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In the East Asian region, the predominant role of the USD is increasingly being challenged by the RMB. Furthermore, international trade with China has increased substantially. Against this backdrop, various types of new currency arrangements have been discussed, up to fixed exchange rates in an RMB currency bloc. This paper re-evaluates earlier literature that draws upon the classical criterion of optimal currency areas. It analyzes co-movement in quarterly real GDP data for China and 10 East Asian countries from 2000Q1 to 2021Q1. Contributions to the literature lie in the consideration of the seasonality of GDP data and the joint modeling of common cycles and common seasonal factors. The results reveal very little evidence of synchronized cycles; only at higher orders does some evidence of codependence exist for Korea, Hong Kong and Taiwan, which contrasts with earlier studies using de-seasonalized data that found more evidence of common cycles.

1. Introduction

Tighter monetary cooperation between East Asian countries and China, possibly leading up to the formation of an renminbi (RMB) currency block, has been discussed in the literature for a number of reasons: first, during the Asian crisis in 1997/8, many East Asian countries unpegged their currencies from the USD and are now working toward greater economic integration within the region. For example, institutions for policy coordination, such as ASEAN+3 and the Chiang Mai Initiative, have been introduced. Furthermore, China has begun to actively promote the spread of the RMB in international markets and has introduced clearing banks in foreign countries, swap line agreements and investment quotas. The RMB now plays a major role in international financial markets, ranking fourth among the most widely used currencies (according to SWIFT). A further reason for tighter monetary cooperation is the increased trade integration. Bilateral trade with China accounts for more than a quarter of the trade for Hong Kong, Taiwan, Macau and Korea. Finally, the Belt and Road initiative aims to enhance trade even further.

In the academic literature, in the light of these developments, the suitability of fixed exchange rate arrangements in East Asia has been discussed by Cheung and Yuen (2005) and Sato and Zhang (2006). They draw upon the classical criterion from Mundells' (1961) theory of optimal currency areas and analyze the correlation of shocks and similar responses to exogenous shocks of participating countries. The focus on the dynamics of shocks in the literature in optimal currency areas (OCA) was initiated by Beine, Candelon and Hecq (2000) and summarized in de Haan et al. (2008), who use the serial correlation common features (SCCF) test by Engle and Kozicki (1993) and Vahid and Engle (1993, 1997) to analyze whether countries show common impulse response patterns. This is in contrast to the earlier literature started by Bayoumi and Eichengreen (1993), who focus on the contemporaneous correlation of shocks. Cheung and Yuen (2005) and Sato and Zhang (2006) already applied the SCCF test to East Asian countries using seasonally adjusted data. Cheung and Yuen (2005) have analyzed China, Hong Kong and Taiwan in terms of a greater China currency union and found that the three countries indeed share common long- and short-run cyclical variations. Sato and Zhang (2006) have assessed the suitability of a monetary union in East Asia for nine Asian countries and found that a monetary union with China would be feasible for both Hong Kong and Korea.

Complex serial correlation patterns as well as both deterministic and stochastic seasonality are key features of macroeconomic data. Cubadda (1999) and Hecq (1998) argue that the seasonal adjustment of data can spuriously affect the codependence properties of time

series.[1] In this analysis, non-deseasonalized data is used, and it is shown that seasonal adjustment can indeed lead to different results, as no evidence is found for strictly common cycles and little evidence is found for less stringent forms of codependence. This differs from the results of earlier studies by Cheung and Yuen (2005) and Sato and Zhang (2006).

The first part of the analysis includes the visual inspection of seasonal GDP growth rates, autocorrelograms and correlation coefficients, which provide a first impression of the relation between China and 10 East Asian countries.[2] These preliminary analysis foreshadow the results, as they reveal only very few similarities. A more formal analysis begins with a seasonal unit root test (Hylleberg et al., 1990) and a seasonal cointegration test, by Cubadda (1999) and Lee (1992). Next, an integrated approach of estimating common serial correlation, common trends and seasonality proposed by Cubadda (1999, 2001) is implemented. This test is conducted using a two-stage least squares (2SLS) and a generalized method of moments (GMM) estimator. The results exhibit very limited evidence for common cyclical response patterns to exogenous shocks. A strict form of common cycles, a codependence of order zero, would imply perfect collinearity between the impulse response patterns but cannot be found in this dataset. The same is true for a less strict form of codependence, which allows for an asymmetric response in the first quarter. In examining codependence of orders two or three, Korea, Taiwan and Hong Kong seem to share common cyclical elements with China. However, Grimm et al. (2021) show that only the strict form of codependence is relevant for a currency union. To check for the robustness of the results, a similar test, proposed by Tiao and Tsay (1989) based on canonical correlations and a sample reduction to the pre-COVID-19 crisis period are used.

The structure of this article is as follows: Section 2 describes the institutional background behind the greater monetary cooperation in East Asia. Section 3 summarizes the literature related to this analysis, and Section 4 briefly describes the data and method used, as well as including a preliminary analysis, such as the visual inspection of seasonal real GDP growth rates and correlograms. Section 5 discusses the results of the seasonal unit root test, the seasonal cointegration test and the results of the common features test, and finally, Section 6 draws conclusions.

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[1] Among others, Ericsson et al. (1998), Ghysels et al. (1993) and Hecq et al. (2017) demonstrate that the seasonal adjustment of data can induce several serious problems in applied economic analysis.
[2] East and South East Asian countries are included in the analysis. For the sake of brevity, both groups of countries are combined under East Asian countries. The countries included in this analysis are Japan, Hong Kong, Indonesia, Malaysia, Philippines, Singapore, South Korea, Thailand, Taiwan and Macau.

2.   Institutional background

Several causes exist for greater monetary cooperation in East Asia and the focus on the RMB, which is gradually taking center stage as an anchor currency that can be summarized in two perspectives. The first is the diminishing influence of the U.S. dollar (USD) following the Asian crisis, while the second is the closer relationship with China, especially based on greater trade integration, and the now strong and independent international role of the RMB.

In response to the Asian financial crisis in 1997/8, many fixed exchange rate regimes that previously existed between Asian currencies considered in this study and the USD were dissolved. By now, the Philippines, Japan, Thailand, Korea and Indonesia have established flexible exchange rate systems, while Taiwan, Singapore, Malaysia and China use managed floating exchange rate regimes. Hong Kong maintains its fixed exchange rate regime with the USD, managed by a currency board. The Macau pataca (MOP) is pegged to the HKD and thus also indirectly to the USD. A graphical representation of the different current exchange rate regimes is shown in Panel A of Figure 1, and a more detailed description of the exchange rate regimes can be found in Appendix I.

When examining bilateral trade, it also becomes clear that the US is not the most important trading partner for the East Asian countries considered in this study. Figure 2 reveals that for each country, the bilateral trade with the US as a share of total trade of the country is lower than the bilateral trade with China. Although the influence of the USD is declining in terms of exchange rate management and bilateral trade, it has maintained its strong position on the foreign exchange market; the USD remains the most actively traded currency worldwide[3] (BIS, 2019).

FIGURE 1 HERE

FIGURE 2 HERE

A closer relationship with China and within East Asia has been fostered by the introduction of various initiatives to facilitate greater integration in the region following the Asian crisis. For instance, several institutions for policy coordination were established: the

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[3] To empirically analyze the dominant role of the USD and the emerging role of the RMB as an anchor currency, a number of studies have investigated the influence of the RMB on the implicit or explicit currency basket of Asian countries. Many build upon a method developed by Frankel and Wei (1994) to estimate the relative weights of currencies in a currency basket. Overall, the results reveal an increasing influence of the RMB over time on currencies in the Asian region, as well as globally, but to a lesser extent. The USD still clearly dominates globally, but its effects are diminishing, especially in the Asian region. See, for example, Fratzscher and Mehl (2014), Kawai and Pontines (2016), Ito (2017), McCauley and Shu (2019), Xu and Kinkyo (2019), Cai (2020), Park and An (2020).

Association of South East Asian National Plus Three (ASEAN+3) forum was founded in December 1997. Furthermore, the Chiang Mai Initiative (CMI) was introduced in 2002 as a safety net of first bilateral, then multilateral, swap agreements. In addition, ASEAN countries and China recently signed a Regional Comprehensive Economic Partnership (RCEP).

The turn toward China is particularly evident in bilateral trade. Figure 3 demonstrates that China became an increasingly important trade partner for East Asian countries over the last 40 years. In 2020, bilateral trade with China accounted for nearly 50% of Hong Kong's trade and for around 30% of Taiwan's and Macau's. A geographical overview of the countries' bilateral trade with China is shown in Panel B of Figure 1. Free trade agreements (FTA) facilitate trade between China and Hong Kong, Singapore, Taiwan and Macau, as well as between ASEAN and China. Furthermore, the Belt and Road initiative contributes to the stronger connection between the countries. Since 2013, China has been reaching agreements with countries in Asia, Africa and Europe. With the exception of Japan, all of the countries considered here are part of this campaign.

FIGURE 3 HERE

In international financial markets, the Chinese currency, the RMB, is becoming one of the most important. The RMB is now the fourth most actively traded currency worldwide after the USD, EUR and GBP. It reached this place for the first time after the announcement of the exchange rate reform in August 2015. This is remarkable considering that 3 years earlier, in August 2012, the RMB ranked 12th, and in October 2011, 17th (SWIFT, 2011, 2015).[45] Other indicators of the RMB's growing international standing are the inclusion in the Special Drawing Rights (SDR) currency basket in 2016 and the development of the RMB Globalization Index, which reached the highest level to date in January 2022.[6]

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[4] Liu et al. (2022) analyze SWIFT data in a network analysis based on a VAR framework and state that in the ASEAN+3 region in particular, the RMB already plays a major role and records large spillovers to local financial systems. In terms of global markets, however, the USD remains the primary actor.

[5] Data from the Bank for International Settlements (BIS) Triennial Surveys on Foreign Exchange Turnover also shows the increasing worldwide diffusion. The global share of RMB average daily turnover was 4.32% and 285,030 million USD in April 2019. In 2016 and 2013, the RMB's share was 3.99% and 2.23%, respectively. This is considerably more than in 2010, when RMB trading accounted only for 0.86% of total trading (BIS, 2010, 2013, 2016, 2019).

[6] The Renminbi Globalization Index, published by the Standard Chartered Bank, provides information about RMB activity across key centers (Hong Kong, Singapore, London, Taiwan, New York, Seoul and Paris). The index was launched in November 2012 and includes five parameters: (i) offshore RMB deposits outstanding, (ii) trade settlement and other international payment, (iii) outstanding issues of dim sum bonds and certificates of deposits, (iv) RMB foreign exchange turnover across specific markets and (v) foreign holdings of onshore assets. The last component was added in September 2017 to cover foreign investors' growing access to China's onshore markets (Standard Chartered, 2021).

Within the set of countries considered, most RMB trading occurs in Hong Kong (BIS, 2019). This is unsurprising because Hong Kong was the first offshore market to launch RMB trading in 2004. It is followed by Singapore and Taiwan. A graphical presentation of the share of RMB trading of each country included in this analysis is shown in Panel C of Figure 1, and an overview of the usage of the RMB in the East Asian countries' foreign exchange markets considered in this study is given in Table 1.

TABLE 1 HERE

Finally, China has introduced a number of policy measures to facilitate the use of the RMB that have contributed to RMB internationalization.[7] These measures include the introduction of the Renminbi Qualified Foreign Institutional Investor (RQFII) quota, the establishment of offshore RMB clearing banks and the conclusion of swap agreements. Of the countries considered in this analysis, Hong Kong, Korea, Malaysia, Singapore and Thailand have agreed to RQFII quotas with China. However, the investment quota was removed in 2020 to facilitate foreign investors' participation in China's financial market (SAFE, 2020). A swap line agreement has also been implemented with all countries except for the Philippines, while clearing banks have been introduced in all countries included in this study, except for Indonesia and Japan.[8] Panel D of Figure 1 shows the existence of swap line agreements and RMB clearing banks as of March 2022.

3. Literature review

While several studies have examined the synchronization of business cycles in Asia in the context of optimal currency areas using correlation or cointegration analyses,[9] only two studies that examine business cycles for common serial correlation features relate directly to this analysis. Cheung and Yuen (2005) and Sato and Zhang (2006) examine Asian countries in terms of correlated shocks and equal responses to them in the context of a monetary union using cointegration analysis and common features tests.[10]

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[7] The results of empirical studies regarding the effectiveness of the policy measures are mixed. Bilateral trade, financial linkages and the Belt and Road Initiative were identified as other drivers. See, for example, Cheung and Yiu (2017), Cheung et al. (2019), Cai (2020), Chey and Hsu (2020), Park and An (2020) and Cheung et al. (2021).

[8] Which factors force countries to introduce RMB internationalization infrastructure has also been tested empirically. These include holding RMB reserves or a trade agreement, having more developed financial markets and territorial disputes (Liao & McDowell, 2015; Chey et al., 2019).

[9] See, among others, Bayoumi and Eichengreen, (1994), Bayoumi et al. (2000), Bacha (2008), Sato et al. (2009), Sharma and Mishra (2012) and Gong and Kim (2018). Fidrmuc and Korhonen (2018) present a meta-analysis of Chinese business cycle correlations.

[10] Some studies also exist for European and Latin American countries. See, among others, Beine et al. (2000), Cubadda et al. (2013) and Trenkler and Weber (2020).

Cheung and Yuen (2005) study what is known as Greater China Region, consisting of China, Hong Kong and Taiwan, with respect to a possible currency union. They analyze seasonally adjusted real GDP data from 1994Q1 to 2002Q4. For the cointegration analysis, they use the Johansen test, proposed by Johansen (1991) and Johansen and Juselius (1990), in a multivariate setting. The null hypothesis of no cointegration relationship is rejected, and evidence for a cointegrating vector is shown. This is interpreted as evidence of synchronous long-term movements. The results of the subsequent codependence tests indicate that China, Hong Kong and Taiwan also share common business cycles.

Sato and Zhang (2006) examine the suitability of a monetary union in East Asia, in a sample from 1978Q1 to 2004Q4, and analyze seasonally adjusted real GDP for the existence of long-term co-movement in a bivariate approach also using the Johansen cointegration test. In addition, they perform a common features test following Vahid and Engle (1993) and Engle and Kozicki (1993). Sato and Zhang (2006) analyze not only relationships among Asian countries but also relationships with the US and Japan, which could be possible anchor currencies. Cointegration relationships are found between the US and most East Asian countries, as well as some between Japan and East Asian countries. Various cointegration relationships are found among East Asian countries. Furthermore, Taiwan and Hong Kong are cointegrated with China, and a subsequent codependence test reveals common features between Hong Kong and China.

Grimm et al. (2021) provide the theoretical underpinning for these approaches, formally showing that not only does the correlation of shocks matter for forming an OCA but that the common persistence of shocks is also necessary for a common monetary policy without welfare losses due to the loss of the flexible exchange rate. As such, the test for codependence is indeed the appropriate methodology. They further argue that only the strict form of codependence that captures identical impulse response patterns of shocks is relevant for OCA theory. Grimm et al. (2021) build on the theoretical setup from Berger et al. (2001) and extend it for autocorrelation to derive the results.

4. Data and preliminary analysis

In this study, quarterly real GDP data from 2000Q1 until 2021Q1 for China and 10 East and South East Asian countries[11] from the IMF IFS database, and individual country statistics

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[11] The countries are Japan, Hong Kong, Indonesia, Malaysia, Philippines, Singapore, South Korea, Thailand, Taiwan and Macau.

reporting institutions is analyzed. All GDP data is in logs of millions of RMB.[12]

This study first applies the HEGY-seasonal unit root test proposed by Hylleberg et al. (1990). Second, the data is analyzed for cointegration at different seasonal frequencies, following the approach of Lee (1992). Finally, the test for common cycles is performed.

The concept of codependence was initially introduced by Gouriéroux and Peaucelle (1988). Engle and Kozicki (1993) and Vahid and Engle (1993, 1997) introduced the notion of a common features test to analyze whether impulse response patterns to external shocks are similar across countries. The SCCF test tests for common higher-order autoregressive processes in different time series by identifying the existence of a linear combination of two variables that is free of autocorrelation. As such, it is a suitable approach to empirically test for the existence of an OCA, as shown by Grimm et al. (2021). In this analysis, the common features test for seasonally cointegrated time series introduced by Cubadda (1999) is applied, which disentangles trends and cycles from seasonality.

In principle, two distinct approaches to conducting a SCCF test exist; one is regression based, and one is based on canonical correlation analysis, similar to the Engle and Granger (1987) two-step and the Johansen (1991) multivariate approach to the cointegration test. Both the results of the Engle-Granger 2SLS and the GMM estimator are reported. The null hypothesis of the 2SLS is the existence of a SCCF. The test statistic is χ^2 distributed with the number of instruments as degrees of freedom. Following Vahid and Engle (1993), in the 2SLS approach, first the real GDP of China (C) is regressed on a set of instruments, including lagged values of both the respective Asian country (A) and China and a constant (c). The standardization of the coefficient of ΔC_t to one yields the following equation: $\Delta C_t = c + \sum \delta \Delta A_{t-p} + \beta EC_{t-1} + u_t$, where $(1 \quad \delta)$ is the common feature vector. The regression of the estimated residuals $\hat{\varepsilon}_t$ on the set of instruments is the second stage of the regression: $\hat{\varepsilon}_t = \beta + \sum \mu + \Delta C_{t-p} + \sum \eta \Delta A_{t-p} + \beta EC_{t-1} + u_t$. The GMM estimator suggested by Vahid and Engle (1997) and Cubadda (1999) minimizes the distance $Q_t(\beta) = g(\beta)'Wg(\beta)$, where W is the weighting matrix that satisfies certain conditions.[13]

Finally, as robustness analysis, the older canonical correlation-based codependence test by Tiao and Tsay (1989) is applied, which tests for $k = 1$ or $k = 2$ zero canonical correlations. The null hypothesis is that the dimension of the common feature space is at least

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[12] Quarter-end exchange rates were extracted from the Pacific Exchange Rate Service.
[13] Note that at frequency zero, the GMM and 2SLS tests are equivalent.

s. It tests for $(n-s)$ common cycles. The test statistic for codependence of order 0 $C(p,s) = -(T - P - 1)\sum_{j=1}^{8}\ln(1 - \hat{\lambda}_j^2), j = 1,2$ is χ^2-distributed with $s(np + r + s - n)$ degrees of freedom, where $\hat{\lambda}_j^2$ is the jth smallest squared canonical correlation between the first differences (Δx_t) and the set of instruments and p is the order of the SECM, and r is the number of cointegrating vectors.

Preliminary analysis

Eyeballing the real GDP data in Figure 4, one can see immediately that the growth rates of China look very different from those of the other countries. For instance, except for the beginning of the COVID-19 pandemic, negative growth rates never occur. For the other East Asian countries, one can see commonalities across countries, including the cyclical downturn and subsequent rebound after the global financial crisis in 2008/9, followed by a rebound. Of course, there are differences in the magnitude of the impact of the global financial crisis and differences in the impact and timing of the pandemic. Thus, the first impression is that the growth rates do not support the idea of common cycles.

FIGURE 4 HERE

More formally, correlations between each country's logged real GDP growth rates and China's are estimated. The estimation of correlation coefficients (Table 2) reveals mixed results. While the logged GDP growth rates from Hong Kong, Korea, Macau, Malaysia, the Philippines and Taiwan are each significantly correlated with China's logged GDP growth, Indonesia, Japan, Singapore and Thailand do not show significant correlation coefficients.

TABLE 2 HERE

The next step is the analysis of the persistence of shocks. For each country, the standard response to an exogenous shock is shown in comparison with China. The autocorrelation can be interpreted as the cyclical response pattern of each country to an exogenous shock. Again, the displayed autocorrelation functions look quite different across countries. China's autocorrelation is characterized by a positive autocorrelation for the first 23 quarters, followed by a negative autocorrelation, which becomes positive again after 71 quarters. (Figure 5).

FIGURE 5 HERE

The autocorrelation functions of the other East Asian countries show positive autocorrelations for the first 4–5 quarters, negative autocorrelations thereafter, and further ups and downs. The duration of the negative autocorrelation differs among the countries. However,

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accumulating these impulse response patterns in the GDP growth rates results in the typical up-and-down swing pattern in the associated levels of GDP around its trend. Overall, China seems to have a much longer cycle.

A further non-regression-based simple method to analyze the persistence of shocks is the estimation of half-lifes. Estimates are reported in Figure 6. The point estimates of the 10 East Asian countries and China are quite close to each other. Malaysia exhibits the shortest half-life, of 2.57 quarters and Hong Kong shows the longest half-life estimate, of 4.01 quarters. China's half-life estimate of 3.46 quarters lies in between. Thus, although China exhibits longer cycles, the largest part of the mean reversion occurs in a broadly similar timespan.

FIGURE 6 HERE

5.   Results and discussion

a)   Seasonal unit root test

The first step of the formal analysis is the seasonal unit root test by Hylleberg et al. (1990). The results of the analysis of the logged GDP data for unit roots at the zero and seasonal frequencies are reported in Table 3. Except for Indonesia and the Philippines, all time series are integrated of order one at the zero frequency. Since log-level data is used, it is plausible to find integrated series at the 0 frequency. At the frequencies π and $\frac{\pi}{2}$, all time series are stationary.[14]

TABLE 3 HERE

b)   Seasonal cointegration

The next step is the test for cointegration of the logged GDPs of the individual countries and China, at zero and seasonal frequencies. The results of the seasonal cointegration test are reported in Table 4. The optimal lag order for the bivariate VAR is derived from the AIC. The cointegration test reveals that all countries are indeed cointegrated at the zero frequency and share a common long-term trend with China. At frequency π, Japan, Malaysia, Singapore, Thailand, Korea, Hong Kong and Macau are cointegrated and also share a common stochastic seasonal trend with China.

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[14] In this analysis, all countries show unit root at the same zero and seasonal frequencies with China (except Indonesia and Philippines), which is crucial for the later analysis. Castro et al. (2021) introduce testing for cointegration if time series exhibit different roots.

The latter result is somewhat puzzling because the time series are all stationary at seasonal frequencies and cointegration can only exist if they are integrated at a specific frequency. It is conventional in the literature that the frequencies of interest are derived from a seasonal unit root test such as the HEGY test, but the cointegration test proposed by Lee (1992) does not require any prior knowledge about the presence of seasonal unit roots. Nevertheless, the HEGY test results are reported, as is frequently done in the literature.

TABLE 4 HERE

c)   Common cycles

This section analyzes whether individual Southeast Asian and East Asian countries share a common impulse response pattern to exogenous shocks with China. Table 5 summarizes the results of the SCCF test following Cubadda (1999). Both the results of the Engle-Granger 2SLS and the GMM estimator are reported. The results formally show that there is indeed not much evidence for similar reactions to shocks between China and other East Asian countries, which continues the visual impression from the previous section.

TABLE 5 HERE

The codependence of order zero column in Table 5 captures the result of identical impulse response patterns; the null hypothesis of codependence of order $q = 0$ is rejected for all countries. This means that no country shares an identical impulse response pattern with China. In addition, in terms of a codependence of order one, both estimators, the GMM and 2SLS, again reject a common but not perfectly synchronized cycle with China for all countries. In terms of a codependence of order two, Korea and Taiwan seem to share common cyclical elements with China (for at least one of the two estimators). At a codependence of order three, Korea and Hong Kong display some similarities with China.

In this analysis, no country demonstrates identical impulse response patterns with China, and also the null hypothesis of less strict codependence of order one is rejected for all countries. Common cyclical elements of codependence of orders two and three that capture very loose relationships are only robust for Korea, Taiwan and Hong Kong.

The robustness of these results is verified using an earlier canonical correlation-based version of the common features test by Tiao and Tsay (1989). Results are reported in Table 6. The columns of codependence of order zero and codependence of order one reveal that, again, the null hypothesis of the codependence of order zero and of order one is rejected. Regarding

less strict codependence orders of two or three, more countries exhibit common cyclical elements with China. At a codependence of order two, Korea, Hong Kong, Taiwan and Macau share common cyclical elements with China, and at a codependence of order three, Japan, Malaysia, Singapore, Korea, Hong Kong, Taiwan and Macau do as well.

TABLE 6 HERE

To further investigate the robustness of the main results, the sample is reduced to the period before the COVID-19 crisis, as this could critically affect the analysis. As the first cases of COVID-19 were discovered in China in December 2019, the sample used for robustness checks spans 2000Q1 to 2019Q3. Results are reported in the Appendix, and the results of the HEGY test are shown in Table A1. Except for Indonesia, which is now also integrated at the 0 frequency, this results correspond to the previously reported results. The results of the seasonal cointegration test (Table A2) reveal that fewer countries are cointegrated. Hong Kong, Korea and Macau no longer show cointegration relations with China on either the 0 frequency or frequency π. On frequency π, however, Indonesia also shares a common stochastic seasonal trend with China. The results of the previous two codependence tests (Korea, Taiwan and Hong Kong show common cyclical elements with China when considering a codependence of orders two or three) are robust also in the reduced sample. Without the influence of the COVID-19 crisis, however, more evidence exists overall for higher-order codependence for other countries as well (Tables A3 and A4).

6. Conclusion

After the Asian financial crisis of 1997/98 and the termination of many fixed exchange rate systems of Asian currencies with the USD, efforts toward more financial integration among East Asian countries have been made. Furthermore, China and its currency play an increasingly important role in international trade and financial markets. Based on this strengthened role of the RMB, different exchange rate regimes, including even an RMB currency block, have been discussed. Fixed exchange rate regimes or the adoption of a common currency may cause welfare losses, however, due to the loss of the flexible exchange rate. This is particularly true when countries react differently to shocks, and thus a common monetary policy may not be optimal for each country.

This study has thus examined whether the responses to shocks of East Asian countries are similar to that of China. This relationship has been studied previously by Sato and Zhang (2006) and Cheung and Yuen (2005). The main difference is that this study considers the seasonality

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of quarterly GDP data and does not use seasonally adjusted data. In addition, the sample used in this paper is considerably longer than that of Cheung and Yuen (2005), and the data is more recent. Previous studies find more evidence for common business cycles, which illustrates the relevance of using approaches for seasonalized data. Moreover, the results emphasize that East Asian countries do not form an optimal currency area with China from an economic perspective. The additional welfare losses from the adoption of a common currency should be considered by policymakers when forming opinions on the optimal exchange rate regime.

References

Bacha, O. I. (2008). A Common Currency Area for ASEAN? Issues and feasibility. *Applied Economics*, *40*(4), 515–529. https://doi.org/10.1080/00036840600675653

Bayoumi, T., & Eichengreen, B. (1993). Shocking aspects of European monetary integration. In *Adjustment and Growth in the European Monetary Union* (pp. 193–235). Cambridge University Press. https://doi.org/10.1017/CBO9780511599231.014

Bayoumi, T., & Eichengreen, B. (1994). ONE MONEY OR MANY? ANALYZING THE PROSPECTS FOR MONETARY UNIFICATION IN VARIOUS PARTS OF THE WORLD. In *PRINCETON STUDIES IN INTERNATIONAL FINANCE* (Issue 76).

Bayoumi, T., Eichengreen, B., & Mauro, P. (2000). On Regional Monetary Arrangements for ASEAN. *Journal of the Japanese and International Economies*, *14*(2), 121–148. https://doi.org/10.1006/jjie.2000.0446

Beine, M., Candelon, B., & Hecq, A. (2000). Assessing a Perfect European Optimum Currency Area: A Common Cycles Approach. *Empirica*, *27*, 115–132.

Berger, H., Jensen, H., & Schjelderup, G. (2001). To peg or not to peg? A simple model of exchange rate regime choice in small economies. *Economics Letters*, *73*, 161–167. www.elsevier.com/locate/econbase

BIS. (2010). *Triennial Central Bank Survey: Report on global foreign exchange market activity in 2010*. www.bis.org

BIS. (2013). *Triennial Central Bank Survey: Global foreign exchange market turnover in 2013*. http://www.bis.org

BIS. (2016). *Triennial Central Bank Survey: Global foreign exchange market turnover in 2016*. http://www.bis.org

BIS. (2019). *Triennial Central Bank Survey: Global foreign exchange market turnover in 2019*. http://www.bis.org

Cai, W. (2020). Determinants of the renminbi anchor effect: From the perspective of the belt and road initiative. *International Journal of Finance and Economics*. https://doi.org/10.1002/ijfe.2328

Cheung, Y. W., Grimm, L., & Westermann, F. (2021). The evolution of offshore renminbi trading: 2016 to 2019. *Journal of International Money and Finance*, *113*. https://doi.org/10.1016/j.jimonfin.2021.102369

Cheung, Y. W., McCauley, R. N., & Shu, C. (2019). Geographic Spread of Currency Trading: The Renminbi and Other Emerging Market Currencies. *China and World Economy*, *27*(5), 25–36. https://doi.org/10.1111/cwe.12292

Cheung, Y. W., & Yiu, M. S. (2017). Offshore renminbi trading: Findings from the 2013 Triennial Central Bank Survey. *International Economics*, *152*, 9–20. https://doi.org/10.1016/j.inteco.2017.09.001

Cheung, Y.-W., & Yuen, J. (2005). The Suitability of a Greater China Currency Union. *Pacific Economic Review*, *10*, 83–103.

Chey, H. K., & Hsu, M. (2020). The impacts of policy infrastructures on the international use of the Chinese renminbi: A cross-country analysis. *Asian Survey*, *60*(2), 221–244. https://doi.org/10.1525/AS.2020.60.2.221

Chey, H. kyu, Kim, G. Y., & Lee, D. H. (2019). Which foreign states support the global use of the Chinese renminbi? The international political economy of currency internationalisation. *The World Economy*, *42*(8), 2403–2426. https://doi.org/10.1111/twec.12794

Cubadda, G. (1999). Common cycles in seasonal non-stationary time series. *Journal of Applied Econometrics*, *14*(3), 273–291. https://doi.org/10.1002/(SICI)1099-1255(199905/06)14:3<273::AID-JAE498>3.0.CO;2-N

Cubadda, G. (2001). Common features in time series with both deterministic and stochastic seasonality. *Econometric Reviews*, *20*(2), 201–216. https://doi.org/10.1081/ETC-100103823

Cubadda, G., Guardabascio, B., & Hecq, A. (2013). A general to specific approach for constructing composite business cycle indicators. *Economic Modelling*, *33*, 367–374. https://doi.org/10.1016/j.econmod.2013.04.007

de Haan, J., Inklaar, R., & Jong-A-Pin, R. (2008). Will business cycles in the euro area converge? A critical survey of empirical research. *Journal of Economic Surveys*, *22*(2), 234–273. https://doi.org/10.1111/j.1467-6419.2007.00529.x

del Barrio Castro, T., Cubadda, G., & Osborn, D. R. (2021). On cointegration for processes integrated at different frequencies. *Journal of Time Series Analysis*. https://doi.org/10.1111/jtsa.12620

Engle, R. F., & Granger, C. W. J. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica*, *55*(2), 251–276. https://about.jstor.org/terms

Engle, R. F., & Kozicki, S. (1993). Testing for Common Features. *Source: Journal of Business & Economic Statistics*, *11*(4), 369–380.

Ericsson, N. R., Hendry, D. F., & Mizon, G. E. (1998). Exogeneity, Cointegration, and Economic Policy Analysis. *Source: Journal of Business & Economic Statistics*, *16*(4), 370–387.

Fidrmuc, J., & Korhonen, I. (2018). Meta-Analysis of Chinese Business Cycle Correlation. *Pacific Economic Review*, *23*(3), 385–410. https://doi.org/10.1111/1468-0106.12173

Frankel, J. A., & Wei, S.-J. (1994). Yen Bloc or Dollar Bloc? Exchange Rate Policies of the East Asian Economies. In T. Ito & A. Krueger (Eds.), *Macroeconomic Linkage: Savings, Exchange Rates, and Capital Flows* (Vol. 3, pp. 295–333). University of Chicago Press.

Fratzscher, M., & Mehl, A. (2014). China's Dominance Hypothesis and the Emergence of a Tri-polar Global Currency System. *Economic Journal*, *124*(581), 1343–1370. https://doi.org/10.1111/ecoj.12098

Ghysels, E., Lee, H. S., & Siklos, P. L. (1993). On the (Mis)Specification of Seasonality and its Consequences: An Empirical Investigation with US Data1. *Empirical Economics*, *18*, 747–760.

Gong, C., & Kim, S. (2018). Regional business cycle synchronization in emerging and developing countries: Regional or global integration? Trade or financial integration? *Journal of International Money and Finance*, *84*, 42–57. https://doi.org/10.1016/j.jimonfin.2018.02.006

Gouriéroux, C., & Peaucelle, I. (1988). Detecting a Long Run Relatioonship (With an Application to the P.P.P. Hypothesis). In *Economica* (No. 8902).

Grimm, L., Steinkamp, S., & Westermann, F. (2021). *Are the acceding countries ready to join the EMU? A reassessment of the evidence on business-cycle comovement* (No. 120).

Hecq, A. (1998). Does seasonal adjustment induce common cycles? In *Economics Letters* (Vol. 59).

Hecq, A., Telg, S., & Lieb, L. (2017). Do seasonal adjustments induce noncausal dynamics in inflation rates? *Econometrics*, *5*(4). https://doi.org/10.3390/econometrics5040048

Hylleberg, S., Engle, R. F., Granger, C. W. J., & Yoo, B. S. (1990). Seasonal Integration and Cointegration. *Journal of Econometrics*, *44*, 215–238.

IMF. (2007). *Review of Exchange Arrangements, Restrictions, and Controls*.

IMF. (2016). *Annual Report on Exchange Arrangements and Exchange Restrictions 2016*. www.imfbookstore.org

Ito, T. (2017). A new financial order in Asia: Will a RMB bloc emerge? *Journal of International Money and Finance*, *74*, 232–257. https://doi.org/10.1016/j.jimonfin.2017.02.019

Johansen, S. (1991). Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models. *Econometrica*, *59*(6), 1551–1580. https://about.jstor.org/terms

Johansen, S., & Juselius, K. (1990). MAXIMUM LIKELIHOOD ESTIMATION AND INFERENCE ON COINTEGRATION-WITH APPUCATIONS TO THE DEMAND FOR MONEY. *Oxford Bulletin of Economics and Statistics*, *52*.

Kawai, M., & Pontines, V. (2016). Is there really a renminbi bloc in Asia?: A modified Frankel-Wei approach. *Journal of International Money and Finance*, *62*, 72–97. https://doi.org/10.1016/j.jimonfin.2015.12.003

Lee, H. S. (1992). Maximum likelihood inference on cointegration and seasonal cointegration. *Journal of Econometrics*, *54*, 1–47.

Liao, S., & McDowell, D. (2015). Redback Rising: China's Bilateral Swap Agreements and Renminbi Internationalization. *International Studies Quarterly*, *59*(3), 401–422. https://doi.org/10.1111/isqu.12161

Liu, T., Wang, X., & Woo, W. T. (2022). The rise of Renminbi in Asia: Evidence from Network Analysis and SWIFT dataset. *Journal of Asian Economics*, *78*, 101431. https://doi.org/10.1016/j.asieco.2021.101431

McCauley, R. N., & Shu, C. (2019). Recent renminbi policy and currency co-movements. *Journal of International Money and Finance*, *95*, 444–456. https://doi.org/10.1016/j.jimonfin.2018.03.006

Mundell, R. A. (1961). A Theory of Optimum Currency Areas. *American Economic Review*, *51*(4), 657–665.

Park, B., & An, J. (2020). What Drives Growing Currency Co-movements with the Renminbi? *East Asian Economic Review*, *24*(1), 31–59. https://doi.org/10.11644/kiep.eaer.2020.24.1.371

SAFE. (2020). *PBOC & SAFE Remove QFII / RQFII Investment Quotas and Promote Further Opening-up of China's Financial Market*.

Sato, K., & Zhang, Z. (2006). Real output co-movements in East Asia: Any evidence for a monetary union? *The World Economy*, *29*(12), 1671–1689. https://doi.org/10.1111/j.1467-9701.2006.00863.x

Sato, K., Zhang, Z., & Allen, D. (2009). The suitability of a monetary union in East Asia: What does the cointegration approach tell? *Mathematics and Computers in Simulation*, *79*(9), 2927–2937. https://doi.org/10.1016/j.matcom.2008.10.004

Sharma, C., & Mishra, R. K. (2012). Is an Optimum Currency Area Feasible in East and South East Asia? *Global Economic Review*, *41*(3), 209–232. https://doi.org/10.1080/1226508X.2012.709991

Standard Chartered. (2021, November 16). *Renminbi Globalization Index*. Https://Www.Sc.Com/En/Banking/Renminbi/.

SWIFT. (2011). *SWIFT RMB Tracker, November 2011*.

SWIFT. (2015). *Chinese Yuan demonstrates strong momentum to reach #4 as an international payments currency*.

Tiao, G. C., & Tsay, R. S. (1989). Model Specification in Multivariate Time Series. *Journal of the Royal Statistical Society: Series B (Methodological)*, *51*(2), 157–195. https://doi.org/10.1111/j.2517-6161.1989.tb01756.x

Trenkler, C., & Weber, E. (2020). Identifying shocks to business cycles with asynchronous propagation. *Empirical Economics*, *58*(4), 1815–1836. https://doi.org/10.1007/s00181-018-1563-z

Vahid, F., & Engle, R. F. (1993). Common Trends and Common Cycles. *Source: Journal of Applied Econometrics*, *8*(4), 341–360. https://about.jstor.org/terms

Vahid, F., & Engle, R. F. (1997). Vahid and Engle 1997. *Journal of Econometrics*, *80*, 199–221.

Xu, L., & Kinkyo, T. (2019). Changing patterns of Asian currencies' co-movement with the US dollar and the Chinese renminbi: Evidence from a wavelet multiresolution analysis. *Applied Economics Letters*, *26*(6), 465–472. https://doi.org/10.1080/13504851.2018.1486976

Appendix I

Exchange rate regimes

The fixed rates of the Philippine peso (PHP) and the Japanese yen (JPY) to the USD were replaced by a flexible exchange rate system in the early 1970s. In 1997, Thailand, Korea and Indonesia introduced floating exchange rate regimes so that exchange rates would be determined by supply and demand in foreign exchange markets. Taiwan has a managed floating exchange rate regime, and Singapore authorities manage the Singapore dollar (SGD) against a basket of currencies of the country's major trading partners and competitors. Malaysia retained the conventional peg of its currency, the Malaysian ringgit (MYR), against the USD until July 2005, when Bank Negara Malaysia (BNM) adopted a managed float for the ringgit with reference to a currency basket. In 2016, the BNM announced that market forces shall determine the direction and level of the exchange rate. Hong Kong maintains its fixed exchange rate regime with the USD, which is managed by a currency board. The Macau pataca (MOP) is pegged to the HKD and thus also indirectly to the USD.[15] In July 2005, China started to reform its exchange rate regime and announced the change from a fixed rate to the USD to a managed floating regime. The RMB exchange rate is determined with reference to an initially undisclosed basket of currencies. Although market supply and demand play a role in determining the exchange rate, the exchange rate appears to be determined mainly by official measures (IMF, 2007). During the global financial crisis, the former peg to the USD was revived for an intermediate period.[16] In 2010, a stronger focus on the currency basket and a managed floating regime were again announced. In August 2015, the Peoples Bank of China (PBC) decided to further increase the flexibility of the RMB–USD exchange rate to improve the market determination of the RMB exchange rate (IMF, 2016). The basket of currencies on the basis of which China determines the exchange rate of the RMB was expanded from 13 to 24 in January 2017, with new currencies accounting for about 21% of the new basket (IMF, 2016). However, the USD still carries the largest weight, at 22.4%. Except for the Indonesian rupiah and the MOP, all currencies of the countries under review are included in the current currency basket.

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[15] Information on exchange rate regimes is retrieved from IMF AREAER.
[16] The RMB was pegged to the USD since 1994.

Appendix II

Table A1: HEGY-Seasonal Unit Root Tests for log-levels

	Frequency			
Country	0	PI	PI/2	All seasonal frequencies
Japan	-2.906	-3.856***	13.143***	13.215***
Indonesia	-3.553	-5.694***	12.663***	24.663***
Malaysia	-2.237	-4.793***	24.686***	25.897***
Philippines	-3.994***	-3.234**	12.887***	11.917***
Singapore	-2.296	-4.330***	16.073***	17.776***
Thailand	-2.837	-3.388**	9.488***	10-651***
Korea	-2.264	-5.963***	22.235***	29.325***
Hong Kong	-2.085	-4.306***	13.569***	15..184***
Taiwan	-2.476	-4.589***	17.055***	19.344***
Macau	-1.292	-3.961***	7.029***	10.199***
China	-0.257	-3.312**	10.235***	11.135***

Note: Regressors include, intercept, trend, and seasonal dummies. Optimal lag order is derived from the Akaike Information Criterion.

Table A2: Seasonal Cointegration Tests for log-levels with trend / Bivariate against China

	0		π	
	r = 0	r ≤ 1	r = 0	r ≤ 1
Japan	17.396***	55.857***	31.374***	8.245*
Indonesia	21.496***	8.217	35.876***	3.983
Malaysia	16.897**	5.737	35.857***	11.502**
Philippines	21.395***	8.442	-	-
Singapore	25.063***	5.967	31.462***	10.348**
Thailand	14.299**	6.787	27.021***	8.470*
Korea	11.681*	4.88	-	-
Hong Kong	9.729	2.256	-	-
Taiwan	10.518	2.466	-	-
Macau	9.759	4.347	-	-

Notes: Trace Statistics. *,**,** indicates the rejection of the null based on linearly interpolated critical values of Lee and Siklos (1995). Optimal lag order between 1 and 7 is derived by Akaike Information Criterion of the bivariate VAR incl. deterministic trends and seasonal dummies.

Table A3: Optimal GMM Test

| | Cointegration at Frequency | Null | Codependence of order | | | | | | | |
| | | | 0 | | 1 | | 2 | | 3 | |
			Stat.	Prob.	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.
Japan	0, π	GMM	75.572	0.000	25.642	0.000	9.388	0.009	3.563	0.168
		2SLS			47.181	0.000	24.391	0.000	11.107	0.004
Indonesia	0, π	GMM	54.766	0.000	22.289	0.004	10.276	0.246	4.588	0.801
		2SLS			33.907	0.000	15.592	0.049	7.157	0.520
Malaysia	0, π	GMM	60.954	0.000	23.713	0.000	10.590	0.005	5.049	0.080
		2SLS			43.840	0.000	27.308	0.000	15.451	0.000
Philippines	0	GMM	38.382	0.000	11.200	0.001	0.239	0.624	3.850	0.050
		2SLS			18.937	0	0.486	0.486	11.863	0.001
Singapore	0, π	GMM	45.162	0.000	19.067	0.000	9.062	0.011	4.457	0.108
		2SLS			35.157	0.000	23.381	0.000	13.452	0.001
Thailand	0, π	GMM	62.806	0.000	25.280	0.000	9.934	0.007	4.358	0.113
		2SLS			46.845	0.000	23.934	0.000	11.181	0.004
Korea	-	GMM	71.633	0.000	24.945	0.000	3.138	0.076	0.022	0.881
		2SLS			45.146	0.000	7.434	0.006	0.063	0.802
Hongkong	-	GMM	75.937	0.000	25.052	0.000	6.273	0.012	0.651	0.420
		2SLS			45.538	0.000	15.406	0.000	1.889	0.169
Taiwan	-	GMM	66.793	0.000	25.793	0.000	2.035	0.154	1.493	0.222
		2SLS			47.550	0.000	4.736	0.029	4.150	0.042
Macau	-	GMM	35.384	0.026	17.641	0.671	32.182	0.056	21.509	0.428
		2SLS			19.130	0.577	10.343	0.974	6.765	0.999

Notes: Optimal GMM/2SLS $\chi2$ test statistics and relative p-values. Optimal lag order is derived from the Akaike Information Criterion.
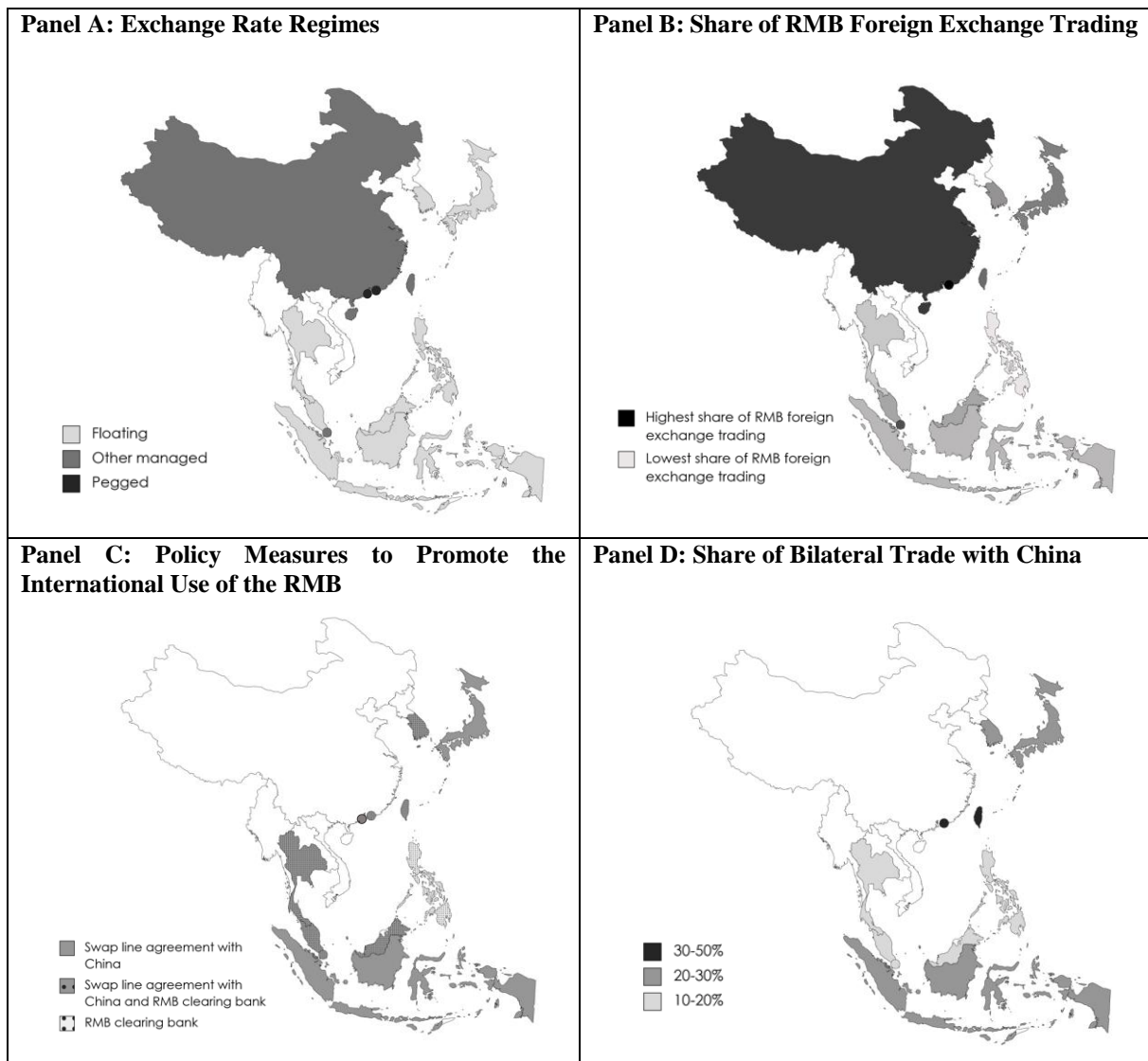
Table A4: Tiao and Tsay (1989) Codependence Test

	Cointegration at Frequency	Null	Codependence of order 0		1		2		3	
			Stat.	Prob.	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.
Japan	0, π	**k=1**	80.091	0.000	18.081	0.000	8.915	0.012	4.850	0.088
		k=2	212.395	0.000	39.875	0.000	20.493	0.002	13.125	0.041
Indonesia	0, π	**k=1**	74.715	0.000	21.086	0.007	13.032	0.111	9.849	0.276
		k=2	213.168	0.000	44.841	0.000	24.819	0.130	18.649	0.414
Malaysia	0, π	**k=1**	90.374	0.000	17.081	0.000	8.495	0.014	6.211	0.045
		k=2	224.461	0.000	41.022	0.000	21.957	0.001	17.014	0.009
Philippines	0	**k=1**	65.553	0.000	8.446	0.004	0.271	0.602	2.090	0.148
		k=2	197.102	0.000	31.102	0.000	11.731	0.019	10.209	0.037
Singapore	0, π	**k=1**	98.193	0.000	19.482	0.000	9.595	0.008	5.903	0.052
		k=2	230.891	0.000	44.357	0.000	24.450	0.000	18.012	0.006
Thailand	0, π	**k=1**	82.655	0.000	10.479	0.005	1.660	0.436	1.348	0.510
		k=2	222.227	0.000	35.361	0.000	15.915	0.014	12.009	0.062
Korea	-	**k=1**	77.206	0.000	8.111	0.004	0.862	0.353	0.106	0.745
		k=2	220.581	0.000	34.434	0.000	15.915	0.003	11.633	0.020
Hongkong	-	**k=1**	77.530	0.000	11.132	0.001	2.559	0.110	0.232	0.630
		k=2	219.094	0.000	35.219	0.000	15.620	0.004	9.905	0.042
Taiwan	-	**k=1**	65.372	0.000	6.271	0.012	0.089	0.766	1.275	0.259
		k=2	205.028	0.000	30.361	0.000	12.434	0.014	9.950	0.041
Macau	-	**k=1**	127.739	0.000	25.844	0.212	17.487	0.681	7.496	0.997
		k=2	302.880	0.000	48.317	0.303	30.775	0.934	16.845	0.999

Notes: Tiao and Tsay (1989) test statistics and relative p-values. Optimal lag order is derived from the Akaike Information Criterion.

Figure 1: Financial and Trade Integration in East Asia

Panel A: Exchange Rate Regimes	Panel B: Share of RMB Foreign Exchange Trading
Floating / Other managed / Pegged	Highest share of RMB foreign exchange trading / Lowest share of RMB foreign exchange trading
Panel C: Policy Measures to Promote the International Use of the RMB	Panel D: Share of Bilateral Trade with China
Swap line agreement with China / Swap line agreement with China and RMB clearing bank / RMB clearing bank	30-50% / 20-30% / 10-20%

Notes: Information on exchange rate regimes is retrieved from IMF AREAER Database and from country monetary authorities. Information on the dissemination of policy measures are from news from the State Aministration of Foreign Exchange (SAFE) and Peoples Bank of China. Foreign exchange data is from the BIS Triennial Survey on Foreign Exchange Turnover 2019. Bilateral trade data is from the IMF DOTS database. The map was created with mapchart.net. Countries colored in white are shown for better geographical overview.

Figure 2: Bilateral Trade with China and the USA in 2020
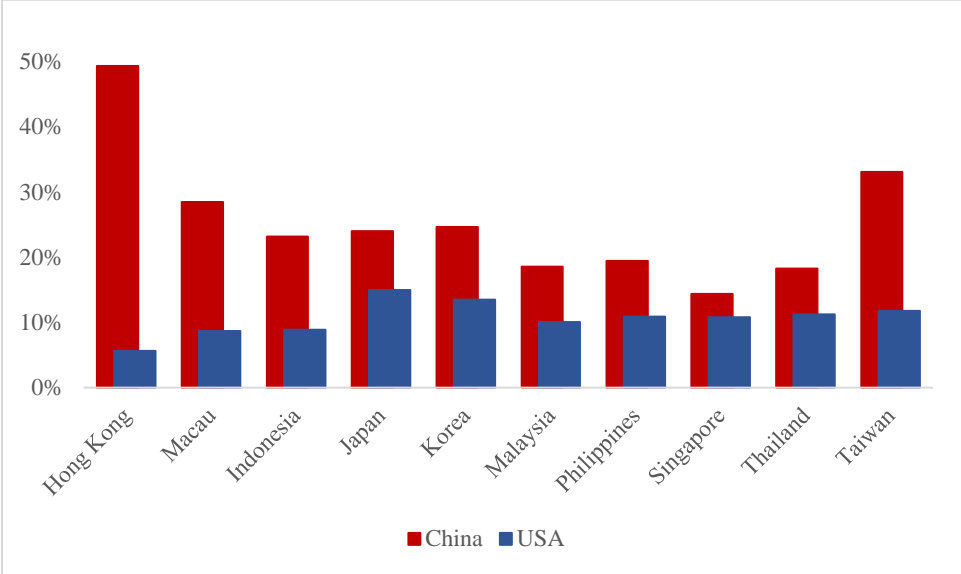
Notes: The graph shows the share of trade (exports + imports) of the East Asian country with China (United States) in relation to the trade of this country with the world (data: IMF dots).

Figure 3: Bilateral Trade with China
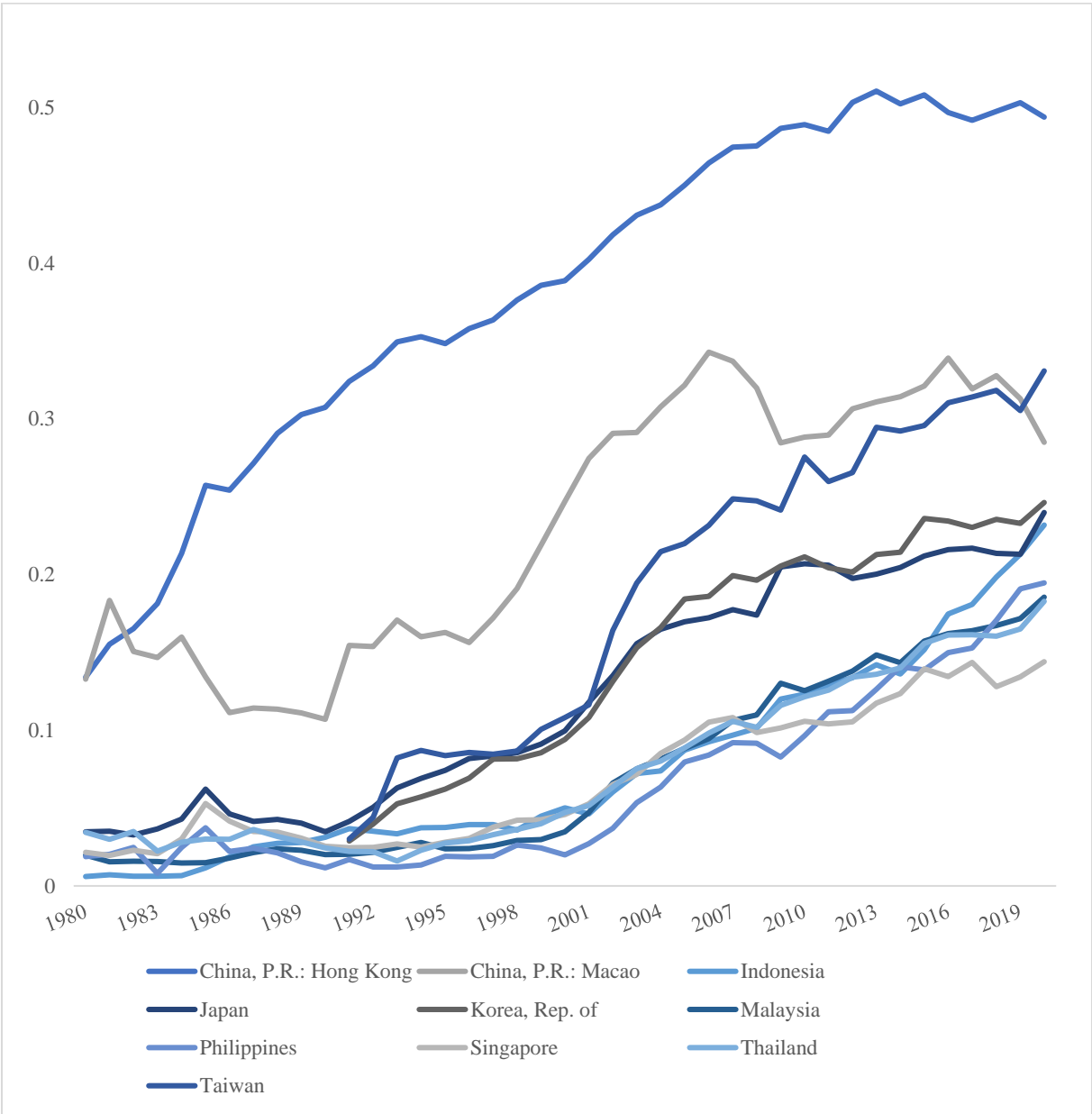
Notes: The graph shows the share of trade (exports + imports) of the East Asian country with China in relation to the trade of this country with the world (data: IMF dots).

Figure 4: Graphical Analysis of (Seasonal) Real GDP Growth Rates
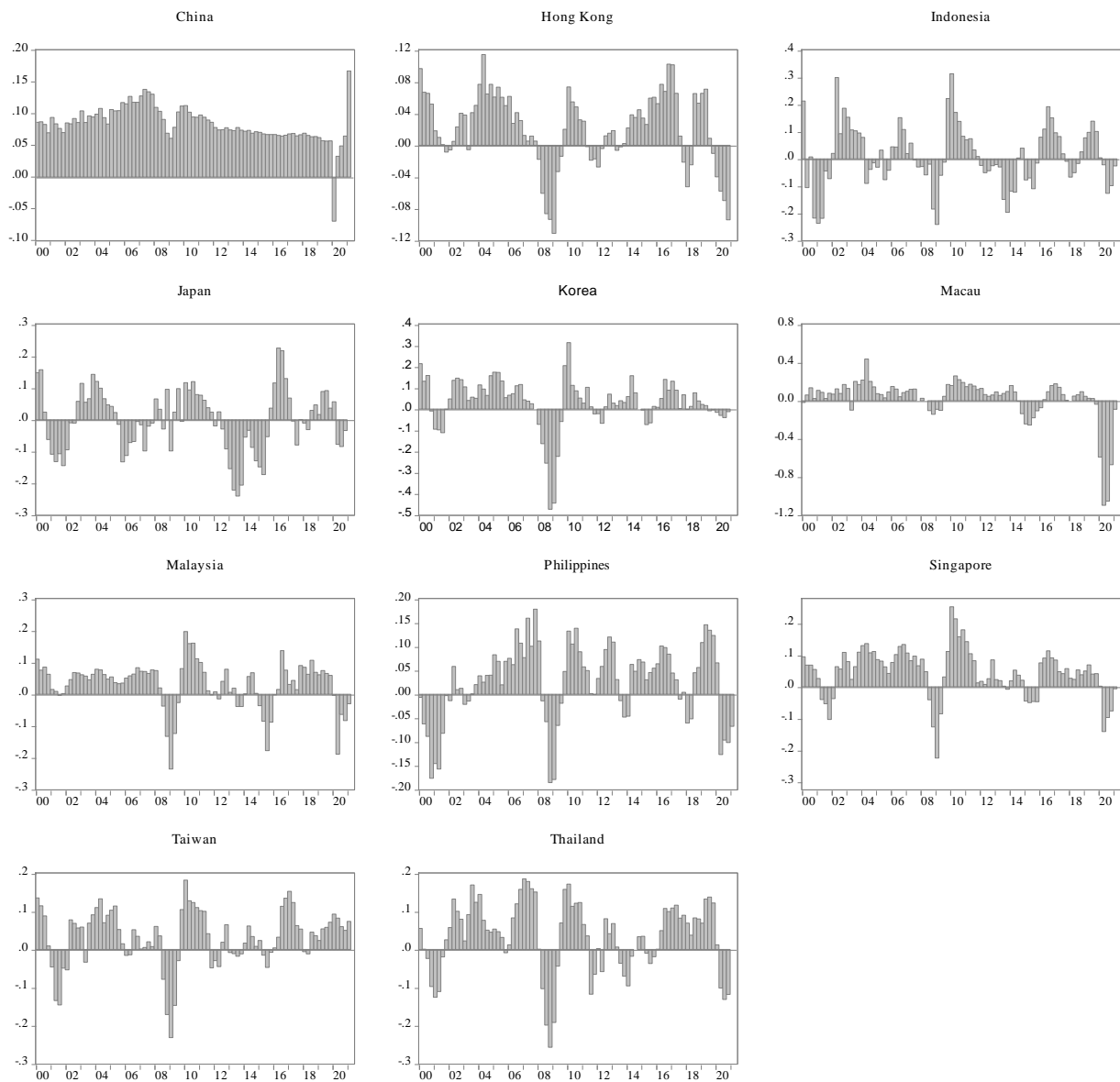
Notes: Figure 4 depicts seasonal growth rates of real GDP for China, Hong Kong, Indonesia, Japan, Korea, Macau, Malaysia, Philippines, Singapore, Taiwan and Thailand. Data is from the IMF IFS database and individual country statistics reporting institutions.

Figure 5: Autocorrelogram
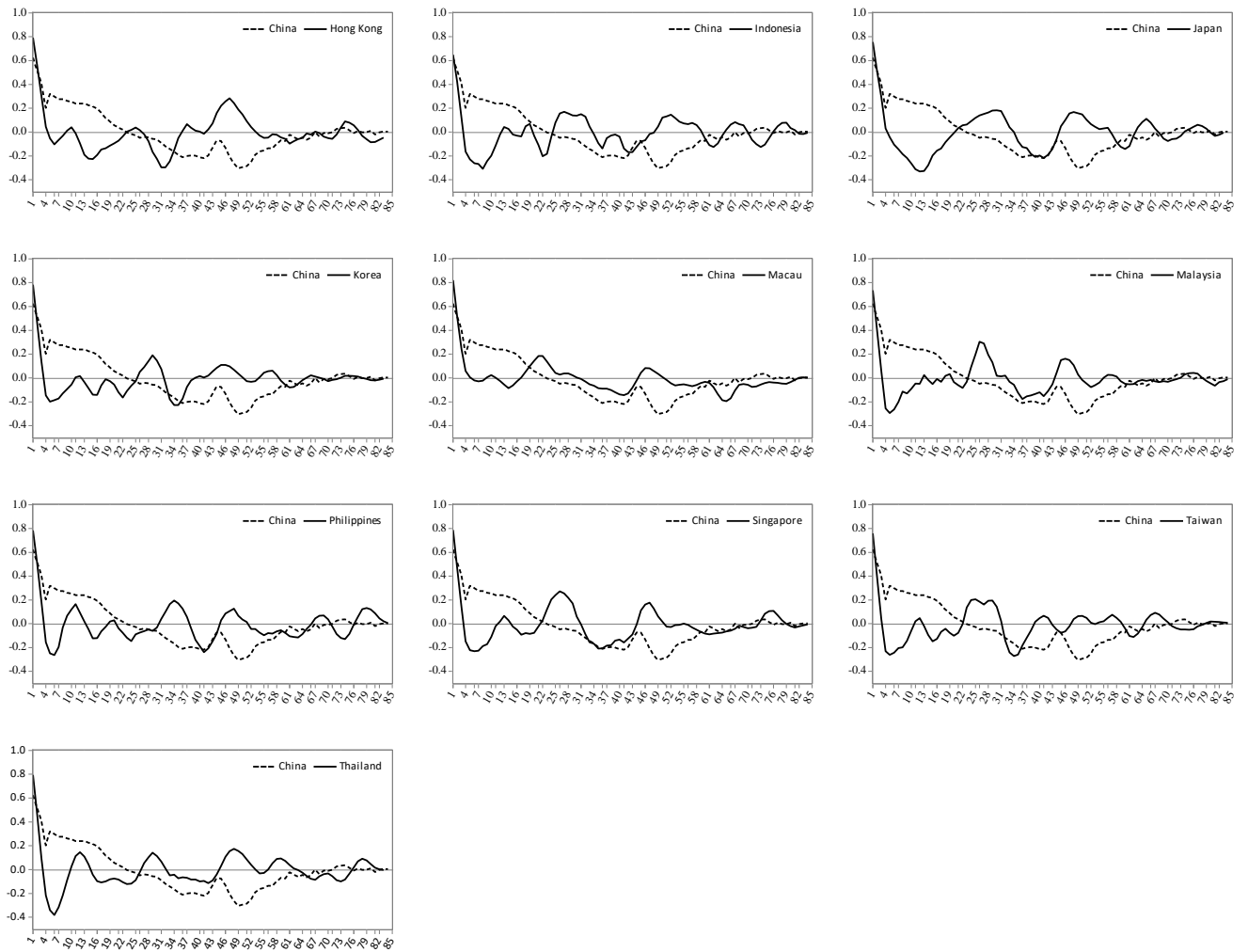
Notes: Figure 3 shows estimated sample autocorrelation functions of real GDP growth rates (seasonal differences of logged values) over 84 quarters.

Figure 6: Half-life estimates
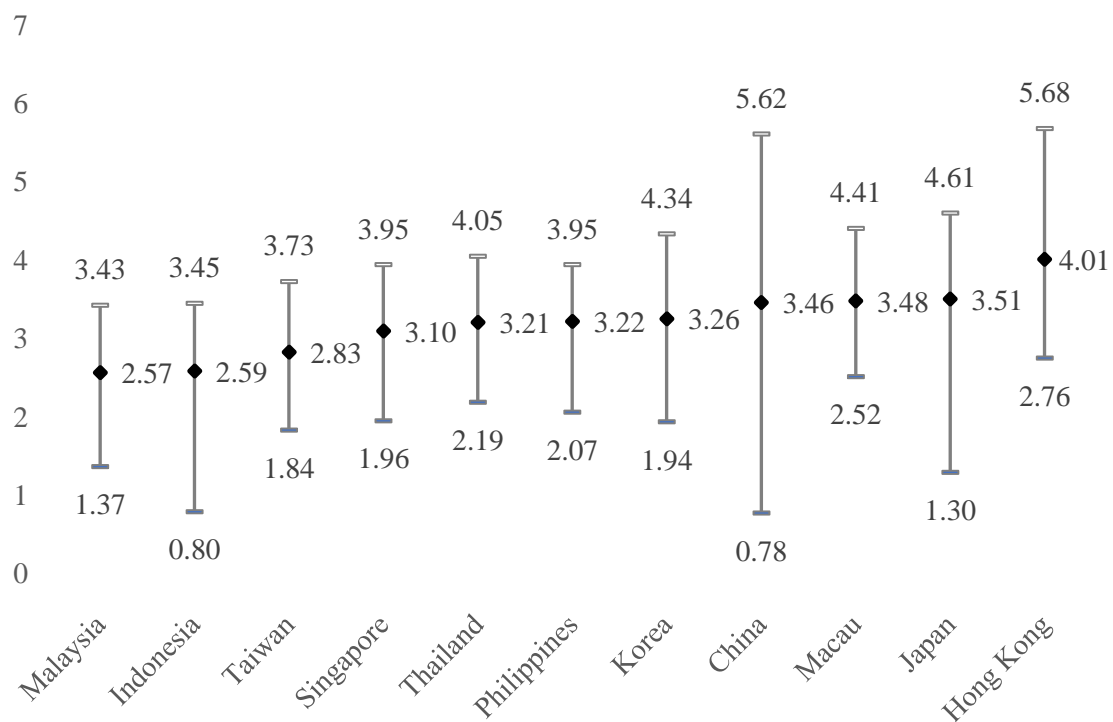
Notes: Figure 1 depicts half-life estimates (+/– 2 standard errors) based on the impulse response functions of a vector autoregressive model with 4 lags.

Table 1: RMB foreign exchange trading in the Asian Region in 2019

Country	RMB avg. daily fx turnover	Share of RMB trading	Rank by amount of RMB trade	Most traded currencies (more than RMB)	Subsequent position of the RMB
Hong Kong	107615	29.78%	1	USD, HKD	3
China	101226	28.01%	2	USD	2
Singapore	42565	11.78%	4	USD, JPY, EUR, AUD, SGD, GBP	7
Taiwan	3655	1.01%	7	USD, TWD, EUR	4
Japan	3220	0.89%	8	JPY, USD, EUR, AUD, GBP, NZD, CAD, CHF, ZAR	10
Korea	3125	0.86%	9	USD, KRW	3
Malaysia	241	0.07%	16	USD, EUR, SGD, GBP, AUD, HKD, JPY	8
Indonesia	101	0.03%	22	USD, SGD, EUR, GBP, AUD, JPY	7
Thailand	177	0.05%	19	USD, EUR, JPY, GPB	5
Philippines	40	0.01%	27	USD, JPY, EUR, AUD, GBP, SGD, HKD	8
Total RMB	361390	4.35%		USD, EUR, JPY, GBP, CAD, CHF	7

Notes: The average daily turnover is reported in USD millions. The share of RBM trading is the share of the trading venue in the respective country in global RMB trading. The rank represents the rank of a country according to its share in RMB trade. All countries that reported data on RMB trade in the BIS 2019 Triennial Survey were included in the ranking. The position of the RMB is derived from all currencies considered individually in the BIS survey. These are: AUD; BRL, CAD, CHF, CNY, DKK, EUR, GBP, HKD, HUF, INR, JPY, KRW, MXN, NOK, NZD, PLN, RUB, SEK, SGD, TRY, TWD, USD, ZAR. For total RMB the share represents the share of the RMB in global FX trading.

Table 2: Correlation Coefficients

	Hong Kong	Indonesia	Japan	Korea	Macau	Malaysia	Philippines	Singapore	Taiwan	Thailand
China	0.743*** (10.068)	-0.009 (-0.082)	0.214* (1.989)	0.745*** (10.114)	0.800*** (12.142)	0.508*** (5.378)	0.730*** (9.742)	0.190 (1.761)	0.800*** (12.142)	0.157 (1.442)
obs	84	85	84	84	85	85	85	85	85	84

Notes: Table reports (Pearson) correlation coefficients between countries' real GDP growth rates (first differences). t-statistics for the null of the coefficient being unequal to zero are given in parenthesis. *, **, *** indicate statistical significance at 10%, 5%, and 1% level, respectively. The sample period is 2000Q1-2021Q1.

Table 3: HEGY-Seasonal Unit Root Tests for log-levels

Country	**Frequency**			
	0	PI	PI/2	All seasonal frequencies
Japan	-3.031	-4.010**	14.733***	14.324***
Indonesia	-3.592**	-5.125***	12.761***	22.355***
Malaysia	-2.632	-4.106***	13.674***	11.111***
Philippines	-4.166***	-3.574***	12.591***	12.224***
Singapore	-1.939	-3.969***	19.260***	17.535***
Thailand	-3.137*	-3.539***	8.750***	10.623***
Korea	-2.376	-6.073***	22.516***	30.017***
Hong Kong	-2.447	-4.420***	13.652***	15.457***
Taiwan	-2.264	-4.803***	20.063***	22.614***
Macau	-0.268	-4.492***	10.702***	14.144***
China	0.391	-3.082**	12.061***	9.869***

Note: Regressors include, intercept, trend, and seasonal dummies. Optimal lag order is derived from the Akaike Information Criterion.

Table 4: Seasonal Cointegration Tests for log-levels with trend / Bivariate against China

	0		π	
	r = 0	r ≤ 1	r = 0	r ≤ 1
Japan	20.643***	6.367	19.555***	0.963
Indonesia	24.392***	8.794	-	-
Malaysia	25.667***	5.742	32.920***	8.103**
Philippines	25.553***	10.426*	-	-
Singapore	29.876***	4.984	30.123***	9.460**
Thailand	21.390***	8.720	13.766***	0.410
Korea	16.720**	6.297	34.690***	0.449
Hong Kong	14.351**	5.794	24.651***	0.491
Taiwan	10.837*	2.363	-	-
Macau	16.035**	3.001	21.503***	3.861

Notes: Trace Statistics. *,**,** indicates the rejection of the null based on linearly interpolated critical values of Lee and Siklos (1995). Optimal lag order is derived by Akaike Information Criterion of the bivariate VAR incl. deterministic trends and seasonal dummies.

Table 5: Optimal GMM Test

	Cointegration at Frequency	Null	Codependence of order							
			0		**1**		**2**		**3**	
			Stat.	Prob.	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.
Japan	0, π	**GMM**	68.763	0.000	25.907	0.000	8.718	0.013	7.495	0.024
		2SLS			36.451	0.000	14.017	0.001	15.735	0.000
Indonesia	0	**GMM**	108.986	0.000	85.096	0.000	88.733	0.000	50.939	0.000
		2SLS			77.798	0.000	55.648	0.000	46.351	0.000
Malaysia	0, π	**GMM**	64.111	0.000	28.704	0.000	17.086	0.000	6.707	0.035
		2SLS			38.313	0.000	28.945	0.000	12.522	0.002
Philippines	0	**GMM**	50.711	0.000	20.649	0.000	7.164	0.007	8.086	0.004
		2SLS			25.570	0.000	12.295	0.000	14.773	0.000
Singapore	0, π	**GMM**	45.834	0.000	19.569	0.000	6.785	0.034	7.797	0.020
		2SLS			25.511	0.000	10.688	0.005	14.352	0.001
Thailand	0, π	**GMM**	56.815	0.000	23.105	0.000	8.419	0.015	12.640	0.002
		2SLS			32.941	0.000	13.360	0.001	23.138	0.000
Korea	0, π	**GMM**	66.925	0.000	26.031	0.000	4.896	0.086	1.009	0.604
		2SLS			37.909	0.000	8.419	0.015	2.407	0.300
Hongkong	0, π	**GMM**	63.596	0.000	24.340	0.000	8.126	0.017	2.006	0.367
		2SLS			33.608	0.000	12.967	0.002	5.233	0.073
Taiwan	-	**GMM**	73.356	0.000	22.682	0.000	1.829	0.176	3.945	0.047
		2SLS			32.439	0.000	3.732	0.053	8.146	0.004
Macau	0, π	**GMM**	97.868	0.000	66.450	0.000	48.553	0.000	18.315	0.000
		2SLS			90.365	0.000	75.760	0.000	34.277	0.000

Notes: Optimal GMM/2SLS $\chi2$ test statistics and relative p-values. Optimal lag order is derived from the Akaike Information Criterion.

Table 6: Tiao and Tsay (1989) Codependence Test

	Cointegration at Frequency	Null	Codependence of order							
			0		**1**		**2**		**3**	
			Stat.	Prob.	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.
Japan	0, π	**k=1**	62.545	0.000	16.998	0.000	8.366	0.015	5.463	0.065
		k=2	148.666	0.000	38.057	0.000	20.802	0.002	14.158	0.028
Indonesia	0	**k=1**	59.901	0.000	17.692	0.013	12.474	0.086	2.472	0.929
		k=2	129.390	0.000	42.438	0.000	26.957	0.042	13.951	0.602
Malaysia	0, π	**k=1**	40.094	0.000	15.125	0.001	9.361	0.009	2.699	0.259
		k=2	145.850	0.000	34.405	0.000	22.508	0.001	16.918	0.010
Philippines	0	**k=1**	39.054	0.000	8.461	0.004	0.587	0.444	0.669	0.413
		k=2	115.744	0.000	24.246	0.000	10.889	0.028	7.663	0.105
Singapore	0, π	**k=1**	34.651	0.000	14.081	0.001	7.867	0.020	1.743	0.418
		k=2	159.460	0.000	36.508	0.000	22.311	0.001	18.687	0.005
Thailand	0, π	**k=1**	58.335	0.000	16.852	0.000	8.849	0.012	8.689	0.013
		k=2	162.857	0.000	35.823	0.000	19.875	0.003	18.239	0.006
Korea	0, π	**k=1**	69.469	0.000	8.953	0.011	1.140	0.566	1.990	0.370
		k=2	153.215	0.000	30.240	0.000	14.280	0.027	13.869	0.031
Hongkong	0, π	**k=1**	66.324	0.000	13.988	0.001	3.137	0.208	2.478	0.290
		k=2	160.980	0.000	33.578	0.000	15.117	0.020	12.724	0.048
Taiwan	-	**k=1**	46.194	0.000	6.756	0.009	0.115	0.734	0.658	0.417
		k=2	119.315	0.000	21.868	0.000	7.806	0.099	4.834	0.305
Macau	0, π	**k=1**	47.726	0.000	17.454	0.000	5.831	0.051	1.215	0.545
		k=2	171.419	0.000	40.458	0.000	20.035	0.003	9.665	0.139

Notes: Tiao and Tsay (1989) test statistics and relative p-values. Optimal lag order is derived from the Akaike Information Criterion.