Meanwhile, only three data points are available for Mongolia (2013, 2014, and 2016) due to data limitations.

Figure 11: Intraregional and Intrasubregional Integration Indexes—Northeast Asian Economies

Intraregional Integration Index



Intrasubregional Integration Index



PRC = People's Republic of China, ROK = Republic of Korea.
Source: Authors' calculations

4.2. Intraregional versus Intrasubregional Integration: Country-Level Analysis

Using the trends and patterns derived from the ARCII and the intrasubregional integration indexes, we analyze the degree of Northeast Asia's integration with Asia relative to its integration within the region on a per-country basis. Due to data constraints, both overall intraregional and intrasubregional indexes could only be computed for the PRC, Japan, the Republic of Korea, and Mongolia. Nevertheless, we were able to compile several dimensional subindexes for the Russian Federation and the DPRK that could offer insights into how intraregional integration compares with intrasubregional integration for the two countries in trade and investment, money and finance, regional value chain, and infrastructure and connectivity.

Among Northeast Asian economies, the PRC, Japan, and the Republic of Korea show an expansion of regional integration beyond their own subregion; that is, the level of the economy's regional integration is significantly higher than its intrasubregional integration and the gap is widening. Though the data is incomplete, Mongolia shows an opposite trend, with its subregional integration higher than its broader regional integration. The available subindexes for the DPRK and the Russian Federation also suggest more narrowly based subregional integration than broader regional integration.

The PRC has been more integrated with Asia than with its Northeast Asian neighbors through the years (Figure 12). The wedge between the PRC's intraregional and intrasubregional integration is most apparent along the dimensions of trade and investment, movement of people, and institutional and social integration. Similarly, Japan exhibited stronger intraregional than intrasubregional linkages, particularly in trade and investment, movement of people, and institutional and social integration. The widening gap between Japan's regional and subregional integration also suggests a more open approach in its regional integration trend.

The Republic of Korea's intraregional index likewise shows consistently higher magnitude than its intrasubregional index throughout the sample period. Noteworthy are the wide gaps between the intraregional dimensional subindexes for trade and investment and institutional and social integration and their intrasubregional counterparts.

On the other hand, Mongolia—despite having only three data points for its overall intraregional index—appears to be more integrated with Northeast Asia than with Asia as a whole, as shown by the higher values of intrasubregional integration index relative to the overall intraregional integration index. Mongolia's greater linkage with Northeast Asia than Asia partly reflects the country's dependence on the subregion, particularly with the PRC, for its external trade. This is depicted by the generally higher magnitude of intrasubregional sub-index for the trade and investment dimension relative to the intraregional sub-index. In addition, Mongolia's trade and investment sub-index, both at the intraregional and intrasubregional levels, depicts an erratic pattern. This illustrates the vulnerability of the country's natural resource exports to the "boom-bust" cycle of international commodity prices.

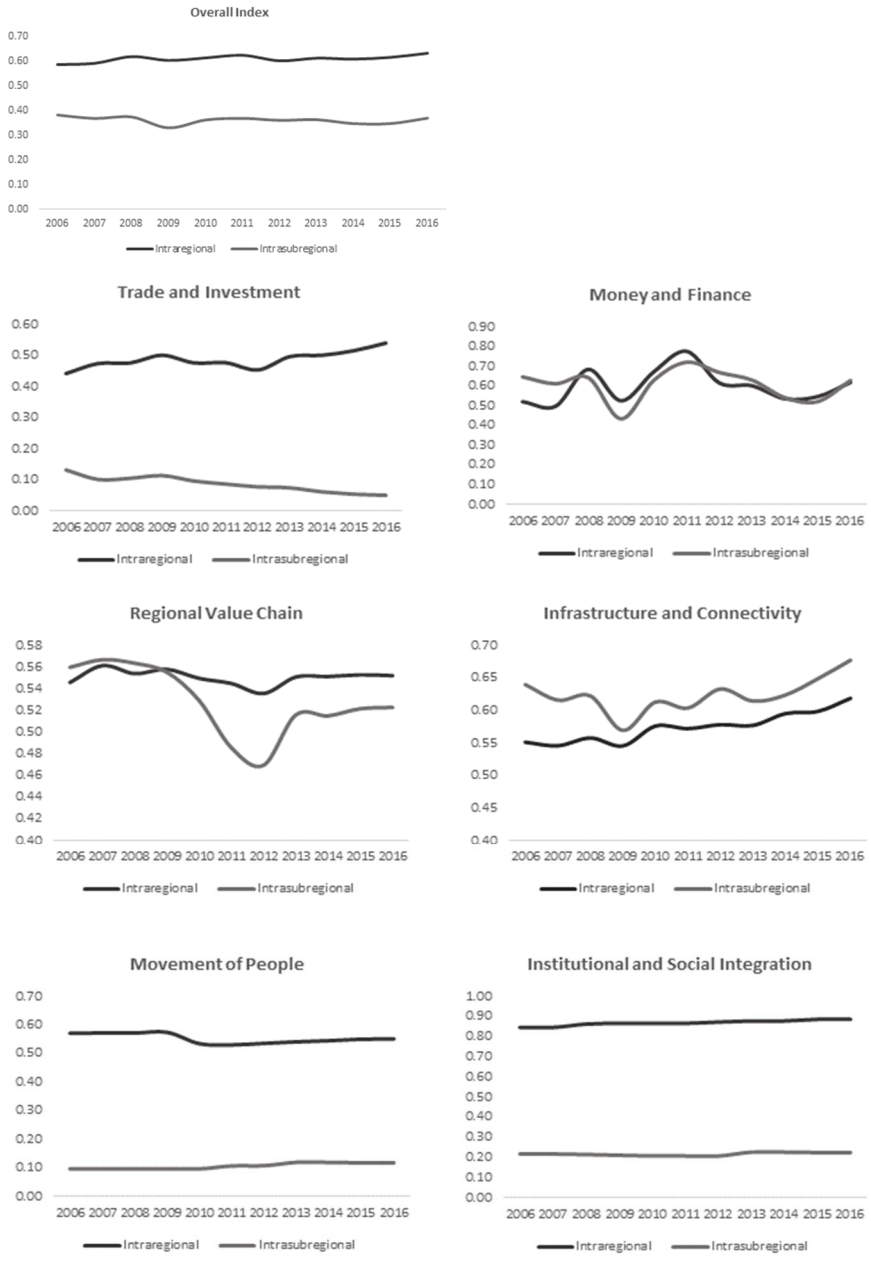
While the overall intraregional and intrasubregional indexes could not be compiled for the Russian Federation due to data constraints, the country showed greater linkages with Asia than with Northeast Asia on trade and investment and regional value chain. Nevertheless, the intraregional and intrasubregional subindexes for trade and investment both displayed a rising trend beginning in 2013, plausibly reflecting the Russian Federation's recent pivot to Asia, as a way to diversify the former's export market.

The absence of official statistics for the DPRK yielded an incomplete series for the trade and investment dimension. Nonetheless, the subindexes depict close levels of intraregional and intrasubregional integration in the said dimension. Meanwhile, the DPRK appears to have more stable integration with Asia than with its subregional counterparts on regional value chain.

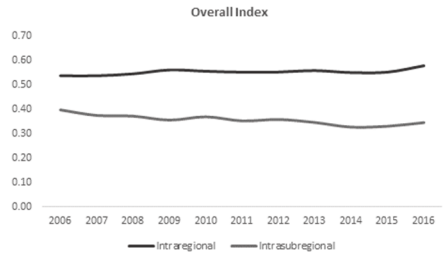
Overall, the country level analysis reveals a broadening geographic coverage in regional integration among the more developed economies in Northeast Asia as opposed to a more narrowly based subregional integration among its less developed economies. Greater integration at a wider regional level in the PRC, Japan, and the Republic of Korea is driven by trade and investment, movement of people, and institutional and social integration, reflecting that they are actively broadening their markets and suppliers as well as trade orientation. For the PRC, Mongolia, and the Russian Federation, the progress of infrastructure and connectivity is quite noticeable. Lower-income economies appear to employ subregional integration as a stepping stone to broader regional integration, based on the establishment of regional value chain as well as infrastructure and connectivity.

Figure 12: Country-Level Overall and Dimensional Indexes, Intraregional versus Intrasubregional—Northeast Asian Economies

People's Republic of China

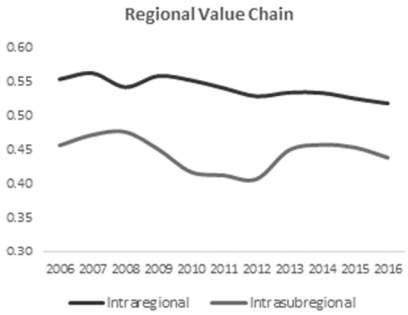


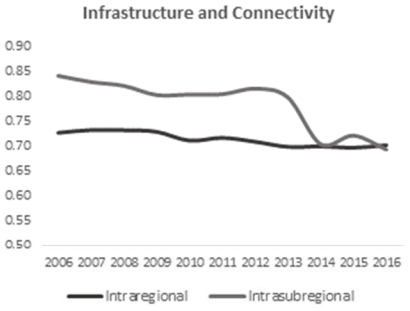
Japan

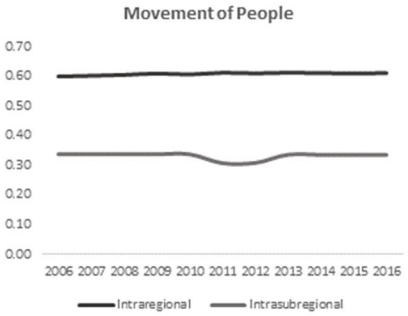

Overall Index
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Intraregional
Intrasubregional


Trade and Investment
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Intraregional
Intrasubregional


Money and Finance
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Intraregional
Intrasubregional

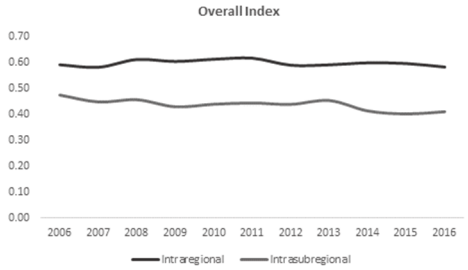

Regional Value Chain
0.60
0.55
0.50
0.45
0.40
0.35
0.30
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Intraregional
Intrasubregional

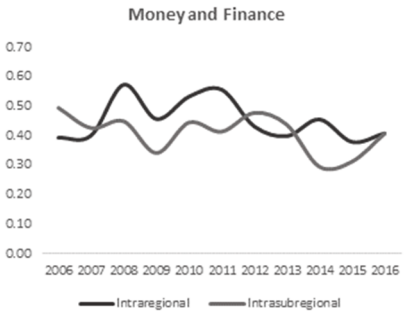

Infrastructure and Connectivity
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Intraregional
Intrasubregional

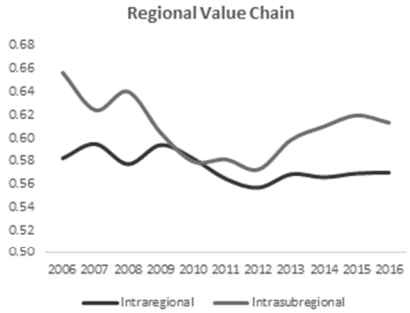

Movement of People
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Intraregional
Intrasubregional

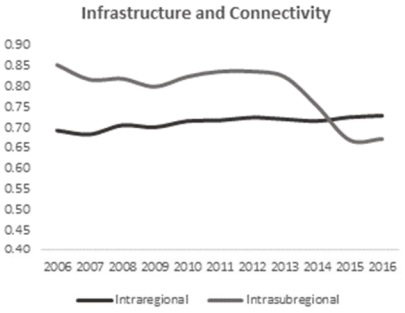

Institutional and Social Integration
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Intraregional
Intrasubregional

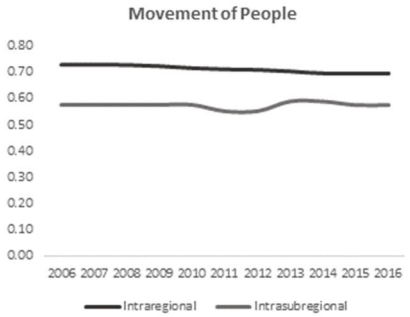
Republic of Korea

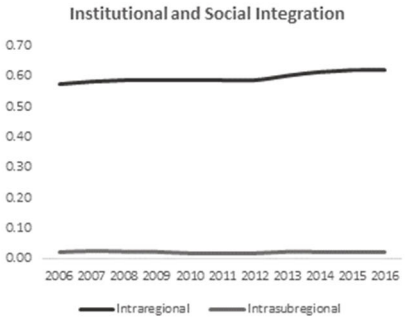




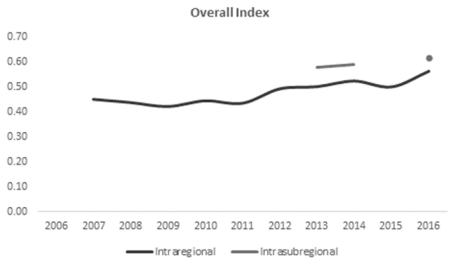




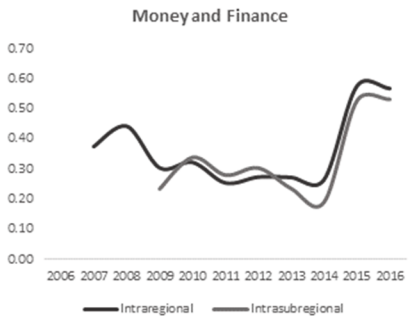


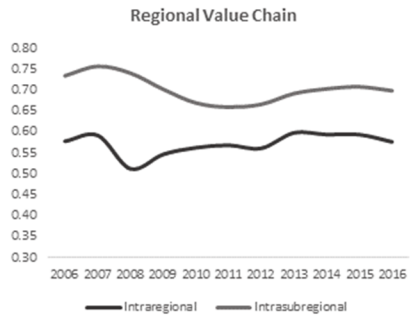


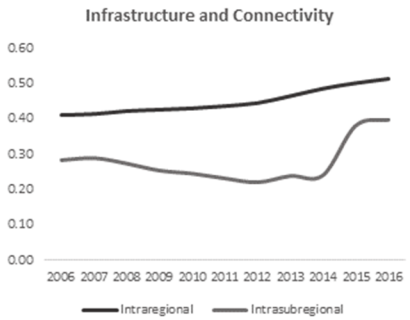
Mongolia

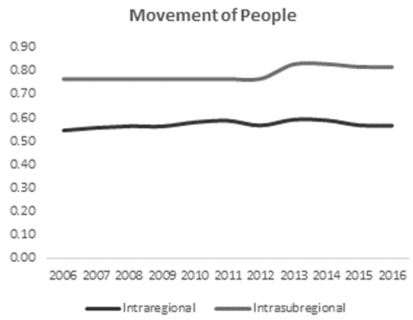

Overall Index
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Intraregional
Intrasubregional


Trade and Investment
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Intraregional
Intrasubregional


Money and Finance
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Intraregional
Intrasubregional

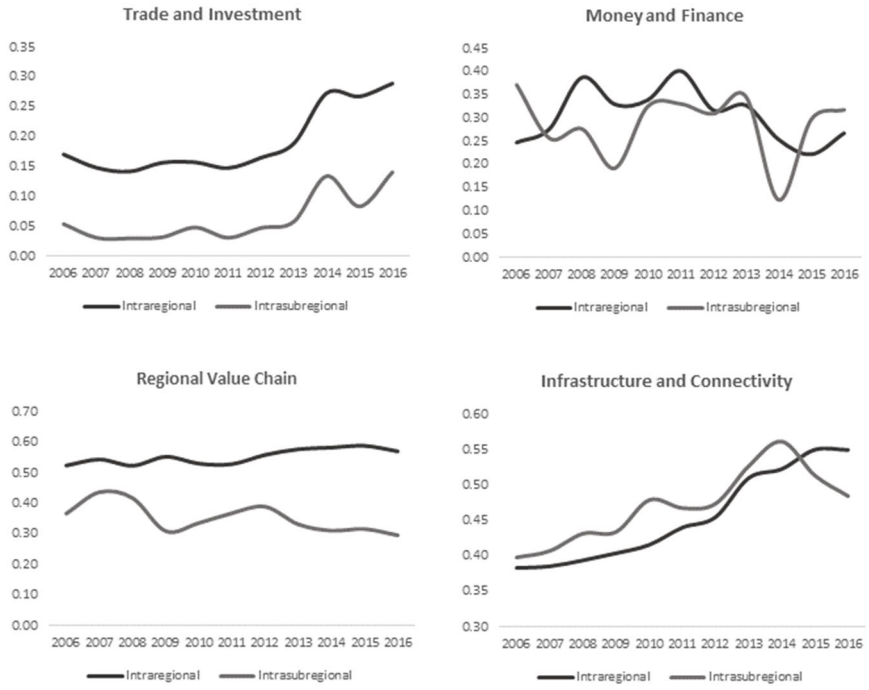

Regional Value Chain
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Intraregional
Intrasubregional


Infrastructure and Connectivity
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Intraregional
Intrasubregional

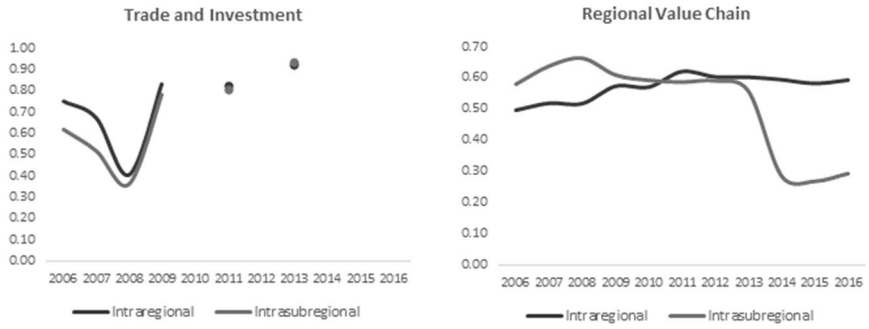

Movement of People
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Intraregional
Intrasubregional


Institutional and Social Integration
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Intraregional
Intrasubregional

Russian Federation



Democratic People's Republic of Korea



DPRK = Democratic People's Republic of Korea.
Source: Authors' calculations.

5 Conclusion

From the evidence presented in this paper, the Asia-Pacific Regional Cooperation and Integration Index indicates that the pace of integration in Asia was modest

during the 11-year sample period. Nevertheless, most economies in the sample strengthened regional integration from 2006 to 2016. Of the six dimensions of ARCII, infrastructure and connectivity, trade and investment, and movement of people appeared to drive regional integration judging from the magnitudes of their dimensional scores, and their dimensional contribution to the overall index. Money and finance proved the weakest dimension in overall integration in Asia; its panel-PCA derived weight was lowest and its contribution to overall ARCII was smallest.

The paper's use of the composite index approach in assessing regional integration in Asia and the Pacific reflects the composite index's power in identifying key trends in regional integration, identifying the strongest and weakest dimensions, and benchmarking performance across subregions. In particular, the analysis here expanded the index to cover other Northeast Asian economies such as the Democratic People's Republic of Korea and the Russian Federation.

On average, Southeast Asia is most integrated with Asia as a whole, while Northeast Asia has been catching up in recent years. Central Asia is the least regionally integrated. When computed for the subregions, Southeast Asia likewise takes precedence over Northeast Asia and South Asia overall, particularly along the dimension of institutional and social integration.

An in-depth analysis of the Northeast Asian subregion indicates that infrastructure and connectivity, as well as institutional and social integration, drive the subregion's integration with all of Asia. This reflects the subregion's significant progress in facilitating cross-border connectivity and advancing the ASEAN+3 process.

By contrast, integration within the subregion is lowest on institutional and social integration, suggesting a dearth of formal integration mechanisms in Northeast Asia.

Finally, the country level analysis suggests different patterns of regional integration between more developed and less developed economies in Northeast Asia. Higher-income economies (such as the PRC, Japan, and the Republic of Korea) in general show broader regional integration than more narrowly based subregional integration in the DPRK and Mongolia. The Russian Federation, albeit less integrated with Asia or Northeast Asia than other Northeast Asian economies, is making some progress, as its trade and infrastructure is increasingly connected with the region.

These results suggest significant policy implications for countries trying to strengthen cooperation and deepen economic integration in Asia. While the region has made gradual progress in overall regional integration, uniform progress has not been observed across the different dimensions. Money and financial integration has tended to fall short of trade and investment and movement of people throughout the region. Meanwhile, for Northeast Asia, subregional integration appears to be market-driven rather than institution-led. These features call for greater policy cooperation to ensure the region's overall stability. To achieve more balanced financial, social, and institutional integration across the region, collective efforts are needed

to remove national barriers to regional integration, adopt regional standards, and institutionalize regional integration frameworks.

The Asia-Pacific Regional Cooperation and Integration Index (ARCII) employs 26 socioeconomic indicators categorized into six different dimensions to measure the diversity of regional cooperation and integration efforts. All indicators are based on bilateral data, as regional integration is expressed as a ratio of the intraregional sum (or average) to total sum (or average) of cross-border economic activity. There are three exceptions: indicator II-d (pair-wise correlation of equity returns) takes the difference between intraregional and total averages, whereas indicators IV-c (Logistics performance index) and IV-d (Doing Business Index) reflect national levels due to data availability.

The ARCII was constructed using the following steps and procedures. First, minimum-maximum scaling is used to normalize all indicators which convey quantitatively different information in different measurement units. The normalized indicators range between 0 and 1, with higher values denoting greater regional integration. Second, principal component analysis (PCA) is performed to calculate the weights for each component to aggregate them into a single composite index. A two-step procedure is used for the ARCII: (i) to perform PCA on the indicators in each dimension to construct a composite index for each of the six dimensions; and (ii) to use PCA again to combine the six composite indexes into an overall ARCII index.

Imputation of Missing Data

In filling data gaps, indicator V-a (proportion of intraregional outbound migration to total outbound migration) is interpolated using bilateral migration data published every five years. For indicator V-c (Logistics Performance Index), available data in even years is averaged to impute missing data for the odd years in between.

Regression imputation is employed for several indicators that lack data for specific countries such as IV-a (regional and global average trade cost ratio), IV-c (Logistics Performance Index) and IV-c (Doing Business Index).

Meanwhile, in lieu of linear extrapolation, missing observations at the beginning or end of a series are substituted by the closest observation available. In particular, the last non-missing observation is carried backward (forward) in the case of missing observations at the beginning (end) of a series.

Normalization

Panel normalization is employed to maintain the time consistency of the index. Each individual indicator x_{qc}^{t} of type q for a country c and time t, is transformed into:

$$I_t = \frac{x_{qc}^t - min_{t\in T} min_c(x_q^t)}{max_{t\in T} max_c(x_q^t) - min_{t\in T} min_c(x_q^t)}$$

where the minimum and maximum values for each indicator are calculated across countries and time. The values of I_t range from 0 to 1, with higher values denoting greater integration. For indicators where higher values of the original variable imply lower integration, such as II-c (pairwise dispersion of deposit rates), III-b (average trade concentration ratio) and IV-a (average trade cost ratio), the transformation is given as:

$$I_t = 1 - \frac{x_{qc}^t - min_{t\in T} min_c(x_q^t)}{max_{t\in T} max_c(x_q^t) - min_{t\in T} min_c(x_q^t)}$$

Hence, the minimum and maximum for each indicator are calculated across countries and time to allow for the evolution of the indicators and the resulting composite index.

One of the drawbacks of min-max scaling is that extreme values could distort the distribution of normalized values. This could also understate/overstate the resulting composite index. To prevent outliers from exerting undue influence over the normalized indicators and the composite index, the normalized data is transformed according to the inclusive percentile ranking of the raw indicators.

Normalization can also be carried out on a regional or worldwide basis. Regional normalization utilizes minimum and maximum values within a region (e.g. Asia, Africa, European Union and Latin America and the Caribbean). This is a standard approach to measure and compare the integration levels of member countries in the region. However, it is possible that each region has very different maximum and minimum values. As a result, the constructed regional indexes can have different bases, and this could make comparison across regions obscure and unappealing. To have a more direct comparison between different regions, a more appropriate normalization method would be worldwide normalization, i.e. normalizing indicators using world maximum and minimum values for all regions. An obvious advantage is that the constructed regional indexes can be compared at the same base.

Weighting and Aggregation

Weighting and aggregation of data continues to be guided by the goal of improving comparability by utilizing all information at hand. The most important source of incomparability is said to be the systemic statistical properties of the index components that affect weighting (UNCTAD 2007). To avoid this issue, reference weights must be applied to all the years in the sample period, in turn, making comparison of the composite index across the years possible.

PCA is the main statistical tool to obtain the weights utilized for compiling the ARCII. In this paper, a panel PCA estimation is carried out to obtain time-consistent weights for aggregation. Following Park and Claveria (2018), the data vector $X = (x_1, x_2, \ldots, x_Q)$ denotes a multidimensional data vector $X_{TxQ} = (x_1^t, x_2^t, \ldots, x_Q^t)$, $t = 1, \ldots, T$, where T is the total number of periods and Q is the number of indicator (dimensions). Let Σ_{QxQ} be the correlation matrix of X_{TxQ}. The principal component (PC), Z_i^t, $i = 1, 2, \ldots, Q$, $t = 1, \ldots, T$, is defined as

$$Z_1^t = a_{11}x_1^t + a_{12}x_1^t + \cdots + a_{1Q}x_1^t$$

$$Z_2^t = a_{21}x_1^t + a_{22}x_1^t + \cdots + a_{2Q}x_1^t$$

$$Z_Q^t = a_{Q1}x_1^t + a_{22}x_1^t + \cdots + a_{QQ}x_1^t$$

Or in matrix form, $Z = A'X_{TxQ}$ where $A = (a_1, a_2, \ldots, a_Q)$. The coefficient matrix A maximizes the variance of $Z = E(ZZ') = A'\Sigma A$ subject to the following constraints:

$a_1'a_1 = a_2'a_2 = \cdots = a_Q'a_Q = 1$ (unit vector length) and

$cov(a_i'x, a_j'x) = 0$, $i \neq j$ (orthogonality condition)

The solution to the eigenvalue-eigenvector problem resulting from the above constrained maximization problem is λ_i, which is equal to the variance of Z. Moreover, $\lambda_1 > \lambda_2 > \cdots > \lambda_Q$.

Suppose that the first two principal components (Z_1 and Z_2) are sufficient to characterize the data variation. Correlation coefficients between X and Z are called *loadings* and are given as Corr(x_i, Z_j)= $\rho_{ij} = e_{ij}\sqrt{\lambda_j}$, i=1, 2, 3, 4, and j=1 and 2, where e_{ij} is the i^{th} element of the eigenvector j (For a derivation, see Johnson and Wichern, 2007, p. 433). The square of loadings, ρ_{ij}^2, represents the proportion of variance in variable x_i, explained by the principal component Z_j. As $\sum_{i=1}^4 e_{i1}^2 = \sum_{i=1}^4 e_{i2}^2 = 1$, the sums of squared loadings of Z_1 and Z_2 are λ_1

and λ_2, which are the variances of Z_1 and Z_2, respectively. Using this, we normalized the squared loadings to unity sum, that is, $\overline{\rho}_{ij}^2 = \rho_{ij}^2 / \lambda_j$. Finally, we constructed $\theta_j = \lambda_j / (\lambda_1 + \lambda_2)$, where *j*=1 and 2, to measure the proportion of explained variance in the data when considering only the first two principal components. θ_1 and θ_2 are the weights assigned to the respective principal components for aggregation. Hence, the composite index is

$$(\overline{\rho}_{11}^2 * \theta_1 + \overline{\rho}_{12}^2 * \theta_2) x_1 + (\overline{\rho}_{21}^2 * \theta_1 + \overline{\rho}_{22}^2 * \theta_2) x_2 + (\overline{\rho}_{31}^2 * \theta_1 + \overline{\rho}_{32}^2 * \theta_2) x_3 + (\overline{\rho}_{41}^2 * \theta_1 + \overline{\rho}_{42}^2 * \theta_2) x_4 .$$

Appendix 1: Asia-Pacific Regional Integration Index Country Coverage

Northeast Asia	**Southeast Asia**	**South Asia**	**Central Asia**	**Oceania**
PRC	Brunei Darussalam	Afghanistan	Armenia	Australia
Japan	Cambodia	Bangladesh	Azerbaijan	New Zealand
Republic of Korea	Indonesia	Bhutan	Georgia	
DPRK	Lao PDR	India	Kazakhstan	**Pacific**
Mongolia	Malaysia	Maldives	Kyrgyz Republic	Cook Islands
Russian Federation	Myanmar	Nepal	Tajikistan	Fiji
	Philippines	Pakistan	Turkmenistan	Kiribati
	Singapore	Sri Lanka	Uzbekistan	Marshall Islands
	Thailand			Micronesia, Fed. States of
	Viet Nam			Nauru
				Palau
				Papua New Guinea
				Samoa
				Solomon Islands
				Timor-Leste
				Tonga
				Tuvalu
				Vanuatu

PRC = People's Republic of China, DPRK = Democratic People's Republic of Korea, Lao PDR = Lao People's Democratic Republic.
Note: Hong Kong, China and Taipei, China are likewise included in the country coverage.
Source: Authors' calculations.

Appendix 2: Asia-Pacific Regional Cooperation and Integration Index Indicators and Data Sources

Dimension	Indicator		Data sources
I. Trade and Investment Integration	I-a	Proportion of intrasubregional goods exports to total goods exports	International Monetary Fund (IMF). Direction of Trade Statistics. www.imf.org/en/Data
	I-b	Proportion of intrasubregional goods imports to total goods imports	
	I-c	Intrasubregional trade intensity index	
	I-d	Proportion of intrasubregional Foreign Direct Investment (FDI) inflows to total FDI inflows	fDi Markets (Greenfield FDI); and Zephyr Merger and Acquisitions Database
	I-e	Proportion of intrasubregional FDI inflows plus outflows to total FDI inflows plus outflows	
II. Money and Finance Integration	II-a	Proportion of intrasubregional cross-border equity liabilities to total cross-border equity liabilities	IMF. Coordinated Portfolio Investment Survey. http://cpis.imf.org (accessed June 2016)
	II-b	Proportion of intrasubregional cross-border bond liabilities to total cross-border bond liabilities	
	II-c	Pair-wise dispersion of deposit rates averaged regionally relative to that averaged globally	CEIC; Haver Analytics; and IMF. International Financial Statistics. www.imf.org/en/Data
	II-d	Pair-wise correlation of equity returns averaged regionally minus that averaged globally	Bloomberg; Bourse Régionale des Valeurs Mobilières. http://www.brvm.org; CEIC; Eastern Caribbean Securities Exchange. http://www.ecseonline.com/; Haver Analytics; South Pacific Stock Exchange. http://www.spse.com.fj; and USZE Exchange (Uzbekistan). https://www.uzse.uz/
III. Regional Value Chain	III-a	Ratio between average trade complementarity index over regional trading partners and average trade complementarity index over all trading partners	United Nations Conference on Trade and Development (UNCTAD). UNCTADstat. http://unctadstat.unctad.org/EN/
	III-b	Ratio between average trade concentration index over regional trading partners and average trade concentration index over all trading partners	
	III-c	Proportion of intrasubregional intermediate goods exports to total intrasubregional goods exports	United Nations. Commodity Trade Database. https://comtrade.un.org/
	III-d	Proportion of intrasubregional intermediate goods imports to total intrasubregional goods imports	

Appendix 2: Asia-Pacific Regional Cooperation and Integration Index Indicators and Data Sources (continued)

IV. Infrastructure and Connectivity	IV-a	Ratio between average trade cost over regional trading partners and average trade cost over all trading partners	World Bank and United Nations Economic and Social Commission for Asia and the Pacific. Trade Costs Database. www.databank.worldbank.org
	IV-b	Ratio between average liner shipping connectivity index over regional trading partners and average liner shipping connectivity index over all trading partners	UNCTAD. UNCTADstat. http://unctadstat.unctad.org/EN/
	IV-c	Logistics performance index (overall)	World Bank. Logistics Performance Index. lpi.worldbank.org
	IV-d	Doing Business Index (overall)	World Bank. Doing Business 2016. http://www.doingbusiness.org
V. Movement of People	V-a	Proportion of intrasubregional outbound migration to total outbound migration	United Nations. Department of Economic and Social Affairs, Population Division. International Migration Stock 2015. http://www.un.org/en
	V-b	Proportion of intrasubregional tourists to total tourists (inbound plus outbound)	World Tourism Organization. 2016. Tourism Statistics Database.
	V-c	Proportion of intrasubregional remittances to total remittances	World Bank. Migration and Remittances Data. http://www.worldbank.org
	V-d	Proportion of other Asian countries that do not require an entry visa	International Air Transport Association. www.iata.org; national sources; Wikipedia. https://en.wikipedia.org
VI. Institutional and Social Integration	VI-a	Proportion of other Asian countries that have signed free trade agreements	Design of Trade Agreements (DESTA). www.designoftradeagreements.org
	VI-b	Proportion of other Asian countries that have an embassy	The Europa World Yearbook 2016. Europa Publications.
	VI-c	Proportion of other Asian countries that have signed business investment treaties	DESTA. www.designoftradeagreements.org; UNCTAD. Bilateral Investment Treaties. http://investmentpolicyhub.unctad.org
	VI-d	Proportion of other Asian countries that have signed double taxation treaties	UNCTAD. 2016. Country specific list of double taxation treaties. http://investmentpolicyhub.unctad.org
	VI-e	Cultural proximity with other Asian countries relative to that with all other countries	Centre d'Etudes Prospectives et d'Informations Internationales. www.cepii.fr

Appendix 3: Asia-Pacific Regional Cooperation and Integration Index Methodology

The Asia-Pacific Regional Cooperation and Integration Index (ARCII) employs 26 socioeconomic indicators categorized into six different dimensions to measure the diversity of regional cooperation and integration efforts. All indicators are based on bilateral data, as regional integration is expressed as a ratio of the intraregional sum (or average) to total sum (or average) of cross-border economic activity. There are three exceptions: indicator II-d (pair-wise correlation of equity returns) takes the difference between intraregional and total averages, whereas indicators IV-c (Logistics performance index) and IV-d (Doing Business Index) reflect national levels due to data availability.

The ARCII was constructed using the following steps and procedures. First, minimum-maximum scaling is used to normalize all indicators which convey quantitatively different information in different measurement units. The normalized indicators range between 0 and 1, with higher values denoting greater regional integration. Second, principal component analysis (PCA) is performed to calculate the weights for each component to aggregate them into a single composite index. A two-step procedure is used for the ARCII: (i) to perform PCA on the indicators in each dimension to construct a composite index for each of the six dimensions; and (ii) to use PCA again to combine the six composite indexes into an overall ARCII index.

Imputation of Missing Data

In filling data gaps, indicator V-a (proportion of intraregional outbound migration to total outbound migration) is interpolated using bilateral migration data published every five years. For indicator V-c (Logistics Performance Index), available data in even years is averaged to impute missing data for the odd years in between.

Regression imputation is employed for several indicators that lack data for specific countries such as IV-a (regional and global average trade cost ratio), IV-c (Logistics Performance Index) and IV-c (Doing Business Index).

Meanwhile, in lieu of linear extrapolation, missing observations at the beginning or end of a series are substituted by the closest observation available. In particular, the last non-missing observation is carried backward (forward) in the case of missing observations at the beginning (end) of a series.

Normalization

Panel normalization is employed to maintain the time consistency of the index. Each individual indicator x_{qc}^{t} of type q for a country c and time t, is transformed into:

$$I_t = \frac{x_{qc}^t - min_{t\in T} min_c(x_q^t)}{max_{t\in T} max_c(x_q^t) - min_{t\in T} min_c(x_q^t)}$$

where the minimum and maximum values for each indicator are calculated across countries and time. The values of It range from 0 to 1, with higher values denoting greater integration. For indicators where higher values of the original variable imply lower integration, such as II-c (pairwise dispersion of deposit rates), III-b (average trade concentration ratio) and IV-a (average trade cost ratio), the transformation is given as:

$$I_t = 1 - \frac{x_{qc}^t - min_{t\in T} min_c(x_q^t)}{max_{t\in T} max_c(x_q^t) - min_{t\in T} min_c(x_q^t)}$$

Hence, the minimum and maximum for each indicator are calculated across countries and time in order to take into account the evolution of the indicators and the resulting composite index.

One of the drawbacks of min-max scaling is that extreme values could distort the distribution of normalized values. This could also understate/overstate the resulting composite index. To prevent outliers from exerting undue influence over the normalized indicators and the composite index, the normalized data is transformed according to the inclusive percentile ranking of the raw indicators.

Normalization can also be carried out on a regional or worldwide basis. Regional normalization utilizes minimum and maximum values within a region (e.g. Asia, Africa, European Union and Latin America and the Caribbean). This is a standard approach to measure and compare the integration levels of member countries in the region. However, it is possible that each region has very different maximum and minimum values. As a result, the constructed regional indexes can have different bases, and this could make comparison across regions obscure and unappealing. To have a more direct comparison between different regions, a more appropriate normalization method would be worldwide normalization, i.e. normalizing indicators using world maximum and minimum values for all regions. An obvious advantage is that the constructed regional indexes can be compared at the same base.

Weighting and Aggregation

Weighting and aggregation of data continues to be guided by the goal of improving comparability by utilizing all information at hand. The most important source of incomparability is said to be the systemic statistical properties of the index components that affect weighting (UNCTAD 2007). To avoid this issue, reference weights must be applied to all the years in the sample period. This makes the comparison of the composite index across the years possible.

PCA is the main statistical tool to obtain the weights utilized for compiling the ARCII. In this paper, a panel PCA estimation is carried out to obtain time-consistent weights for aggregation. Following Park and Claveria (2018), the data vector

$X = (x_1, x_2, \ldots, x_Q)$ denotes a multidimensional data vector $X_{TxQ} = (x_1^t, x_2^t, \ldots, x_Q^t)$, $t = 1, \ldots, T$, where T is the total number of periods and Q is the number of indicator (dimensions). Let Σ_{QxQ} be the correlation matrix of X_{TxQ}. The principal component (PC), Z_i^t, $i = 1, 2, \ldots, Q$, $t = 1, \ldots, T$, is defined as

$$Z_1^t = a_{11}x_1^t + a_{12}x_1^t + \cdots + a_{1Q}x_1^t$$
$$Z_2^t = a_{21}x_1^t + a_{22}x_1^t + \cdots + a_{2Q}x_1^t$$
$$\cdots$$
$$Z_Q^t = a_{Q1}x_1^t + a_{22}x_1^t + \cdots + a_{QQ}x_1^t$$

Or in matrix form, $Z = A'X_{TxQ}$ where $A = (a_1, a_2, \ldots, a_Q)$. The coefficient matrix A maximizes the variance of $Z = E(ZZ') = A'\sum A$ subject to the following constraints:

$a_1'a_1 = a_2'a_2 = \ldots = a_Q'a_Q = 1$ (unit vector length) and

$cov(a_i'x, a_j'x) = 0$, $i \neq j$ (orthogonality condition)

The solution to the eigenvalue-eigenvector problem resulting from the above constrained maximization problem is λ_i, which is equal to the variance of Z. Moreover, $\lambda_1 > \lambda_2 > \cdots > \lambda_Q$.

Suppose that the first two principal components (Z_1 and Z_2) are sufficient to characterize the data variation. Correlation coefficients between X and Z are called *loadings* and are given as Corr(x_i, Z_j)= $\rho_{ij} = e_{ij}\sqrt{\lambda_j}$, i=1, 2, 3, 4, and j=1 and 2, where e_{ij} is the i^{th} element of the eigenvector j (For a derivation, see Johnson and Wichern, 2007, p. 433). The square of loadings, ρ_{ij}^2, represents the proportion of variance in variable x_i, explained by the principal component Z_j. As $\sum_{i=1}^4 e_{i1}^2 = \sum_{i=1}^4 e_{i2}^2 = 1$, the sums of squared loadings of Z_1 and Z_2 are λ_1 and λ_2, which are the variances of Z_1 and Z_2, respectively. Using this, we normalized the squared loadings to unity sum, that is, $\bar{\rho}_{ij}^2 = \rho_{ij}^2 / \lambda_j$. Finally, we constructed $\theta_j = \lambda_j / (\lambda_1 + \lambda_2)$, where j=1 and 2, to measure the proportion of explained variance in the data when considering only the first two principal components. θ_1 and θ_2 are the weights assigned to the respective principal components for aggregation. Hence, the composite index is

$$(\bar{\rho}_{11}^2 * \theta_1 + \bar{\rho}_{12}^2 * \theta_2) x_1 + (\bar{\rho}_{21}^2 * \theta_1 + \bar{\rho}_{22}^2 * \theta_2) x_2 + (\bar{\rho}_{31}^2 * \theta_1 + \bar{\rho}_{32}^2 * \theta_2) x_3 + (\bar{\rho}_{41}^2 * \theta_1 + \bar{\rho}_{42}^2 * \theta_2) x_4 .$$

The weighting scheme is summarized as follows:

	Loading		Squared loading (scaled to unit sum)		Weight
	Z_1	Z_2	Z_1	Z_2	
x_1	ρ_{11}	ρ_{12}	$\bar{\rho}_{11}^2$	$\bar{\rho}_{12}^2$	$\bar{\rho}_{11}^2 * \theta_1 + \bar{\rho}_{12}^2 * \theta_2$
x_2	ρ_{21}	ρ_{22}	$\bar{\rho}_{21}^2$	$\bar{\rho}_{22}^2$	$\bar{\rho}_{21}^2 * \theta_1 + \bar{\rho}_{22}^2 * \theta_2$
x_3	ρ_{31}	ρ_{32}	$\bar{\rho}_{31}^2$	$\bar{\rho}_{32}^2$	$\bar{\rho}_{31}^2 * \theta_1 + \bar{\rho}_{32}^2 * \theta_2$
x_4	ρ_{41}	ρ_{42}	$\bar{\rho}_{41}^2$	$\bar{\rho}_{42}^2$	$\bar{\rho}_{41}^2 * \theta_1 + \bar{\rho}_{42}^2 * \theta_2$
Exp. Var.	λ_1	λ_2			
Exp/Tot	θ_1	θ_2			

REFERENCES

Asian Development Bank. 2017. Asian Economic Integration Report 2017: The Era of Financial Interconnectedness: How Can Asia Strengthen Financial Resilience? Manila.

Chowdhury, Biplob, Mardi Dungey, Moses Kangogo, Mohammad Abu Sayeed, and Vladimir Volkov. 2018. "The Changing Network of Financial Market Linkages: The Asian Experience." ADB Economics Working Papers No. 558.

Dollar, David. 1992. "Outward-Oriented Developing Countries Really Do Grow More Rapidly: Evidence from 95 LDCs, 1976–1985." Economic Development and Cultural Change 40 (3): 523–44.

——— and Aart Kraay. 2004. "Trade, Growth, and Poverty." Economic Journal 114 (493): F22–F49.

Edwards, Sebastian. 1992. "Trade Orientation, Distortions, and Growth in Developing Countries."Journal of Development Economics 39 (1): 31–57.

———. 1993. "Openness, Trade Liberalization, and Growth in Developing Countries." Journal of Economic Literature 31 (3): 1358–93.

Frankel, Jeffrey A., and David H. Romer. 1999. "Does Trade Cause Growth?" American Economic Review 89 (3): 379–99.

Harrison, Ann. 1996. "Openness and Growth: A Time-Series Cross-Country Analysis for Developing Countries." Journal of Development Economics 48 (2): 419–47.

Harrison, Ann, and Gordon Hanson. 1999. "Who Gains from Trade Reform? Some Remaining Puzzles." Journal of Development Economics 59 (1): 125–54.

Huh, Hyeon-Seung, and Cyn-Young Park. 2017. "Asia-Pacific Regional Integration Index: Construction, Interpretation, and Comparison." ADB Economics Working Papers No. 511.

_____. 2018. "Asia-Pacific Regional Integration Index: Construction, Interpretation, and Comparison." Journal of Asian Economics 54 (February).

Johnson, Richard and Wichern, Dean. 2007. Applied multivariate statistical analysis, (6th ed.) Upper Saddle River: Pearson.

Park, Cyn-Young and Racquel Claveria. 2018. "Constructing the Asia-Pacific Regional Cooperation and Integration Index: A Panel Approach." ADB Economics Working Paper Series. No. 544. Manila.

Pempel, T.J. 2007. "Northeast Asian Economic Integration: A Region in Flux." Asia-Pacific Review Volume 14, Issue 2, pp. 45.61.

Sachs, Jeffrey, and Andrew Warner. 1995. "Economic Reform and the Process of Global Integration." Brookings Papers on Economic Activity 1995(1): 1-118.

United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). 2017. Unlocking the potential for East and North-East Asian regional economic cooperation and integration. https://www.unes-

cap.org/sites/default/files/publications/Unlocking%20the%20Potential%20for%20East%20and%20North-East%20Asian%20Regional%20Economic%20Cooperation%20and%20Integration_0.pdf