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Developing Unprecedented Restlessness As The New Strong Indicator of Rice Crisis at National Level

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Abstract

This paper develops, validates, and runs a new rice crisis indicator. The hypothesis to be tested is: "Unprecedented restlessness (UR) is the strong indicator of rice crisis". UR is tested masively in nineteen countries. This research successfully identifies that UR is strong indicator for rice crisis at national level. UR has passed two statistic tests, rg and Q and both statistics are significant.This paper recommends UR is used to assess effectiveness of an agricultural plan that aim to avoid rice crisis

Keywords: Rice Crisis, Strong Indicator, Unprecedented Restlessnes

Rice Crisis Definition

Merriam-Webster online defines the word "crisis" as *a difficult and dangerous situation that needs serious attention*. Referring to this definition, we perceive crisis as a situation in which intolerable bad things happen because it is when things become intolerably bad theyneed serious attention. In this sense, we perceiverice crisis as a difficult, dangerous, intolerable situation caused by ricescarcity. However, what is that difficult, dangerous, intolerable situation? Is it the situation in which a million people die of hunger? If it is so, why is one person died not perceived as crisis?What about one thousand?

There are not any widely accepted criteria defining the severity of situation as crisis. Defining a level of crisis for both analytical and operational purposes has proven an elusive task (J.Cuesta,.Htenas, andS.Tiwari, 2014), FAO-GIEWS (Global Information and Early Warning System on Food and Agriculture) does not have a formal definition for food crisis either, but establishes three conditions that categorize a region asin a food crisis: (i) lack of food availability; (ii) limited access to food; and (iii) severe but localized problems. The World BankGlobal Food Crisis Response Program—under whose guidelines US$1.2 billion were mobilized between 2008 and 2012—also does not contain an explicit definition of food crisis.the UN International Strategy for Disaster Reduction (UNISDR) discusses disasters that affect food security; however, its Strategic Framework 2025 does not mention food crisis (UNISDR, 2011).

Nevertheless, we cannot define crisis by the number of suffering people because itis contextual, subjective, as well as artificial. We have to think of something that is more substantive than just the number.

In this paper we definerice crisis as a situation in which *a prolonged uncontrollable riot occurs because of rice scarcity.* We pursue this definition because we assume that solutions to the rice scarcity problem will be hard to find or to implement when people are rioting uncontrollably. How can government find or implement solutions when people are blocking roads, destroying public facilities, and looting food?This kind of riot may also ruin research investments as well as research facilities. Scientists will loose their productive time. It is not impossible that this situation leadsto political chaos. In this situation government will shift its focus to restoring public order and facilities. This will consume significant state resources and disrupt the solution finding process eventually. This is indeed a critical situation that has to be avoided. Rice may hard to find, people may suffer, but as long as the government stays focus on finding solutions we have little to worry.

What is the uncontrollable riot which we are so afraid of? There is not any quantitative answer to this question. The scaling system measuring riot controllability rarely exists in papers. The suggested riot scaling systems have not yet accepted globally. However, there were horrific food-related riots in year 2008 that received global attention.The severityof the situation during those years was widely reported. The 2008 food crisis was a wake-up call not just for Africa, other countries around the world with burgeoningpopulations and insufficient resources to feed them also responded to the ‘call’ (CGIAR, 2011).A summary report of food riotsthat erupted across theglobe in 2008outlines state responses to the food riots and sketches the state of democracy in countries where riots occurred (Mindi Schneider, December, 2008).

In this paper, we perceivethe riots happening in year 2008 as the prolonged uncontrollable ones.

The Model: Unprecedented Restlessness as New Strong Indicator for RiceCrisis

Why did people riot uncontrollably in year 2008? It is obvious that people riot because they feel restless. They feel restless when their life burden becomesheavier. However, life burden is likely to changeand the change is expectednot to be favorable to people because supplies increase arithmetically while consumptions increase geometrically (Robert Malthus, 1798). Meanwhile, human being, as well as other creatures, has a capability of adapting to changing environment. In rather exaggerated way, we know from Charles Darwin’s theory of evolution that “…*when members of a population die they are replaced by the progeny of parents* ***better adapted*** *to survive* ...” (Ashley et al., 2012). Yet people rioted uncontrollably in 2008. Why?

The only plausibleanswer to the previous question is because people felt extra ordinary burden in 2008. The burden was so unusual that it impaled the adaptive feature of human being. In short words, the burden of life in 2008 was **unprecedented**. This unprecedented burden ledto **unprecedented restlessness** and forced people to riot uncontrollably eventually.

How can we quantify the burden of life? Some researchers use food price to analyze life burden precedence. The World Bank is currently developing a monitoring framework that defines, identifies, and monitors food price crises at both global and national levels (J. Cuesta, A. Htenas, and S.Tiwari, 2014).International Food Policy Research Institute (IFPRI)presents the latest research undertaken to respond to the global food crisis. The tools developed provide a visual representation of historical periods of excessive global price volatility from 2000-present, as well as a daily volatility status. This status can alert policymakers when world markets are experiencing a period of excessive food price volatility; this information can then be used to determine appropriate country-level food security responses, such as the release of physical food stocks (Food Security Portal, IFPRI, 2012). Many scholars have examines the diverse effects of this rise in food prices, from hindering economic growth (Carolan, 2012; Cruz, Sanchez, & Amann, 2011; Kamgnia, 2011), contributing to general inflation (Jalil & Zea, 2011; Sand & Støholen, 2008), leading to greater inequality (Chaudhry & Chaudhry, 2008; Vu & Glewwe, 2011) to having detrimental effects of health and welfare (Gustavo, Silvio, & Erdgin, ?; Hadley, Stevenson, Tadesse, & Belachew, 2012). Azzeddine & Belaid, and Mohsin & Zaman, 2012 have shown that the poor and those in extreme poverty are especially susceptible to food price shocks.

We findthat this approach is rather counter-intuitive. Why should people feel restless when the food price is increasing if they can still buy the food? The rice price in Indonesia increased 28% from $US 0.16240 in 1992 to $US 0.20840 in 1995 (http://www.fao.org/giews/pricetool/).Did it mean that the burden of life increased too?

Obviously it did not because GNI per capitaalso increased 31% from$US 834.64 in 1992 to 1094.17 in 1995 (http://data.worldbank.org/indicator/).

These facts showthat the fluctuation of food price does not always reflect the fluctuation of burden. Consequently, analyzing burden precedence by inspecting food pricefluctuation can be bias.

In this paper, we develop restlessness ratio to quantify the burden of life. Mathematical expression of restlessness ratio (R) as the ratio between the price and the per capita income is:

$$R = \frac{\mathrm{P}}{\mathrm{I}}$$

Where,

P=Rice price

I=Income percapita (GNI per capita)

Restlessnessratio (restlessness for short) is comparable from year to year.Twoyears having the same restlessness ratio exertthe same burden to people expectedly. The year having greater restlessness exertsheavier burden to people than thathaving the lesserone.

Hypothesis

Unprecedented thing is the onethat has never been experinced before. Something that is unprecedented is not known. We are deservedto worryabout something unprecedented. If someone has never experienced a bad period then we worry about his not being ableto succeed in experiencing that bad times. This also applies to restlessness. Therefore, we will consider the following hypothesis:

"Unprecedented restlessness is the strong indicator of rice crisis at national level"

If this hypothesis can be proved statistically then the indicatorcan be used to assess the effectiveness of the solutions for avoiding rice crisis in the future. When a solution has been made, itcan be assessed whether it is indeed an action plan that provides a safe condition. This is a logical consequence of the strong nature of the indicator. If there is unprecedented restlessness then it will be followed by a crisis immediately.Conversely, if there is not then there will be no crisis.

Methodology

Guided by the previous thought, we want to explore empirically the role of unprecedented restlessnesson rice crisis.Unprecedented restlessness as the proposed indicator of the rice crisis should be verified empirically to obtain statistical justification. Validation test will be conducted toensure that the indicator is a valid one in detecting the presence and the absenceof a rice crisis.Unprecedentedrestlessness is stated as a rice crisis indicator if and only if it has strong characteristic. It has strong characteristic if the presence of unprecedented restlessness event is followed by rice crisis immediately and the absence of it means no rice crisis occurs.

Proving that unprecedented restlessness is the strong indicator of rice crisis is the big deal of this research.It requires collecting datamassivelyon the incidence ofrice crisis and no crisis events in many countries in the world.This isquite a challenge.To test our hypothesis, we have developed a new method to know whetheran indicator is strong or not.The method to obtain convincing statement that the unprecedented restlessnessis a strong indicator is asfollows:

Population Criteria and Data

Population

Criteria of the countryto be included in the study of rice crisis are as follows:

a. The country's staple food is rice.

A country is said to have rice as the staple food if statistics for rice consumption per capita is ranked top. Appendix A (online) reports 180 countries that consume rice in the world.To get countries that meet criteria, we have done the rating on the pattern of food consumption in every country around the world. From 180 countries, there are 33 countries that their rice consumptionsare ranked top.The results of ranking process are presented in Appendix B (online).Thesefacts are not sufficient.Further screening on substitute properties is required.

b. Rice cannot be substituted with other staple foods in rank 2 or 3.

We assume that as long as there is main food substitute, there will be no riot.Why should people riot if they can comfortably eat alternative food?

Statistics of food substitute is determined byinsignificant difference in two or more food consumptions. If the difference between the consumption pattern of riceand that of rank 2 is more than 10% then rice is believed to beirreplaceable in the country. If the difference is not more than 10% then the country is not included in the study. In this case, rice is believed to be substitutable in that country.

Based on these criteria, 29 countries are obtained.The results are presented in Appendix C (online).Deeper obsevation into the 29 countries revealsthat only 19 countries have complete data about the price of rice and per capita income.Therefore, this research has a population size of 19 countries, Table 1.

Table 1.Population of 19 countries where rice consumption is dominant compared to other staple foods.Source: authors'processing-world bank data

No	Country Code	Country Name	Item	Food supply quantity (kg/capita/yr) (Kg)	Gap Between 1st rank and 2nd rank
1	16	Bangladesh	Rice (Milled Equivalent)	174.3	78%
			Potatoes and products	37.8	
			Wheat and products	15.9	
2	26	Brunei Darussalam	Rice (Milled Equivalent)	75.1	46%
			Wheat and products	40.2	
			Maize and products	12.1	
3	28	Myanmar	Rice (Milled Equivalent)	129.9	93%
			Potatoes and products	9.3	
			Cassava and products	5.8	
4	38	Sri Lanka	Rice (Milled Equivalent)	104.8	63%
			Wheat and products	38.9	

			Cassava and products	8	
5	41	China, mainland	Rice (Milled Equivalent)	77.8	17%
			Wheat and products	64.7	
			Potatoes and products	38.2	
6	48	Costa Rica	Rice (Milled Equivalent)	48.6	20%
			Wheat and products	38.9	
			Potatoes and products	17.1	
7	56	Dominican Republic	Rice (Milled Equivalent)	45	45%
			Wheat and products	24.7	
			Cassava and products	9.8	
8	58	Ecuador	Rice (Milled Equivalent)	43.8	16%
			Wheat and products	36.7	
			Potatoes and products	15.5	
9	100	India	Rice (Milled Equivalent)	72.2	16%
			Wheat and products	60.8	
			Potatoes and products	21.8	
10	101	Indonesia	Rice (Milled Equivalent)	128	66%
			Cassava and products	43.5	
			Maize and products	31.6	
11	115	Cambodia	Rice (Milled Equivalent)	158.9	84%
			Cassava and products	25.3	
			Maize and products	11.1	

12	116	Democratic People s Republic of Korea	Rice (Milled Equivalent)	75	44%
			Potatoes and products	42	
			Maize and products	41.8	
13	120	Lao People s Democratic Republic	Rice (Milled Equivalent)	159.6	90%
			Cassava and products	16.7	
			Maize and products	15.7	
14	131	Malaysia	Rice (Milled Equivalent)	80.3	32%
			Wheat and products	54.5	
			Cereals, Other	8.3	
15	166	Panama	Rice (Milled Equivalent)	60.1	39%
			Wheat and products	36.4	
			Maize and products	24.1	
16	171	Philippines	Rice (Milled Equivalent)	131	85%
			Cassava and products	20.2	
			Maize and products	13.5	
17	195	Senegal	Rice (Milled Equivalent)	73.1	60%
			Wheat and products	29.1	
			Maize and products	26.6	
18	216	Thailand	Rice (Milled Equivalent)	117.9	89%
			Cassava and products	13.2	
			Maize and products	9.7	

19	237	Viet Nam	Rice (Milled Equivalent)	145.7	92%
			Maize and products	11.4	
			Wheat and products	10.8	

Precedence Analysis UsingModifiedIndividual Control Chart[I-CHART]
Restlessness(R) is calculated by dividing producer rice price by GNI per capita (constant 2005 $US).The control chart or process behaviour chart is used as statistical tool to describeaccurately what is meant by unprecedented event. The appropriate control chart for precedence analysis is Modified Individual Control Chart (I-CHART), from fixed average to moving average.
Analysis is conductedfor each of 19 countriesand each period of observation.The normal distribution is not assumed nor required in the calculation of control limits, making the I-CHARTa very robust tool. This was demonstrated by Wheeler [Wheeler, Donald J., (2009-07-06), retrieved 2010-02-08] and for a number of highly non-normal distributions [5] [Wheeler, Donald J. (2009-08-05), retrieved 2010-02-08]As with other control charts, the Individual Control Chartconsists of points plotted with the control limits. Points outside these control limits are signals indicating that the process is not operating as consistently as possible; that some assignable causeshave resulted in a change in the process.Individual Control Chartis also used to monitor the effects of process improvement in before-after treatment. Contextual issues in applying Individual Control Chartare discussed by Wheeler, Donald J. (2009-05-26).The key element in using theI-CHARTis to make sure that successive values are logically comparable. This requires some knowledge of the data context.Restlessness variable meetsthe context.
The detection of unprecedented restlessness is done by plottingrestlessness datainthe Individual Control Chart.In doing so, a period of observation, including the crisis period of 2008, is set for the 19 countries. The resulting plots are analyzed, any point above the upper control limit is marked and considered as signal of changes in the underlying process that is worth further investigation.In this case if the value of R fallsunder the upper control limit then it is interpretedas unprecedented event's not being identified. If it rises above the upper control limit then it is interpretedasitsbeing out of control and, therefore, unprecedented restlessness is detected.

Calculation of individualcontrol limits
The average of the individual values is calculated as follow:

Centerline= $\overline{X}$

This corresponds tothe process average (the mean of the normal distribution). This line is usually plotted as a horizontal solid line. Above and below this are the upper control limit (UCL) and lower control limit (LCL) lines which represent L standard deviations above and L standard deviations below the process mean.
L is the "distance" of the control limits from the center line, expressed in standard deviation units.

$\bar{X} \pm L\sigma$

The estimate of the process standard deviation is S.In theUnited Kingdom and parts of Western Europe, probability limits are used, with the standard probability level in each direction being 0.001, then the appropriate multiple of the standard deviation would be 3.09then

LCL= $\bar{X} - 3.09S$

UCL= $\bar{X} + 3.09S$

Where S is a sample standard deviation

$$S^2 = \sum_{i=1}^{n} \frac{(x_i - \bar{X})^2}{n-1}$$

$$S = \sqrt{S^2}, \bar{X} = \sum_{i=1}^{n} \frac{x_i}{n}$$

In modivied Individual chart, I-CHART, n is not fixed as in usual individual control chart then we must calculate the moving average one rather than fixed average.The moving Average denoted by MA(m) can be expressed mathematically as follows:

$$MA(m) = \sum_{i=1}^{m} \frac{x_i}{m},$$

Where m=5, 6, 7,..., N-1, and N represent all data in time series.

The use of three-sigma control limits is justified on the basis that they give good results in practice [Montgomery, Douglas, 2009]. [Shewhart, 1931] argued from experience that the use of three sigma limits made economic sense. Once the average and limits are calculated, all of the individuals data are plotted serially, in the order in which they were recorded. To this plot are added a line at the average value (*x)* and lines at the *UCL* and *LCL* values.

The underlying spirit of Modivied Individual Control Chart [I-CHART]

Definition

Unprecedented restlessness is a situation which is significantly worse than previous habit (never been experinced before).The main objective of accurate control chart design is to obtain a strong evidence on the relationship between rice crisis occurence and precedented restlessness event. It means that unprecedented restlessness is not an indicator if a lot of countries that experienced unprecedented restlessness were not in crisis. We want to obtain a convincing evidence by testing it massively on 19 countries as the proving ground.

Scrutiny of the unprecedented-restlessness definitionreveals three factors that determinethe precedence analysis: “habit”, “previous” and “unprecedented”.What is habit? After how long we may statesomething as“habit”? One year? Two years? Three years? If we already know the meaning of “habit” then we can judge something as unusual, out of the ordinary, or out of the box. The term “habit” is not a mathematical issue, but it is a human issue.

“Habit” is a strategic word to assess the unprecedented event. In this case the habit is expressed by the control chart created in an adequate period to reflect the terminology of habit (usual behaviour). This is because the control chart canseparate the usual variation from the unusual (not previously observed) one.This ability suits the definition of unprecedented event. [Henderson, 2011] The control chart is used to

decide whether a process is stable over time, within limits of variation due to common causes.
The word “previous” in the definition is very important because check year, as a check point the precedence of which is to be determined, is not included in the creation of the control chart. This is new in control chart common practice.
The following are detail explanations concerning the three factors mentioned above.There are three parameters in Individual control chart (I-CHART) that will determine its accuracy.All those three parameters are:
n = the number of observations
L = the width of the control chart
i = check points (time in year)
As a consequence of the underlying spirit above, we cannot apply directlythe existingI-CHARTbecause it does not perform an integrated analysis of the interrelationship among the three parametersof control (n, L, i) that produce accurate I-CHART.
We have an infinite number of combinations of (n, L, i).Someconfigurations lead i tobecome unprecedented-restlessness events. For example, if the control chart isnarrowed by shrinking the L thenthere will be so many bad things or unprecedentedevents.
We propose some modifications in the creation of control chart that correspond to strong indicator detection, thus it can enhance the chart’s ability to detect an out-of-control state.In this case we have to fitI-CHARTto crisis data as listed
in the two documents above.The next process is to measure the accuracy of
I-CHART, whether the chartisaccuratein reflecting the rice crisis events in 19 countries.I-CHART accuracy depends on the choice of n and L without outlier removal.So, the fitting means choosing the values of n and L that are closest to the actual data which are the data of rice crisis and non-crisis in 19 countries as the proving ground.Here are the detailed specifications of the modifications.

The new Creation of Control Chart

A. Specifying Length of range (n):

Weiler(1952) suggested that for a chart, theoptimum sample size should minimize the total amount of inspection required to detect a specified shift.
If the shift is from an in-control state $\mu_0$to an out-of-control state
$\mu_1 = \mu_0 + \delta\sigma$,
then Weiler shows that the optimal sample size is
$n=12/\delta^2$ when 3.09-sigma control limits are used
In this context, the period of a government regime is the starting point in assessing a habit. This is a strategic reason to assess the habit. Thus, the four-year time period is used as initialization to talk about a habit. In this case the Individual control charts are set up, starting from 4 yearrestlessness data and the 5th year restless data is used as the.
Further searches are computrerized to find out the period length of rangethat is accurate in modeling the food riot as a criterion of rice crisis events in 19 countries.A

computer program has been developed to obtain the best result from various possible configurations.

B. Specifying the width of the control chart (L)

n = 4 is an initialization value for the accurate determination of L. Therefore, the first control chart is constructed by using 4 preliminary data on the assumption that a minimum of 4 years is enough to record a habit. Four year experience seems to be good because it is assumedto be recorded in the subconscious mind. In accordance with the objectives, control charts are constructed to detect the incidence of unprecedented restlessness andreflect the facts of food riot events in 19 countries. Based on these considerations a new procedure that take into account the aspect of data outliers was also developed as follows:

I-CHART Without outlier removal procedure

Without outlier removal means that data are not first cleaned of outliers. Therefore, outliers can be found before the check-year. The existence of outliers does not require the I-CHART to be reconstructed. Wedifferentiate unprecedented event from outliers.Outliers can existbefore the check year but unprecedented event can only exist at the check-year. Here is the procedure:

i. Construct the first control chart with a number of observations n = 4 (years) and certain value of L, say 1.50.
ii. Plot the four data on the control chart.
iii. Do unprecedented restlessness tracking using the data on the fifth year period as the check year.Record the result in the check sheet
iv. Stop unprecedented restlessness tracking whenthe check yearsrun out.
v. Present the data of unprecedented-non unprecedented events versus crisis-no crisis facts in contingency table.
vi. Repeat from the first step by changing the number of observations n and the value of L until the resulted contingency table reflects empirical data.

Actually, the procedure above searches the most suitable values of n and L the resulted contingency table of which is the closest to reality. The trial process involves a great number of computations. If the search is not exhaustive enough then there are risks of having the values of n and L that are too large or too small. If the value of n is too large then the I-CHART considers more past data which are no longer relevant to the check year. If the value of n is too small then the I-CHART considers data that are too close to the check year. This contradicts the terminology of “habit” which requires that enough past data are taken into consideration. If the value of L is too large then the I-CHART is too tolerant which is resulting in actually-unprecedented event being regarded as not-unprecedented one. If the value of L is too small then the I-CHART is paranoid which is resulting in actually-not-unprecedented event being regarded as unprecedented one.

To reduce the risks and get the acceptable accuracy, a computer program is developed to do the trial-and-error process of fitting the values of n and L to the riot-and-not-riot events of 19 countries. Once determined, those values become the habit parameters.

C. AnalyzingPrecedence Data on Contingency Table Using G index and Q statistic.

Precedence analysis using individual chart generates a large number of control charts. The Control charts analyze time series data of restlessnes (R) of 19 countries.The events that areout of control are called the unprecedented events and the ones that are in control are called precedented ones. These events are tabulated on a 2×2 contingency table as shown in Table 2. The table is the input for the main part of this study which is testing the following hypotheses:

Hypothesis

$H_0: r_g = 0$ (UR is not a strong indicator for rice crisis)

$H_1: r_g \neq 0$(UR is a strong indicator for rice crisis)

Test Statistics

To test the hypothesis, a measure of association for cross tabulations of nominal-level variables is required. The extent to which Unprecedented Restlessness (UR)is associated with Crisis (C) is measured by examining every possible pairs.Thus a positive association between UR and C is recorded for all concordance pairs in diagonal matrix 2×2.

There are two statistic teststhat can be used, r_g-statistics and Q statistics.

a. r_g-statistics

The **r_g-statistics** in this research is calculated from 2×2 contingency table.It is based upon the proportion of the agreement cases as compared to the proportion of the disagreement ones.

Given a sample of N objects to be classified, Table 2 summarizes the notations used in this thesiswhich characterize four cells inside the agreement table:The cell a refers to the numbers of responses of both raters for the first (or positive) category.The cell b refers to the proportion of agreement responses for the second (or negative) category.Cells a and d are values of entries in diagonal cells of 2 ×2 contingency table, and c and b are numbers of disagreement responses between raters (off diagonal values).

Table 2.Contingency Table 2 x 2 for Precedence Analysis

Precedence Event	Crisis Occurence		
	Rice crisis	No rice crisis	Row Total
Out of control (Unprecedented)	a	b	R1
In control (Not Unprecedented)	c	d	R2
Column Total	C1	C2	N

For the data in a 2×2 contingency table, the accuracy of the agreement table is (Guilford, 1956),

$$r_g = \frac{(a+d)-(c+b)}{N}$$

The test statistic used is

$$z = r_g\sqrt{N}$$

where N is the number of observations.

Decision rule:

Compare calculated value to a critical value which is the normal standard value at the desired confidence level, then reject the null hypothesis if the value of $z > z_{\frac{\alpha}{2}}$ or *p-value* $\leq \alpha = 0.05$ to get the accuracy of the control chart constructed.

b. Q-Statistic

Jopseph F. Hair, JR., William C.Black, Barry J.Babin, Rolph E.Andersen, (2010), Q-statistic is statistically based measures of clasification accuracy relative to chance. Q statisticis able to test the discriminatory power of the contingency table when compared to a chance model.This simple measure compares the entries on the diagonal of the contingency table to the total sample size and the number of groups.The calculated value iscompared to a critical value, then the contingency table can be deemedstatistically better than chance.The Q statistic is calculated by the following formula:

$$\text{Press's Q Statistic} = \frac{[N-(cK)]^2}{N(K-1)}$$

Where

N= total sample size

c=number of observations correctly classified

K=number of groups.

Decision rule: the calculated value is then compared to a critical value which is the chi-square value for 1 degree of freedom at the desired confidence level.

1. Empirical Results

The inputs

Guided by the hypothesis, model and methodology, we analyze restlessness data. In order to do so, input data are collected on the variables summarized inTable3. Restlessness values are calculated after collecting the data of producer rice-price and per capita income (Source of the data: FAO GIEWS) for the 19 countries (10 countries experienced rice crisis and others not crisis). All rice price measures are divided by GNI per capita (constant 2005 $US). The restlessness table presents long-term data on restlessness from year 1991 to 2011. Rice crisis occurences in this research are based on two documents. The first document is:"Working Thesis Number 163 March 2009, Rice Crisis Forensic, How Asian Governments Carelessly set the World Rice Market on Fire", By Tom Slayton and the second one is: "We are Hungry!" A Summary Report of Food Riots, Government Responses, and States of Democracy in 2008 [Mindi Schneider, 2008]

Table 3. Time series Restlessness data (Yearly) and the crisis year in 19 countries

No.	Country Name	Actual Crisis Years	1991	1992	1993	1994	1995	1996	1997
1	Philippines	2008	0.000179	0.000196	0.000206	0.000224	0.000275	0.000291	0.000241
2	Senegal	2008	0.000462	0.000495	0.000504	0.000294	0.000365	0.000291	0.000254
3	Bangladesh	2008	0.000621	0.000565	0.000477	0.000509	0.000568	0.000414	0.000372
4	Thailand	2008	0.002637	0.002379	0.001943	0.002231	0.002282	0.002664	0.002613
5	India	2007 2008	0.000408	0.000376	0.000338	0.000320	0.000325	0.000314	0.000238
6	China, Mainland	No crisis	0.000246	0.000213	0.000236	0.000209	0.000241	0.000461	0.000293
7	Ecuador	1997 1998 1999 2000	0.000003	0.000004	0.000004	0.000006	0.000008	0.000009	0.000013
8	Panama	No crisis	0.000083	0.000078	0.000077	0.000078	0.000082	0.000074	0.000074
9	Costa Rica	2007 2008	0.000084	0.000080	0.000077	0.000072	0.000072	0.000073	0.000076
10	Sri Lanka	2007 2008	0.000241	0.000243	0.000212	0.000195	0.000177	0.000207	0.000198
11	Dominican Republic	2007 2008 2009	0.000368	0.000439	0.000357	0.000256	0.000242	0.000230	0.000228
12	Republic of Korea	No crisis	0.000122	0.000115	0.000111	0.000106	0.000115	0.000163	0.000140
13	*Indonesia*	No crisis	0.000207	0.000195	0.000153	0.000176	0.000190	0.000177	0.000156
14	*Cambodia*	No crisis	0.000684	0.000412	0.000642	0.000657	0.000816	0.000581	0.000580
15	Lao PDR	No crisis	0.000697	0.000665	0.000632	0.000581	0.000507	0.000528	0.000964
16	Malaysia	No crisis	0.000047	0.000047	0.000043	0.000039	0.000046	0.000044	0.000040
17	Myanmar	No crisis	0.002987	0.004848	0.009271	0.011728	0.010267	0.013327	0.018338
18	Brunei	No crisis	0.000064	0.000068	0.000068	0.000065	0.000071	0.000077	0.000083
19	Viet Nam	No crisis	0.000470	0.000394	0.000397	0.000375	0.000433	0.000380	0.000329

No.	Country Name	1998	1999	2000	2001	2002	2003	2004
1	Philippines	0.000182106	0.000196502	0.000179698	0.000150034	0.00015837	0.000146648	0.000144495
2	Senegal	0.000254863	0.000236944	0.000203902	0.000193558	0.000208337	0.000239313	0.000255054
3	Bangladesh	0.000402546	0.000379212	0.000326572	0.000288621	0.000293436	0.000283391	0.000266689
4	Thailand	0.001587197	0.001459896	0.001214303	0.001195965	0.00128611	0.001441641	0.001730143
5	India	0.000228187	0.000257384	0.00023178	0.00021079	0.000205114	0.00020907	0.000304285
6	China, mainland	0.000288906	0.000229701	0.000185326	0.000127598	0.000108867	0.000146077	0.000201326
7	Ecuador	1.69388E-05	2.32362E-05	6.61907E-05	5.38121E-05	4.99155E-05	5.69111E-05	8.1559E-05
8	Panama	7.33118E-05	6.95147E-05	7.2309E-05	6.64834E-05	6.59985E-05	6.6851E-05	6.60849E-05
9	Costa Rica	7.31046E-05	7.33784E-05	6.97996E-05	6.5385E-05	6.1288E-05	5.82223E-05	6.10888E-05
10	Sri Lanka	0.000167923	0.00018229	0.000154779	0.000134917	0.000134103	0.00011443	0.000133154
11	Dominican Republic	0.000198215	0.000185075	0.000184078	0.000168509	0.000129878	0.000101772	0.000192067

12	Republic of Korea	0.000111529	0.000127264	0.000127762	0.000105102	0.000100322	0.000105517	0.000105969
13	Indonesia	9.45348E-05	0.000159672	0.000125652	0.000105333	0.000120941	0.000123899	0.000151108
14	Cambodia	0.000668794	0.000431699	0.000374992	0.000383384	0.000420072	0.000343235	0.000388072
15	Lao PDR	0.000773105	0.000446956	0.000363575	0.000339551	0.000325605	0.000312748	0.000290108
16	Malaysia	3.75709E-05	3.41573E-05	3.15517E-05	3.90138E-05	3.92708E-05	3.90896E-05	3.0955E-05
17	Myanmar	0.028725552	0.037319114	0.025972393	0.070547009	0.073897017	0.077938925	0.076483465
18	Brunei	7.16162E-05	7.30051E-05	6.92952E-05	6.75215E-05	6.49268E-05	6.45434E-05	6.54323E-05
19	Viet Nam	0.000345119	0.000269693	0.000235	0.000202162	0.000201766	0.00020513	0.00022306

No.	Country Name	2005	2006	2007	2008	2009	2010	2011
1	Philippines	0.000158167	0.000165915	0.000188318	0.000239061	0.000231736	0.000234515	0.000244767
2	Senegal	0.000265313	0.000273616	0.000316369	0.0004975	0.000417217	0.000367779	0.000429973
3	Bangladesh	0.000236089	0.000294329	0.000305206	0.00041438	0.000338731	0.000299283	0.000332113
4	Thailand	0.001722	0.001725003	0.003053757	0.002577253	0.002601023	0.002957417	0.003500064
5	India	0.000277188	0.000327402	0.000401667	0.000438336	0.000426324	0.00044279	0.000472598
6	China, mainland	0.000186761	0.000171009	0.000102787	0.000115011	0.000108959	0.000103826	0.000130618
7	Ecuador	6.6296E-05	5.57677E-05	8.00035E-05	9.22985E-05	8.36493E-05	8.42647E-05	8.97388E-05
8	Panama	6.10289E-05	5.23312E-05	4.73535E-05	6.41814E-05	6.60383E-05	6.61557E-05	6.67361E-05
9	Costa Rica	6.1009E-05	6.13297E-05	6.81269E-05	9.14929E-05	0.000115307	0.000119812	0.000111666
10	Sri Lanka	0.000129891	0.000102433	0.00011751	0.000205493	0.000197905	0.000165636	0.000155164
11	Dominican Republic	0.00022055	0.000188517	0.000354497	0.000312033	0.00030978	0.000243606	0.000212545
12	Republic of Korea	0.0001048	9.86405E-05	0.00010286	8.7516E-05	8.03571E-05	7.91383E-05	7.20356E-05
13	Indonesia	0.000173587	0.000182833	0.000208428	0.000199867	0.000144535	0.000196167	0.000215134
14	Cambodia	0.000364221	0.000295086	0.00029555	0.000350885	0.000306507	0.000327346	0.000323799
15	Lao PDR	0.000265779	0.000234746	0.000225963	0.000283207	0.000288635	0.000292804	0.000252341
16	Malaysia	3.08116E-05	3.16969E-05	3.21378E-05	3.74976E-05	4.11996E-05	4.32457E-05	4.36513E-05
17	Myanmar	0.079579976	0.108647885	0.08919795	0.063676471	0.050425171	0.043469079	0.034716976
18	Brunei	6.32315E-05	6.86805E-05	7.35222E-05	7.17782E-06	7.57664E-06	7.86045E-06	8.08475E-06
19	Viet Nam	0.000242774	0.000214475	0.000260301	0.000360139	0.000361334	0.000334589	0.000348947

Process

To implement the modified I-CHART explained above, the following iterative procedure is required to solve the apropriate n and L:

a. Create a control chart for the 19 countries with n = 9, L = 3. For this requirement the data in Table 3 is rearrranged into Table 4. For example, the following is data processing for the country of Bangladesh.

Table 4, Precedence Analysis for Bangladesh Data

Country	Year	Restlessness	Restlessness (n)	Check Year	Unprecedented detection	Actual Crisis Year	t (#alert)	Out Of Control & Crisis	In Control & Crisis	Out Of Control & Non Crisis	In Control & Non Crisis
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Bangladesh	1991	0.00062123									
	1992	0.00056501									
	1993	0.00047729									
	1994	0.00050892									
	1995	0.00056769									

	1996	0.00041417									
	1997	0.00037157									
	1998	0.00040255									
	1999	0.00037921									
	2000	0.00032657	R(9)	2000	0	2008					1
	2001	0.00028862	R(9)	2001	0	2008					1
	2002	0.00029344	R(9)	2002	0	2008					1
	2003	0.00028339	R(9)	2003	0	2008					1
	2004	0.00026669	R(9)	2004	0	2008					1
	2005	0.00023609	R(9)	2005	0	2008					1
	2006	0.00029433	R(9)	2006	0	2008					1
	2007	0.00030521	R(9)	2007	0	2008					1
	2008	0.00041438	R(9)	2008	1	2008		1			
	2009	0.00033873	R(9)	2009	0	2008					1
	2010	0.00029928	R(9)	2010	0	2008					1
	2011	0.00033211	R(9)	2011	0	2008					1

I-CHART creation (without outlier removing) for Bangladesh

Weillustrate the precedence analysis and the modified individual chart using Bangladesh data on the Table 4.

There are 12 control charts presented on figure 1 to figure 12.They arecreated to explain unprecedented restlessness in Bangladesh during theperiodsof 1998-2011. They are created to explain unprecedented restlessness in Bangladesh during the periods of 1991-2011.

The control charts are created using trial sigma at level 3 and n=9 as one combinations among the various possible configurations. R(9) means

I-CHART process 9 data and the check-year is done in the tenth data.

The ninth check-year evaluation in 2008 indicates that the restlessness data is out of control and is interpreted as unprecedented restlessness.

Synchronize with the actual crisis year in column (7).There is crisis in that year in Bangladesh, the actual crisis occurred in year 2008, then this result matches the cell: Out of Control & Crisis therefore is tabulated in column (9) and, (apply) the same procedure to 18 other countries to obtain the nineteen tables, and the control charts for each table.

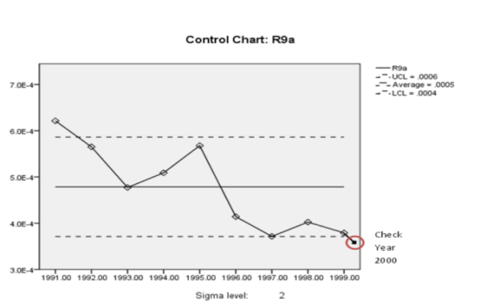

Figure. 1. Control Chart of R(9) Bangladesh

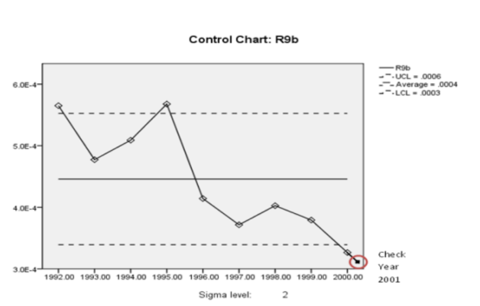

Figure. 2. Control Chart of R(9) Bangladesh

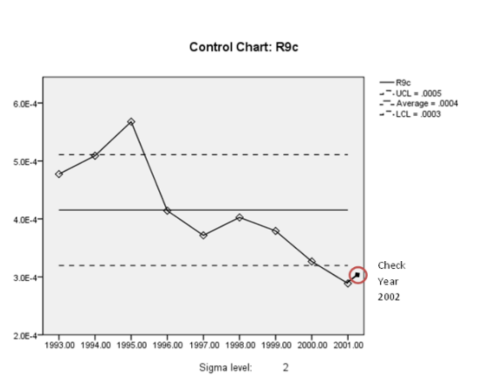

Figure. 3. Control Chart of R(9) Bangladesh

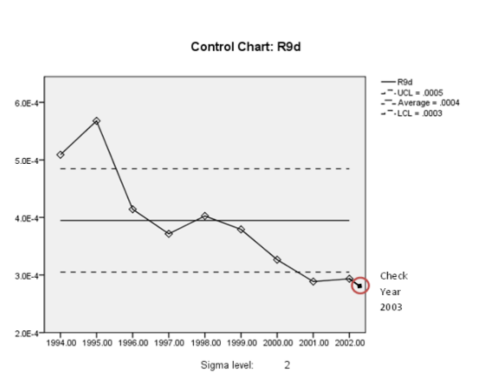

Figure. 4. Control Chart of R(9) Bangladesh

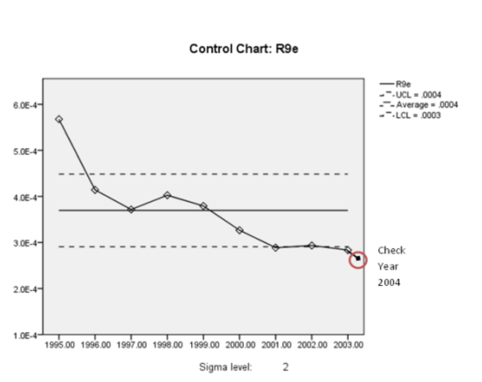

Figure. 5. Control Chart of R(9) Bangladesh

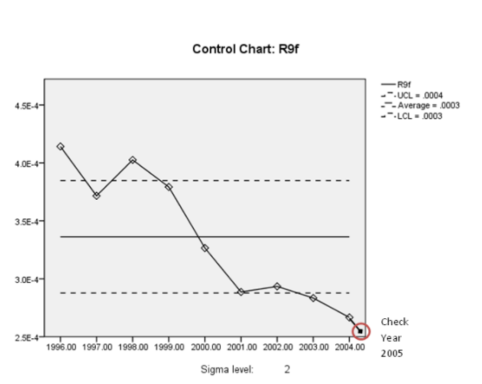

Figure. 6. Control Chart of R(9) Bangladesh

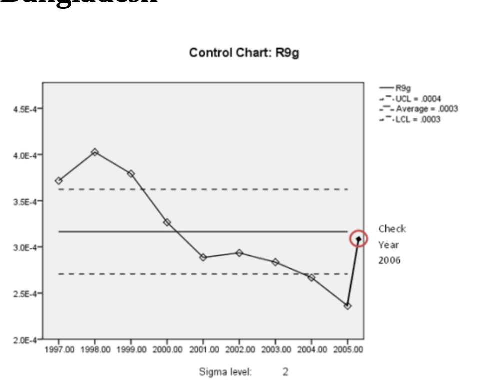

Figure. 7. Control Chart of R(9) Bangladesh

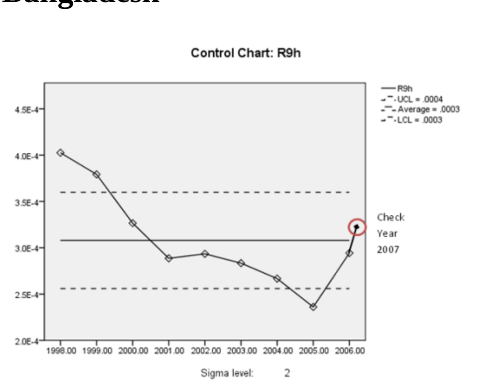

Figure. 8. Control Chart of R(9) Bangladesh

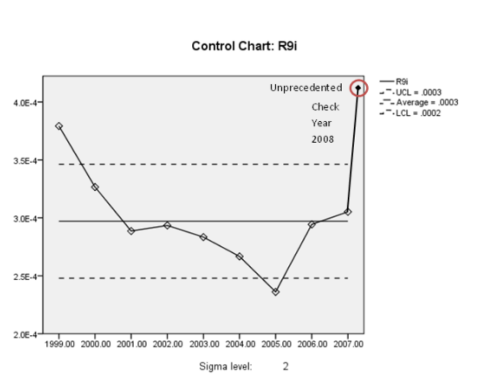

Figure. 9. Control Chart of R(9) Bangladesh

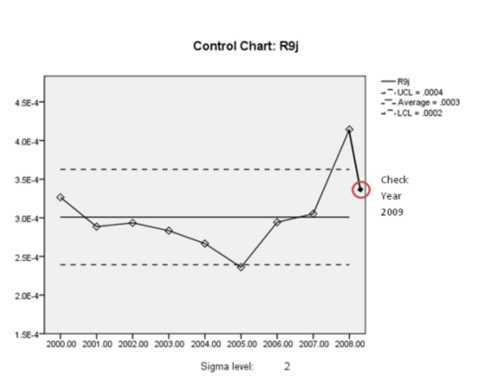

Figure. 10. Control Chart of R(9) Bangladesh

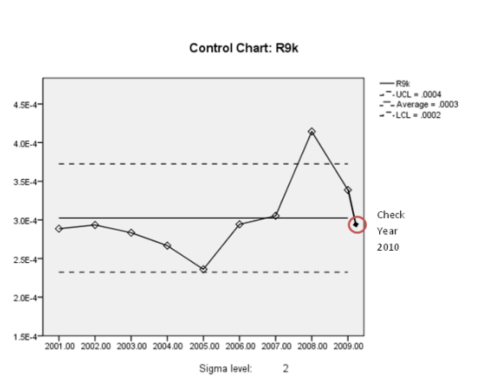

Figure. 11. Control Chart of R(9) Bangladesh

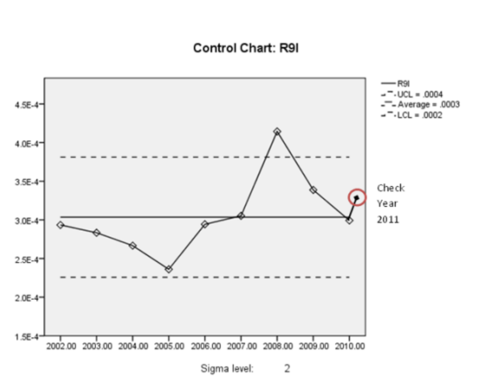

Figure. 12. Control Chart of R(9) Bangladesh

b. Compute r_g of Contingency Table 2×2

Total of two hundred and nine control charts are produced from 19 tables coming from 19 countries. The outputs are then tabulated to create a 2×2 Contingency Table as discussed in part D.$\mathbf{r_g}$ and Q statistics are calculated from the Table. If the results are not significant then the fitting process isrepeated by lowering or increasing the value of L and the procedure in point **a** aboveis repeated. Otherwise stop and all the required processes are completed.

Outputs

Because there are too many configurations of n, L, i which must be processed and take so much timeif the process is done manually, a computer program has been developed for this purpose. Computer has processed a great number of possible configurations to finda control chart with the sufficient $\mathbf{r_g}$-index and good Q-press. Comprehensive results of precedence analysis for 19 countries for n = 9 and L = 3are presented in the Table 5. The details are presented at Appendix D

Table 5. Unprecedented Restlessness Analysis Result in 19 Countries

Control Chart Type	: Modified Moving Chart Without Outlier Removal	
Std. Multiplier (L)	: 3, 00	
n (Number of Observations in Years)	: 9	
Unprec. To Crisis (Years)	: 4	
Number Of Countries	: 19	
Unprecedented vs Crisis	: 7 (77, 78%)	205 (a+d)
Unprecedented vs Not Crisis	: 2 (22, 22%)	4 (c+b)
Not Unprecedented vs Not Crisis	: 198 (99, 00%)	0.961722488 (g)
Not Unprecedented vs Crisis	: 2 (1, 00%)	209 (N)

The information at Table 5.shows that n = 9 as a range length and L = 3 three-sigma control limits) are the best parameters configuration for Modified I-CHART.It means the Modified I-CHART provide accurate information regarding the unprecedented restlessness as a strong indicator of the rice crisis incidence. If we assume that the restlessness is normally distributed, we find from the normal standard table that the probability of type I error is 0.0027. That is, an incorrect out-of-control signal or a false alarm will be generated in only 27 out of 10, 000 points. The table is the input for the main part of this study, which testing following hypotheses:

Hypothesis

$H_0: r_g = 0$ (UR is not strong indicator for rice crisis)

$H_1: r_g \neq 0$(UR is the strong indicator for rice crisis)

These configuration resulted in statistic test $\mathbf{r_g}$ = 0.961722488, then the calculated z would be: $z = r_g\sqrt{N}$ = 13.90346072**,** which is statistically significant at the.00001 level.

The Q statistic would be based on a total sample size of N= 209, c= 205 correctly classified observations and K= 2groups. The Q statistic would be:

Q Statistic = $\frac{[209-(205*2)]^2}{209(1)}$

The Q Statistic = 193.3062201is then compared to 15.4 as the chi-square critical value at the0.00001 significance level for 1 degree of freedom.If it is assumed that the restlessness is normally distributed, it is found from the normal standard table that the probability of type I error is 0.0027. This meansthat an incorrect out-of-control signal or a false alarm will be generated in only 27 out of 10, 000 points

Thus we conclude that the unprecedented restlessness is significantly better than the chance when the I-CHART is constructed with n = 9 and L = 3.$\mathbf{r_g}$-index and Q statistics give the researcher a high level of assurance that there is a strong positive association between unprecedented restlessness and crisis incidence. In other words, rice crisis has strong dependency on the unprecedented restlessness and nonunprecedented restlessness has strong dependency on no rice crisisoccurence.

Conclusion

a. The research finds out that Unprecedented Restlessness is the strong indicator for rice crisis at National level.Unprecedented Restlessness [UR] calculated from producer rice price and GNI per capita (constant 2005 $US) reported by authority [GIEWS-FAO] shows a good performance statistic as the strong indicator for rice crisis. It means that unprecedented restlessness may be used to forecast the rice crisis at national level especially at the 19 countries under study.When forecasted properly, the strong indicator points out the effectiveness of a strategic program for avoiding rice crisis in the future.

b. URis tested on 19 countriesas the proving ground and has passed two statistic tests in order to be concluded as the strong indicator. $\mathbf{r_g}$-Index of UR is 0.961722488and Q press is193.3062201.Both statistics are significantat the.00001 level. $\mathbf{r_g}$-Index shows that the correlation between UR and the event of rice crisis is very high and significant.Thus we would conclude that in this case the incidenceis significantly better than chance which has a correct classification rate of 50%.

Recommendation

a. It has been proven that the unprecedented restlessness events correlate strongly to the rice crisis.Further research should be conducted to assess the predictability of the unprecedented restlessness events. If it is proven predictable then we can forecast the occurrence of rice crisis in the future.

b. It is strongly recommended that the unprecedented restlessness indicator be used to assess the effectiveness of an agricultural plan the objective of which is to avoid rice crisis in the future.

Appendix A.Supplementary material

Supplementary dataassociated with this article can be found in the online version, athttps://drive.google.com/folderview?id=0B8ya6CNWBAbwQWVkeDNDYkU2TmM&usp=sharing

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