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Inflation Co-Movement in Emerging and Developing Asia: The Monsoon Effect

by Patrick Blagrave

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Abstract

Co-movement (synchronicity) in inflation rates among a set of 13 emerging and developing countries in Asia is shown to be strongest for the food component, partly due to common rainfall shocks—a result which the paper terms the 'monsoon effect.' Economies with higher trade integration and co-movement in nominal effective exchange rates also experience greater food-inflation co-movement. By contrast, cross-country co-movement in core inflation is weak and the aforementioned determinants have little explanatory power, suggesting a prominent role for idiosyncratic domestic factors in driving core inflation. In the context of the growing literature on the globalization of inflation, these results suggest that common weather patterns are partly responsible for any role played by a so-called 'global factor' among inflation rates in emerging and developing economies, in Asia at least.

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Contents Page

I. INTRODUCTION

A growing literature on the synchronization of inflation rates across countries—or, the rise of 'global' inflation—highlights the increasing role played by a common factor over time. However, most existing empirical studies focus largely on advanced economies, where inflation volatility is relatively low and food inflation comprises only a small share of the consumer price index (CPI) basket. Although some candidate explanations for the importance of this 'global' factor are offered—including common monetary policies and improved anchoring of inflation expectations in inflation targetters—these are likely less relevant among emerging market and developing economies.

Examining inflation co-movement in a set of emerging and developing economies in Asia, this paper offers a novel explanation for some of the observed co-movement: common rainfall patterns, which the paper terms the 'monsoon effect.' Analysis in the paper extends the literature—outlined further below—in three ways. First, by considering the determinants of co-movement in monthly inflation rates between a set of 13 countries in Asia, the paper provides an analysis of the 'globalization of inflation' hypothesis among emerging and developing economies. Second, the consideration of common rainfall shocks as a determinant of inflation co-movement marks an innovation, linking the literature on global inflation to that on agricultural prices. If two countries face similar weather patterns, one might expect these to have more synchronized inflation rates, at least with respect to food prices, especially insofar as harvest yields are dependent on natural rainfall as is plausibly the case in countries at a lower stage of development. There is ample evidence in the literature that weather patterns play a key role in determining food inflation (for example, see Brown and Kshirsagar, 2015 and Mitra and Chattopadhyay, 2017), and headline inflation (for example, Cashin, Mohaddes and Raissi, 2017, who examine the effects of El Nino weather disturbances). In addition, as discussed in Baffes, Kshirsagar and Mitchell (2017), the role played by natural rainfall patterns would likely be more pronounced in countries (or, among components of the food basket) where the use of modern inputs is more limited (and, the share of land under irrigation is lower); a similar conclusion is reached by Brey and Hertweck (2019) in a study of India. Given the potentially important role for rainfall in food production, not explicitly accounting for such weather-related shocks could bias the results of any empirical analysis, making it more likely that inflation co-movement would be mistakenly attributed to other factors. The explicit consideration of the role of weather-related factors is especially important given the recent climate-change-related trend towards more extreme weather events, which are likely to play an increasingly important role in shaping economic outcomes and driving inflation in years to come. The paper's third contribution is the distinct treatment of food and core inflation, using a continuous measure of co-movement (the instantaneous quasi correlation) not previously applied to this issue. For many countries in Asia, where food comprises a large part of the consumption basket, the drivers of cross-country co-movement in food inflation is of specific interest.

The paper's analysis builds on an existing literature examining the international dimension of the inflation process. Arguably the seminal works on the topic are contributed by Auer and Fischer (2010) and Ciccarelli and Mojon (2010)—both studies highlight a key role for international factors in driving inflation outcomes. Using data on manufacturing industries in the United States, the former finds an important downward effect of imports from low-wage countries on U.S. prices, while the latter shows that a common factor explains nearly 70 percent of the variance in inflation rates among a set of 22 OECD countries. Neely and Rapach (2011) support this finding, using a dynamic latent factor model to show that world and regional factors account for about half of the inflation variation in a set of 64 countries (mostly high-income) and that the role of these factors has increased over time. In one of the only studies to consider emerging and developing economies, Parker (2018) considers a broad set of 223 economies and shows that global factors play a smaller role in less developed countries, and a greater role in driving energy and food-price inflation. Delving into the determinants of why country and world factors matter more/less across a set of 13 high-income countries, Mumtaz and Surico (2012) provide evidence that higher productivity growth and migration tend to reduce the importance of country factors, while common movements in money growth are associated with a greater co-movement in inflation. More recently, Auer, Levchenko and Sauré (2017) show that international input-output linkages play a major role in synchronizing producer-price inflation across countries. Finally, examining a set of OECD countries, Altansukh and others (2017) find that globalization of aggregate inflation is driven by convergence among core-inflation rates, consistent with the introduction of inflation targeting.

Most closely related to the present paper is a study by Auer and Mehrotra (2014) which finds that both producer price and headline consumer price inflation rates are more closely related among countries who have higher trade integration, in a set of 12 large countries in Asia. However, examining sub-components of inflation, Förster and Tillmann (2014) show that two thirds of overall inflation volatility can be explained by country-specific determinants, and that this ratio is even higher for CPI net of food and energy—their findings indicate that only energy price inflation in advanced economies is driven to an important degree by common factors.

In what follows, analysis of headline, core and food-price inflation co-movement is conducted along several dimensions. First, a set of stylized facts are presented for a panel of 13 countries in Asia. The main takeaway is that food inflation is more correlated across countries in Asia than is the case for core inflation. Food inflation correlations across countries are associated with greater trade integration, but also with correlation in rainfall patterns suggesting a role for common rainfall shocks.[2] For core inflation, there is little discernable relationship between cross-country correlations and trade integration. The paper's empirical analysis explores the determinants of country-pair inflation co-movement. This is done using an instantaneous quasi-correlation measure of co-movement commonly used in the literature on business-cycle synchronicity (see Duval and others, 2016) which allows for a more in-depth consideration of co-movement across time (as opposed to a conventional measure of correlation, which can only be calculated for a given sample period). For food and core inflation, this measure is constructed for each country pair and regressed on a set of determinants including trade integration, money-supply-growth, exchange-rate synchronization, and co-movement in rainfall amounts (also quasi-correlations) between country pairs. Results suggest that food price inflation co-movement is driven by trade integration, exchange-rate co-movement and commonality in rainfall patterns. For core inflation, co-movement is weaker and not driven by standard determinants, suggesting that country-specific (idiosyncratic) factors dominate.

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[2] Regarding the domestic food-inflation process in Asian countries, see Bandara (2013), Brey and Hertweck (2019), Chand (2010), Heady and Fan (2008), the Reserve Bank of India (2010), Sonna and others (2014), and the World Bank (2010), among others.

The remainder of the paper is structured as follows. Section 2 presents stylized facts on inflation, rainfall, and trade integration across countries. Section 3 discusses the empirical methodology for examining the drivers of inflation co-movement and presents baseline results. Robustness of the results is discussed in section 4. Section 5 concludes with a brief policy discussion and outlines the main caveats to the analysis as well as possible avenues for future research.

II. STYLIZED FACTS:

A. Data

CPI data for headline, food and core inflation forms the basis for the analysis. Country coverage for these series as well as their sources is shown in an appendix tables A1 and A2.[3] As monthly inflation data are not available prior to 2010 in many of the countries under consideration, the sample period for subsequent empirical analysis runs from 2010m1-2016m12. Baseline analysis is conducted using the 3-month moving-average inflation rate derived from the log values of these CPI indexes.[4] This measure of inflation is intended to strike a balance between month-to-month and year-on-year inflation rates—the former best capture high-frequency movements in prices but tend to be highly volatile and thus hard to explain, while the latter have the desirable property of being smooth but are slow to adjust to shocks, given that they are a function of the price level in the current period and the price level 12 months ago.

As discussed in section 1, a novel feature of this paper is the use of monthly rainfall data, expressed as total monthly rainfall, by country, in millimeters. For each country, these data are plotted in the appendix (Figures A1 and A2). To extract a notion of deficient/surplus rainfall which could plausibly matter for food prices (think here of a surplus or deficit monsoon season), percent deviations from country-specific, month-specific averages ($Rain_{i,t}^{*M}$) are constructed, according to:

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[3] The baseline analysis of core inflation uses whichever series is provided by national sources—in most cases, this is 'inflation excluding food and fuel prices.'

[4] As shown in section 4, the main empirical results are broadly robust to the use of alternative inflation-rate calculations.

$$Rain_{i,t}^{Dev\_M} = \frac{(Rain_{i,t} - Rain_i^{*M})}{Rain_{i,t}^{*M}} \quad for\ M = \{1, \dots, 12\}$$

Commonality in rainfall patterns captured by this measure could also be related to the so-called 'harvest cycle' effect (Sims (1974); Granger (1979)), which could imply heightened co-movement between countries whose seasonal harvests are more closely aligned—this is discussed further in Baffes, Kshirsagar and Mitchell (2017), in the context of within-country local food-price co-movement.

B. Summary Statistics

Cross-country inflation co-movement can be summarized most simply by examining correlations. Appendix tables A3-A5 show cross-country correlations between headline, food, and core inflation—the general takeaway, as summarized in the in-text table, is that correlations are, on average, higher for food inflation than they are for core inflation.

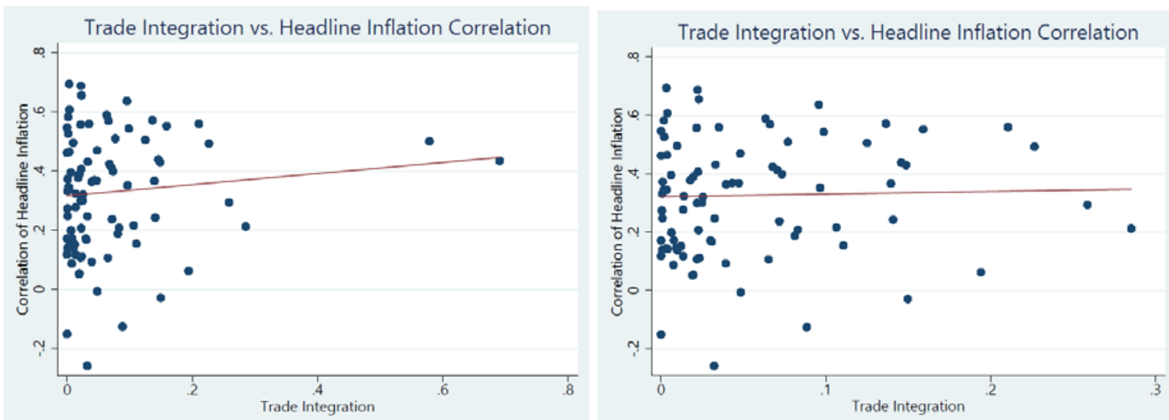
Average Cross-Country Correlations	
Headline CPI Inflation	0.31
Food CPI Inflation	0.20
Core CPI Inflation	0.05

To begin illustrating the possible drivers of this empirical regularity, Figures 1-3 plot the correlation between each country-pair's inflation rates (headline; food; core) vis-à-vis the degree of trade integration between the two countries, based on a prior belief that greater trade integration should foster stronger inflation co-movement (Auer, Levchenko, and Sauré, 2017; Auer and Mehrotra, 2014, among others discussed in section 1). The notion of trade integration used is simply the sum of each country-pair member (i's) imports from the other country-pair member (j) as a share of each country's total imports:

$$Trade_{i,j,t} = \frac{Imports_{i,j,t}}{Imports_{i,t}} + \frac{Imports_{j,i,t}}{Imports_{j,t}}$$

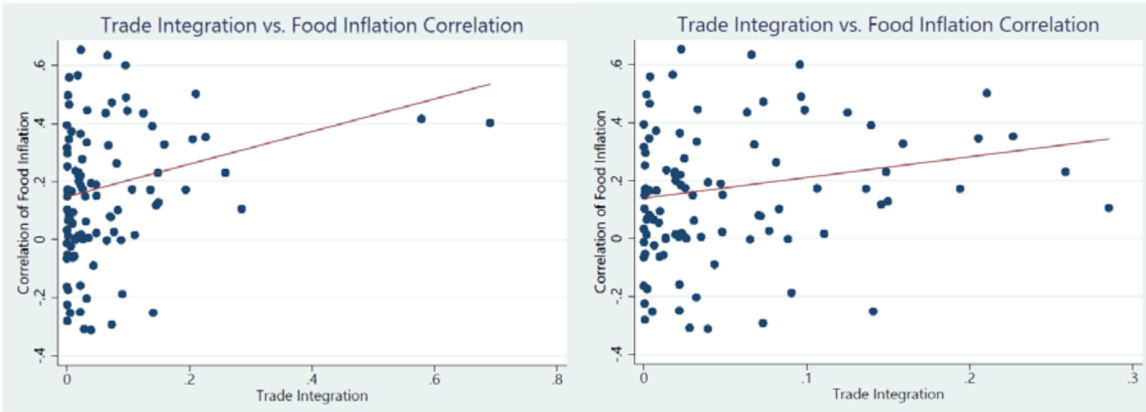
From Figure 1, headline inflation loosely conforms to the idea that trade integration should foster stronger co-movement—there is a positive relationship, though it is driven to an important degree by two outlying country pairs. More concretely, country pairs which have very high trade integration (such as India and Nepal, or India and Bhutan, both of which appear as outliers in the left-side plot) tend to exhibit stronger correlation in their headline inflation rates. Any apparent relationship between headline inflation correlations and trade integration is weakened once the two outlying country pairs are removed (right-side plot, Figure 1).

Figure 1. Relationship between headline inflation co-movement and trade integration



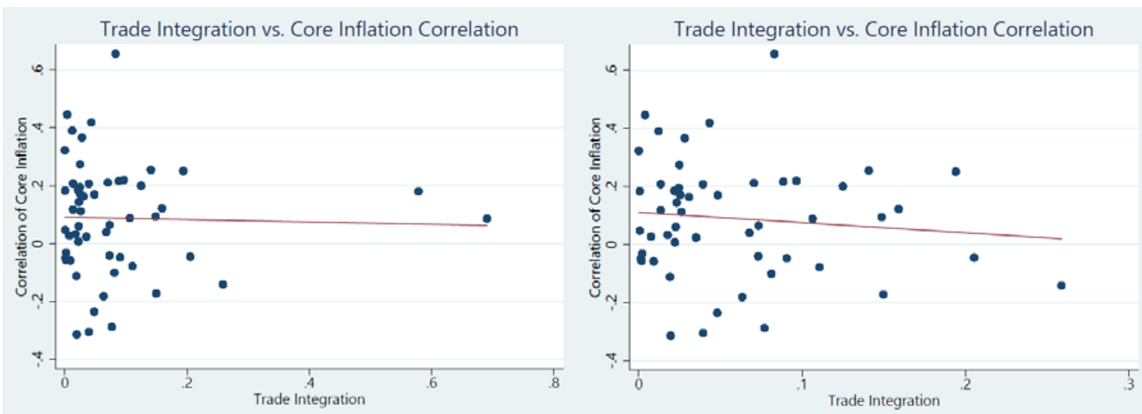
Looking at food-inflation co-movement, Figure 2 shows a stronger relationship between trade integration and cross-country correlations—to the extent that there is any such relationship in headline inflation, this indicates that it may be driven by these food-inflation dynamics. Figure 2 could suggest that countries who import a larger amount of food from one another have more highly connected food-inflation rates, due to the direct impact through the import-price channel—such a result would, for example, suggest important spillovers from one country to another. Alternatively, or in addition to this effect, food inflation co-movement across countries could be driven by a common shock—such as, for example, responses to common weather patterns across these countries. Figure 4 presents suggestive evidence in support of this possibility—food inflation co-movement is positively associated with higher correlation between countries of deviations in rainfall from monthly norms (shown on the left), indicating that common surplus/deficit conditions play a similar role across countries.

Figure 2. Relationship between food inflation co-movement and trade integration



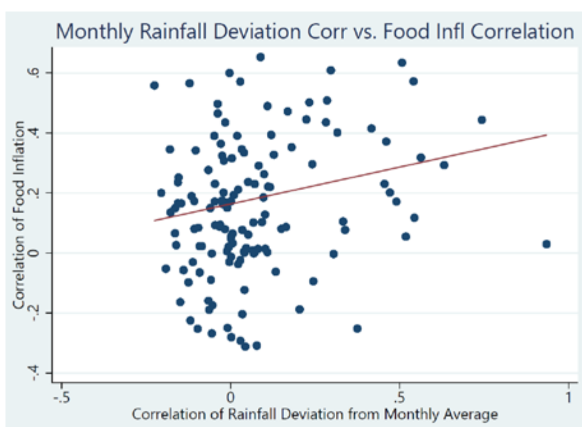
Source: Author's calculations

Figure 3. Relationship between core inflation co-movement and trade integration



Source: Author's calculations

Figure 4. Relationship between food inflation co-movement and rainfall co-movement



Source: Author's calculations

Cross-country correlations in core inflation do not fit the pattern predicted by the literature on trade integration, as shown in Figure 3. This could imply that domestic factors dominate the core inflation process in most countries, as suggested by Forster and Tillman (2014) in their analysis of a group of 40 largely high-income countries. Alternatively, cross-border transmission of core inflation may take time to materialize, with changes in imported input prices taking time to feed through to consumer prices, and thus may not be captured at such a high frequency.[5] It also bears mentioning that over the medium term, price *levels* may be more highly related across countries that are more economically integrated, even if this is not captured in higher frequency inflation rates.

III. EMPIRICAL METHODOLOGY: INFLATION CO-MOVEMENT AND DETERMINANTS

A. Measure of Co-Movement: The Instantaneous Quasi-Correlation

To draw a general conclusion regarding the determinants of inflation co-movement among countries in Asia, the paper uses a panel regression approach. However, using a standard measure of inflation correlation as the dependent variable would provide only one observation per country pair and would mask any sub-sample variations in inflation co-movement, or the co-movement in its determinants. More specifically, there may be periods of time where inflation moves in tandem between a given pair of countries—such as when common shocks are present—and periods when co-movement is much lower, perhaps because such shocks are not present. Such sub-sample variation in cross-country inflation co-movement is valuable in identifying factors which drive this co-movement over time. To preserve this sub-sample variation, an instantaneous quasi-correlation measure, as employed by Duval and others (2016), among others, is used to calculate period-by-period co-movement between inflation and several independent variables, across country pairs (i,j):[6]

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[5] An examination of inflation co-movement at a lower frequency, and/or phase shifting the inflation series, in the spirit of the exercise linking inflation to the output gap conducted for the euro area by Andrle, Bruha, and Solmaz (2013) may yield additional insights and could be investigated in future work.

[6] The sample mean of this measure of co-movement can be shown to asymptotically converge to the more standard (time-invariant) Pearson coefficient of correlation. In addition, since a Pearson coefficient of correlation is bounded by -1 and 1, the error terms from any subsequent regression analysis may not be

$$QCORR_{i,j,t}^{x} = \frac{(x_{i,t} - x_{i,t}^{*})(x_{i,t} - x_{j,t}^{*})}{\sigma_i^x \sigma_j^x}$$

Here, co-movement between a given variable of interest (x) in each country *i* vis-à-vis each other country *j* is assessed in each month (*t*) based on the product of deviations of this variable in that month from some notion of equilibrium (x^*) in the two countries, normalized by the product of the volatility (standard deviation) of this variable in the two countries ($\sigma_i^x \sigma_j^x$). In the baseline specification, the notion of equilibrium used is the (time-varying) country- and variable-specific trend, given by an HP filter. Since monthly data are used in the analysis, the smoothing parameter for the filter is set to be 130,000 (see Ravn and Uhlig, 2002). As discussed in section 4, the results are robust to instead using a (time-invariant) notion of equilibrium, as given by the country- and variable-specific sample average value.

The dependent variable of interest in the regression analysis that follows is always co-movement (quasi-correlation) in inflation (core; food). Most independent variables are also expressed as co-movements (quasi-correlations): money-supply growth, changes in the nominal effective exchange rate, and deviations of rainfall from country-specific, month-specific averages (as introduced in the previous section).

B. Drivers of Co-Movement: Empirical Specification and Results

Similar to Auer and Mehrotra (2014), who estimate determinants of (time-invariant) correlations between headline inflation rates, the following equation is estimated to quantify the determinants of inflation co-movement among countries in Asia, for both core and food inflation:

$$QCORR_{ijt}^{\pi} = \alpha + \beta_1\left(Trade_{i,j,t}\right) + \beta_2\left(QCORR_{ijt}^{M2}\right) + \beta_2\left(QCORR_{ijt}^{NEER}\right) + \beta_4\left(QCORR_{ijt}^{Rain^{Dev}}\right) + \gamma_t + \delta_i + \varepsilon_{ijt}\text{, for } \pi\text{: \{food; core\}}$$

normally distributed—something argued by, for example, Inklaar, Pin and Haan (2008) in their study of business cycle synchronicity. The quasi-correlation is not bounded by -1 and 1.

where $Trade_{i,j,t}$ is as described in the previous section. This is intended to proxy for the degree of trade integration between the two countries, and thus the potential for inflation spillovers across borders to drive inflation co-movement. Other control variables are quasi-correlations of broad money growth ($M2$), nominal effective exchange rates ($NEER$) and deviations of rainfall from seasonal (monthly) norms ($Rain^{Dev}$), between each country pair in the sample. These are intended to control for cross-country co-movement in standard inflation (Phillips curve) determinants.[7] In the baseline specification, all variables enter as 3-month moving averages, though inflation at other frequencies is considered in section 4. The variable γ_t represents time fixed effects (for each monthly period *t* in the sample period), which capture common movements in global inflation determinants, such as demand conditions, global energy or food prices. Analysis is conducted for food and core inflation separately and considers both pooled (random) effects and country-pair fixed-effects specifications (when used, captured by the variable δ_i)—the logic for these specifications is discussed below.

Food Inflation

Regression results for the determinants of food-inflation co-movement ($QCORR_{ijt}^{\pi food}$) are shown in Table 1, for various specifications. In all cases, to account for possible serial correlation, standard errors are clustered at the country-pair level. The regressions shown in the first column rely on a random-effects specification, which treats all observations as arising from the same population. Of course, generally this would be inappropriate in the context of a cross-country (or, in this case country-pair) panel analysis, where country-pairs are known to exhibit idiosyncratic (time-invariant) features. However, given that the regressions include an important country-pair-specific variable—their degree of trade integration—one may argue that this variable captures country-pair fixed effects.[8] Results in column (1) show a positive and statistically significant relationship between food inflation

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[7] A lack of data for many countries in the region precludes the use of a proper business-cycle control variable, such as industrial production, though co-movement in money supply growth and specifications with time fixed effects likely roughly proxy for the role of the business cycle.

[8] As will be argued later on, it may not be feasible to isolate the role of a country-pair's trade integration from its (time-invariant) fixed effect when applying a model with such effects.

co-movement and trade integration between country pairs. As the dependent variable is a quasi-correlation, interpretation of the magnitude of this estimated coefficient is not straightforward. An increase in trade integration of 1 standard deviation (1/10 of the magnitude considered in the table) would increase food-inflation co-movement by about 0.03—this is a small amount, relative to the standard deviation of food-inflation co-movement (about 1). Similarly, commonality in nominal effective exchange rate (NEER) movements is also associated with stronger food inflation co-movement, implying an important (common) role for exchange-rate passthrough between countries whose exchange rates move more in tandem. Here, the magnitude considered in the table—a one-unit change in the co-movement of the NEER—represents approximately a one-standard-deviation shock to this variable, again implying a small impact (about 0.05) in the context of the standard deviation of food inflation co-movement. The most novel finding here is that co-movement in rainfall (deviations from monthly averages) across countries is associated with greater food inflation co-movement—the monsoon effect. This finding indicates that similar (external) weather shocks play a distinct role in determining cross-country inflation co-movement in Asia, above and beyond that of more standard Phillips curve determinants.[9] The result also resonates with the findings of Parker (2018), in which external (global) factors play a greater role in driving food-price inflation. A one-unit shock to rainfall co-movement is large (about 4 standard deviations) and so once again the impact of such a shock on food inflation co-movement is modest—a one-standard-deviation shock would contribute to about a 0.025 unit change in the average food-inflation quasi-correlation. Finally, the impact of co-movement in money-supply growth rates on food inflation co-movement is not statistically significant—this echoes the finding of Auer and Mehrotra (2014).[10]

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[9] For a general discussion on climate change and agriculture in developing countries, see Mendelsohn (2008). The broader issue of climate change and economic activity is considered in IMF (2017), and in the African context the relationship between rainfall and growth is considered by Barrios, Bertinelli and Strobl (2010) and Lanzafame (2014).

[10] Additional specifications using co-movement in deposit rates in place of money supply growth yield very similar results.

Results in column (2) introduce time fixed effects to the analysis (γ_t), intended to capture any common global shock at any given point in time. The main results described above are preserved. Finally, the results in column (3) consider the same specifications as in (2) but allowing for country-pair fixed effects (δ_i). The main results regarding the monsoon effect (rainfall) and NEER co-movement are broadly unchanged, though the role played by trade integration is completely subsumed by this fixed effect. This is likely because country pairs generally have relatively stable trade relationships over time, and so it is impossible to distinguish between (time invariant) country-pair fixed effects and their degree of trade integration.

Table 1. Food inflation co-movement regressions

	(1)	(2)	(3)
QC FOOD (3mma)			
QC RAIN DEV	**0.118*** **	**0.106** **	**0.096***
	(0.042)	(0.042)	(0.048)
TRADE	**0.249*** **	**0.256*** **	-0.825
	(0.075)	(0.072)	(0.971)
QC NEER	**0.050*** **	**0.055*** **	**0.046*** **
	(0.014)	(0.017)	(0.017)
QC M2	0.002	0.003	0.006
	(0.015)	(0.014)	(0.014)
Constant	0.001	-0.070	0.003
	(0.020)	(0.075)	(0.111)
Observations	3,914	3,914	3,914
R-squared	0.01	0.03	0.03
Number of country pairs	59	59	59
Country-pair fixed effects?	no	no	yes
Time fixed effects?	no	yes	yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Core Inflation

Next, the drivers of core inflation co-movement are considered, with regression results reported in Table 2. The specifications considered here, in terms of use of fixed effects, and explanatory variables included, are the same as in Table 1 on food inflation co-movement. The parameter values are much less precisely estimated than in the case of the food inflation co-movement regressions. The lone consistent result is that in all specifications, co-movement in the NEER is positively associated with core inflation co-movement, indicating a (common) role for exchange-rate passthrough among country-pairs in Asia. Although there appears to be a mild positive relationship between rainfall co-movement and core inflation—possibly suggesting a common role for second-round effects from food inflation onto core—this result is not statistically significant. The lack of meaningful relationship between core inflation co-movement and any of the explanatory variables suggests that idiosyncratic (domestic) factors dominate the core inflation process, aligned with the argument of Forster and Tilman (2014). These results also suggest an important nuance to the conclusion of Auer and Mehrotra (2014)—even in cases of heightened trade integration, elevated co-movement in headline CPI inflation may be more attributable to food inflation than core, for emerging and developing countries in Asia. The lack of precise estimates in these regressions could also be an artefact of the limited data available on core inflation in the group of countries under study.

Table 2. Core inflation co-movement regressions

	(1)	(2)	(3)
QC CORE (3mma)			
QC RAIN DEV	0.031	0.022	0.027
	(0.042)	(0.041)	(0.043)
TRADE	-0.059	-0.050	-0.376
	(0.065)	(0.069)	(0.520)
QC NEER	**0.036****	**0.068*****	**0.070*****
	(0.016)	(0.022)	(0.022)
QC M2	-0.000	-0.003	-0.004
	(0.014)	(0.016)	(0.016)
Constant	-0.003	-0.053	-0.084
	(0.028)	(0.060)	(0.109)
Observations	1,565	1,565	1,565
R-squared	0.01	0.11	0.11
Number of country pairs	25	25	25
Country-pair fixed effects?	no	no	yes
Time fixed effects?	no	yes	yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

IV. ROBUSTNESS

The main elements of the baseline specification which warrant robustness testing are the chosen frequency for inflation rates (and rates of change of some independent variables) as well as the definition of equilibrium (x^*) used in the calculation of instantaneous quasi correlations. Three-month moving average rates are used in the baseline analysis; as noted previously, this reflects a desire to smooth out very high frequency fluctuations in the monthly data and impose an implicit lag structure on the analysis. However, this implicit lag structure—in which the variation in explanatory variables over the current and preceding two months can influence the dependent variable—is arbitrary, and so in what follows analysis is also conducted using month-on-month, 4- and 6-month moving average rates of change for all variables. In addition, an alternative method of constructing quasi correlations is explored, using the country- and variable-specific average of each series as the equilibrium ($x^*_{i,t}$) against which deviations are calculated.

Beginning with the food inflation co-movement regressions, robustness checking is conducted for the preferred 'baseline' specification (column 2 of table 1). Results using 4-month moving average rates of change are shown in the first column of table 3. The baseline result for the monsoon effect (common deviations of rainfall from monthly norms) is upheld, with this variable showing a strongly statistically significant association with food-inflation co-movement across country pairs in the sample. Trade integration and the co-movement in the NEER across country pairs continues to be associated with greater food co-movement as well. Additional results are shown for 6-month moving average in column 2. Co-movement in nominal effective exchange rates remains statistically significant, though trade integration is not. The monsoon-effect result remains positive but loses statistical significance (p-value of about 0.2) using the substantially smoothed data implied by the 6-month moving average. This implies some sensitivity of the monsoon effect to the smoothness (or, degree of inertia) of the chosen inflation series.

The sensitivity of the monsoon effect to the chosen frequency of the inflation data is also highlighted in column 3, where month-on-month rates of change are considered. In all likelihood, shocks to weather patterns would take time to feed through into agricultural production, and hence prices, thus it is not surprising that the relationship between inflation and rainfall is muted at such a high frequency. However, trade integration remains an important factor for explaining inflation co-movement, even at this frequency.

In column 4, the results using sample-average estimates of equilibrium values in the quasi-correlation calculations are shown, using the baseline 3mma frequency. Once again, although the point estimates for the main variables of interest differ slightly from those in Table 1, the thrust of the results regarding statistically significant roles for deviations of rainfall from seasonal norms, trade integration and NEER co-movement are upheld.

Proceeding next to the core inflation co-movement regressions, Table 4 presents the same robustness checks. In the case of the 4mma (HP equilibrium notion, column 1), month-on-month (column 3), and 3mma sample-average-equilibrium-notion specifications (column 4), the NEER remains the only explanatory variable which has an intuitive and statistically significant explanatory role for core inflation co-movement. In the specification relying on 6mma rates of change for inflation and the other determinants (column 2), there is no discernable role for any variable in explaining core inflation co-movement.

Table 3. Food inflation co-movement, robustness checks

	(1)	(2)	(3)	(4)
QC FOOD	4mma (HP)	6mma (HP)	mm (HP)	3mma (AVG)
QC RAIN DEV	**0.133****	0.240	0.003	**0.116****
	(0.061)	(0.205)	(0.012)	(0.054)
TRADE	**0.314*****	0.145	**0.221*****	**0.306*****
	(0.081)	(0.091)	(0.071)	(0.079)
QC NEER	**0.044*****	**0.099*****	0.016	**0.058*****
	(0.017)	(0.022)	(0.015)	(0.021)
QC_M2	0.006	-0.013	-0.009	0.008
	(0.012)	(0.026)	(0.011)	(0.012)
Constant	-0.104	-0.048	-0.045	-0.061
	(0.112)	(0.044)	(0.045)	(0.138)
Observations	3,849	3,743	4,082	3,914
R-squared	0.04	0.06	0.03	0.07
Number of country pairs	58	58	61	59
Country-pair fixed effects?	no	no	no	no
Time fixed effects?	yes	yes	yes	yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4. Core inflation co-movement, robustness checks

	(1)	(2)	(3)	(4)
QC CORE	4mma (HP)	6mma (HP)	mm (HP)	3mma (AVG)
QC RAIN DEV	0.008	0.106	-0.021	0.036
	(0.043)	(0.223)	(0.018)	(0.053)
TRADE	-0.054	0.009	-0.028	-0.001
	(0.090)	(0.142)	(0.085)	(0.115)
QC NEER	**0.066*****	0.045	**0.044***	**0.068*****
	(0.022)	(0.030)	(0.024)	(0.023)
QC_M2	-0.004	0.002	-0.014	0.017
	(0.014)	(0.031)	(0.018)	(0.019)
Constant	-0.119	-0.129	-0.053	0.020
	(0.094)	(0.136)	(0.058)	(0.045)
Observations	1,532	1,476	1,648	1,565
R-squared	0.11	0.09	0.06	0.14
Number of country pairs	25	25	27	25
Country-pair fixed effects?	no	no	no	no
Time fixed effects?	yes	yes	yes	yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

V. Conclusions

Common rainfall patterns are associated with higher food-inflation co-movement across emerging and developing countries in Asia, plausibly because agricultural production in these countries is more reliant on natural rainfall. This provides an economic explanation for some results from the literature on ‘global inflation,’ which generally show that common factors across countries can explain a meaningful share of common variation in headline inflation rates. This paper also finds that co-movement in food inflation is partly related to trade integration and common exchange-rate movements. By contrast, co-movement in core inflation rates is weak and not attributable to standard determinants, with the exception of exchange-rate co-movement.

Although these results do nothing to diminish the widely held view that inflation co-movement is strong between countries who are more integrated (the result of Auer and Mehrotra, 2014), they do suggest a need for nuance in this message: in the sample of emerging and developing Asian economies considered here, inflation co-movement is only strong for the food sub-category and is only partly due to inflation spillovers emanating from one country through standard trade channels. A common factor—the monsoon effect identified by this paper—also plays a role. The weak co-movement in core inflation implies that idiosyncratic domestic factors drive the process. These findings are critically important for monetary policy, especially since domestic policy is primarily effective only in controlling core—and not food—inflation. This implies that domestic monetary policy needs to be calibrated to domestic inflationary pressures, and that countries who are highly economically integrated cannot necessarily rely on stable inflation in their neighbors to achieve domestic inflation objectives.

There are several important caveats to the current findings which could be examined more closely in future work. First, a lack of data in many developing countries in Asia limits the sample period over which inflation co-movement can be considered—this implies that the results could be driven by abnormal events, insofar as the sample period considered (spanning seven years) is not representative of the ‘normal’ functioning of the inflation process. Similarly, a lack of data on industrial production or other metrics of demand pressures make it hard to control for co-movement in economic circumstances, though including time fixed effects goes a considerable distance towards addressing this, as does co-movement in M2 growth. Second, the observed strong co-movement in food prices may be driven disproportionately by specific sub-components—future work could delve into the commonality of weather cycles and inflation rates for different crops, with an emphasis on whether those which are more dependent on rainfall exhibit greater co-movement. Finally, although core CPI inflation co-movement appears to be weak in most cases, this does not imply that price *levels* do not move in tandem over time, especially between countries which are more highly integrated.

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Appendix

Table A1 : Data Sources

Series	Data Sources	Countries Missing Data
CPI: Headline	Haver Analytics, National Authorities	(none)
CPI: Food	Haver Analytics, National Authorities	(none)
CPI: Core	Haver Analytics, National Authorities	Cambodia, Mongolia, Pakistan, Vietnam
M2	Haver Analytics, National Authorities, IMF IFS	(none)
Rainfall	The World Bank	(none)
Import Share	DOTS	(none)
Nominal Effective Exchange Rate	IMF INS	(none)

Source: IMF Staff

Note: IFS = International Financial Statistics; INS = Information Notice System; DOTS = Direction of Trade Statistics.

Table A2: Core CPI definitions

Country	Core CPI Definition
Bangladesh	Ex-food
Bhutan	Ex-food
Cambodia	N/A
China	Ex-food and energy
India	Ex-food and energy
Indonesia	Ex-food
Malaysia	Ex-food and energy
Mongolia	N/A
Nepal	Ex-food and selected services
Pakistan	N/A
Philippines	Ex-food and energy
Thailand	Ex-food and energy
Vietnam	N/A

Table A3. Cross-Country Correlations in Headline Inflation

	Bangladesh	Bhutan	Cambodia	India	Indonesia	Malaysia	Nepal	Pakistan	Philippines	Thailand	Vietnam	China	Mongolia
Bangladesh	.												
Bhutan	0.09	.											
Cambodia	0.27	0.45	.										
India	0.24	0.43	0.14	.									
Indonesia	0.32	0.28	-0.26	-0.01	.								
Malaysia	0.54	0.10	0.24	0.06	0.27	.							
Nepal	0.14	0.15	-0.15	0.50	0.30	0.15	.						
Pakistan	0.32	0.55	0.34	0.43	0.17	0.42	0.37	.					
Philippines	0.58	0.38	0.35	0.15	0.36	0.58	0.33	0.53	.				
Thailand	0.69	0.25	0.44	0.11	0.19	0.46	0.05	0.39	0.59	.			
Vietnam	0.61	0.33	0.54	0.30	0.25	0.46	0.17	0.69	0.66	0.57	.		
China	0.55	0.05	0.49	0.15	-0.03	0.19	-0.13	0.37	0.22	0.43	0.56	.	
Mongolia	0.14	0.42	0.17	0.46	0.14	0.09	0.12	0.46	0.25	0.40	0.20	0.21	.

Sources: Author's calculations

Table A4. Cross-Country Correlations in Food Inflation

	Bangladesh	Bhutan	Cambodia	India	Indonesia	Malaysia	Nepal	Pakistan	Philippines	Thailand	Vietnam	China	Mongolia
Bangladesh	.												
Bhutan	0.37	.											
Cambodia	0.15	0.31	.										
India	-0.25	0.40	0.09	.									
Indonesia	0.17	0.00	-0.20	0.15	.								
Malaysia	0.39	0.09	-0.03	-0.10	0.32	.							
Nepal	0.08	0.05	-0.16	0.42	0.28	0.08	.						
Pakistan	0.24	0.39	0.17	0.45	0.15	-0.03	0.30	.					
Philippines	0.50	0.57	0.01	-0.06	0.19	0.61	0.25	0.07	.				
Thailand	0.36	0.16	0.12	0.02	0.26	0.51	0.23	0.20	0.44	.			
Vietnam	0.56	0.21	0.44	-0.16	0.33	0.57	0.17	0.35	0.65	0.63	.		
China	0.33	0.01	0.35	0.02	0.13	0.02	0.00	0.39	0.17	0.23	0.50	.	
Mongolia	-0.28	0.34	0.03	0.47	0.08	-0.27	-0.06	0.32	-0.05	0.06	-0.02	0.11	.

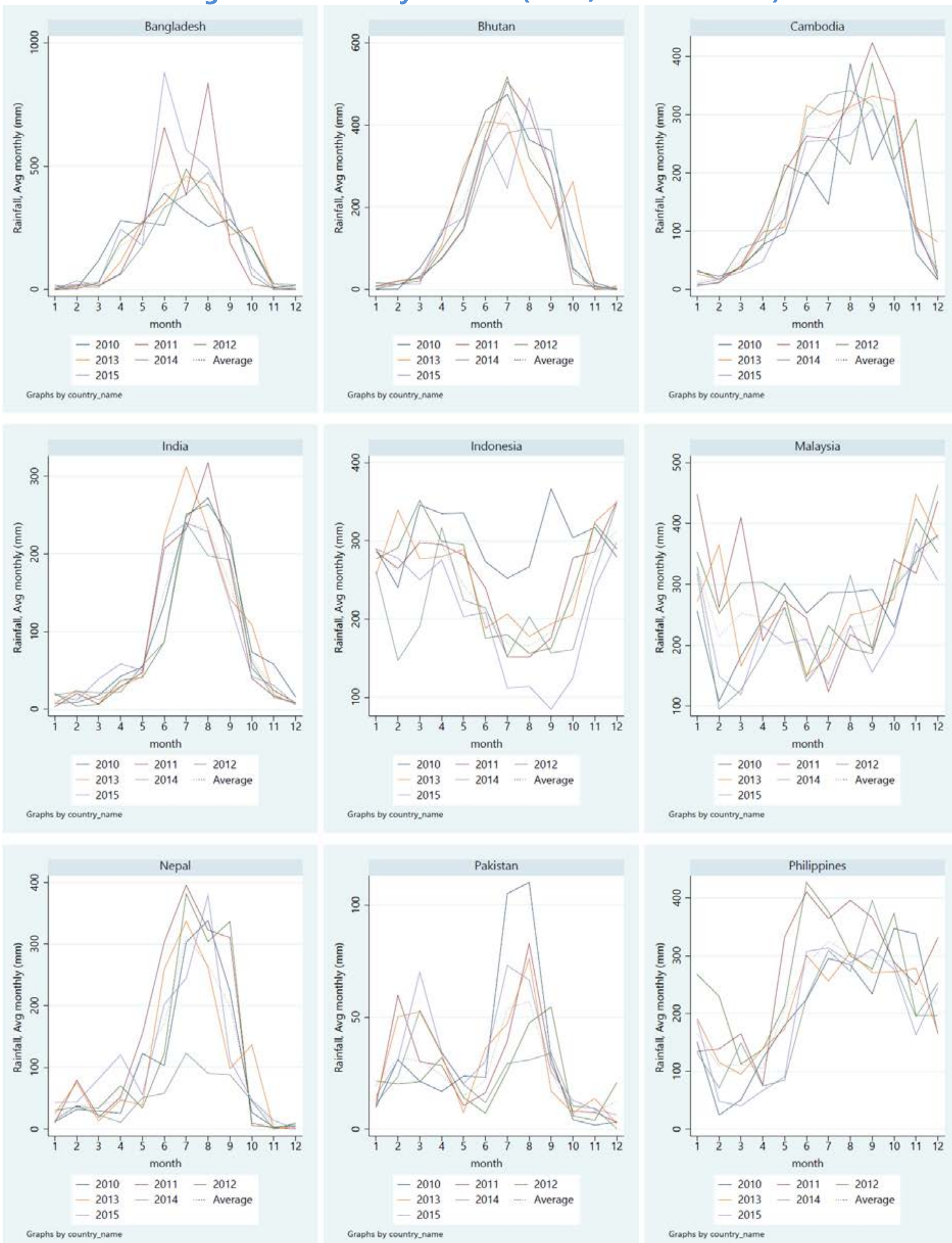
Sources: Author's calculations

Table A5. Cross-Country Correlations in Core Inflation

	Bangladesh	Bhutan	Cambodia	India	Indonesia	Malaysia	Nepal	Pakistan	Philippines	Thailand	Vietnam	China	Mongolia
Bangladesh	.												
Bhutan	0.03	.											
Cambodia	.	.	.										
India	0.25	0.09	.	.									
Indonesia	0.17	0.21	.	0.17	.								
Malaysia	0.22	-0.05	.	-0.16	0.31	.							
Nepal	0.45	-0.06	.	0.18	0.27	0.17	.						
Pakistan	.	.	.	.	.	.	.	.					
Philippines	-0.06	0.03	.	0.39	-0.30	-0.28	0.05	.	.				
Thailand	0.01	-0.07	.	0.14	-0.10	-0.08	-0.11	.	-0.18	.			
Vietnam	.	.	.	.	.	.	.	.	.	.	.		
China	0.12	-0.31	.	-0.08	-0.17	0.22	0.22	.	0.09	0.09	.	.	
Mongolia	.	.	.	.	.	.	.	.	.	.	.	.	.

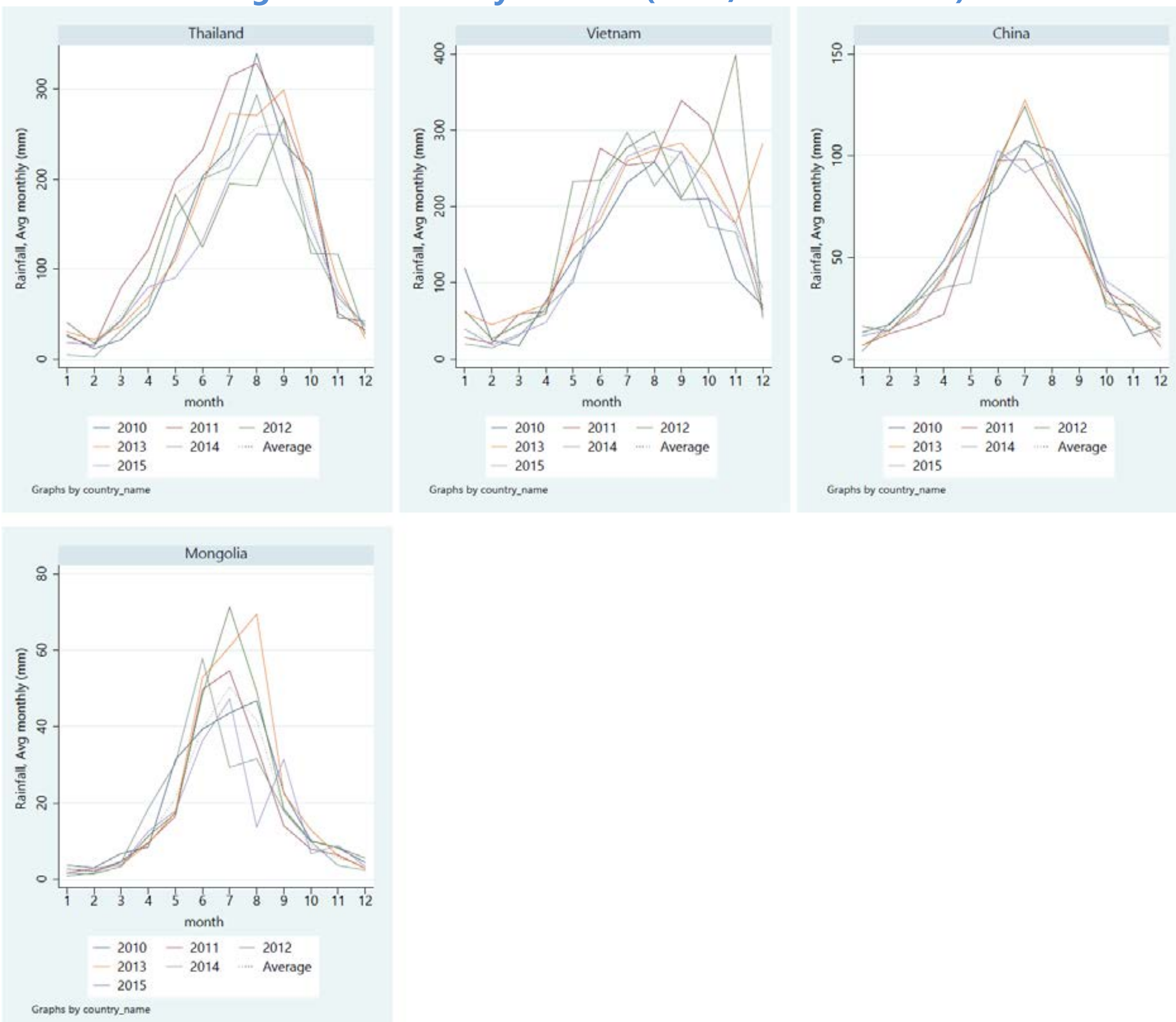
Sources: Author's calculations

Figure A1. Monthly Rainfall (*total, in millimeters*)



Sources: World Bank Climate Change Portal, and Author's calculations

Figure A2. Monthly Rainfall (*total, in millimeters*)



Sources: World Bank Climate Change Portal, and Author's calculations