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THE RELATIONSHIP BETWEEN INCOME INEQUALITY AND ECONOMIC GROWTH IN CHINA

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ABSTRACT

China has experienced a rapid growth in their economy since the economic reform in early 1980s. However, along with the rapid economic growth, China has also, faced an increment in income inequality. Prior to the economic reformation in 1978, China had maintained a stable income inequality as indicated by the unfluctuating Gini coefficient (measures the inequality on a scale of 0 to 1 from perfect equality to perfect inequality). However, after the reform, the Gini coefficient increased (Benjamin, 2011). The increment in Gini coefficient infers that the income inequality has grown; hence, the data seems to be positively correlated. However, by solely looking at the data, do we know the causality between economic growth and income inequality? This paper will examine the correlations and determine whether income inequality causes economic growth in China using the panel data of GDP per capita and GINI coefficient from 1960 to 2000.

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Chapter 1
Introduction

Chapter 1.1: Brief History of China From 1960 to 2000

From 1960 to 2000, Chinese history can be divided into 2 major phases: the Pre-rural reform from 1960 to 1979 and the post-rural reform from 1979 to 2000. The first phase, Phase 1, is the pre-rural reform and can be divided into the following sub-phases:

Phase 1.1: Great Leap Forward and Great Famine (1960-1962)

Phase 1.2 : Post-Famine Recovery (1963-1965)

Phase 1.3: Cultural Revolution and Transition to Reform (1966-1978)

The second phase, Phase 2, is the post-rural reform and can be divided into following sub-phases:

Phase 2.1: Rural Reform (1979-1984)

Phase 2.2: Decentralization, Opens to Trade, and Direct Investment (1985-2000)

In this chapter, we will explore whether or not economic growth and income inequality is correlated in Phase 1, Phase 2 and whole Phase. If correlated, we will next determine which direction they are correlated (Kanbur and Zhang, 2005).

Chapter 1.2: Correlation between Income inequality and Economic Growth

Table 1 demonstrates the economic and inequality indicator of China from 1960 to 2000; GDP, GDP per capita (GDPPC), GDP per capita growth (GDPPCG) are used as an economic indicator and the regional Gini coefficient (GINI) is used as an inequality indicator. Table 2 illustrates correlation coefficient of major phases and sub-phases.

According to Table 1, GDPPCG is negative value, indicating that GDPPC is decreasing in Phase 1.1. During Phase 1.1, Communist Party of China (CPC) led by Mao Zedong started the economic campaign called Great Leap Forward. This economic campaign aimed to transform China from an agrarian economy into a socialist society by industrialization. However, there was a massive decrease in GFP and GDPPC due to the rapid and repetitive failure of attempts to industrialize traditional farming system, along with severe drought caused the Great Famine, (Tao Yang, 2008). Fortunately, China quickly recovered from the Great Famine during Phase 1.2, As a result, the GDPPCG ranged in the positive values and GDPPC increased from 1962 to 1965. During Phase 1.3, GDPPC decreased until 1968, but in the process of transitioning into a rural reform, GDPPC returned to increasing manner. The income inequality shows similar trends as the economic growth during Phase 1. According to Table 1, GINI decreased from 32.2 to 28.5 in Phase 1.1 and increased from 27.6 to 28.7 in Phase 1.2. During Phase 1.3, GINI decreased from 28.7 to 25.5 until 1967 but returned to its increasing manner after 1968. Therefore, during Phase 1, the economic growth and inequality illustrate same pattern in growth that both of them are increasing during Phase 1.1 and Phase 1.2, decreasing during beginning of Phase 1.3, and increasing afterwards.

Since both GDPPC and GINI shows equivalent pattern in Phase 1, one can assume that GDPPC and GINI are correlated. However, having the same pattern does not necessarily mean that these two variables are correlated. Referring to Figure 1, GDPPC and GINI indeed shows similar fluctuating pattern, but GDPPC fluctuates in an increasing manner from the beginning while GINI does so in a decreasing manner until 1967 and then increasing. According to Table 2, correlation coefficient between GDPPC and GINI in Phase 1 is 0.203 with p-value of 0.4052. In other words, it is inaccurate to conclude that GDPPC and GINI are correlated in Phase 1. the data Although Phase 1.2 and 1.3 shows strong positive correlations, the data set is not large enough to conclude that GDPPC and GINI are not correlated;

GDPPC increased gradually during the rural reform from 419 to 695 in Phase 2.1. After the rural reform, China became decentralized and expanded its trade to foreign countries, which allowed them to commence direct investments. As a result, GDPPC increased drastically during Phase 2.2 from 695 in to 7858. Unlike GDPPC, GINI decreased from 28.6 to 25.6 in Phase 2.1. Then, GINI increased dramatically from 25.8 to 37.2 in Phase 2.2. According to Table 2, the correlation coefficient is 0.939 with p-value of 0.0000, which means it is significant to conclude that GDPPC and GINI are positively correlated in Phase 2.

Therefore, the overall relationship between economy growth and inequality is positive except for the rural reform period. Table 2 illustrates that the correlation coefficient of whole period is 0.841 with p-value of 0.0000. Thus it is significant to conclude that GDPPC and GINI are positively correlated in the whole phase.

We are not only interested in finding the correlation but also the causality of economic growth and inequality. By solely looking at the table 1 and 2, one can conclude economic growth and inequality positively correlated in whole Phase and Phase 2. However, one cannot determine the causality between economic growth and income inequality because there could be a third variable that might affect the causality of economic growth and inequality. So in this paper, we will explore and examine whether income inequality directly caused a positive economic growth in whole phase and Phase 2 particularly.

Table 1. Lists of GDP and GINI Coefficient

Year	GDP	GDPPC	GDPPCG	GINI
	Billions	Unit	annual %	%
Phase 1				
Phase 1.1 1960	146	218		32.2
1961	122	185	-27	30.3
1962	115	173	-6	28.5
Phase 1.2 1963	123	181	8	27.6
1964	145	208	16	28.2
1965	172	240	14	28.7
Phase 1.3 1966	187	254	8	26.6
1967	177	235	-8	25.5
1968	172	222	-7	26.3
1969	194	243	14	27.1
1970	225	275	16	27
1971	243	288	4	26.9
1972	252	292	1	28.1
1973	272	309	5	27.9
1974	279	310	0	28.8
1975	300	327	7	29.5
1976	294	316	-3	30.9
1977	320	339	6	30.8
1978	365	381	10	29.3
Phase 2				
Phase 2.1 1979	406	419	6	28.6
1980	455	463	6	28.2
1981	489	492	4	27
1982	532	528	7	25.6
1983	596	583	9	25.9
1984	721	695	14	25.6
Phase 2.2 1985	902	858	12	25.8
1986	1028	963	7	26.8
1987	1206	1112	10	27
1988	1504	1366	10	28.2
1989	1699	1519	2	29.7
1990	1867	1644	2	30.1
1991	2178	1893	8	30.3
1992	2692	2311	13	31.4
1993	3533	2998	13	32.2
1994	4820	4044	12	32.6
1995	6079	5046	10	33
1996	7118	5846	9	33.4
1997	7897	6420	8	33.9
1998	8440	6796	7	34.4
1999	8968	7159	7	36.3
2000	9921	7858	8	37.2

Source: GDP, GDP per capita, and GDP growth from World Development Indicator; GINI from Kanbur, R., & Zhang, X. (2005).

Table 2. Correlation between GDPPC and GINI

	Correlation r-value between GDPPC and GINI	p-value
Major Phases		
Phase 1	0.203	0.4052
Phase 2	0.939	0.0000
Whole Phase	0.841	0.0000
Sub-Phases		
Phase 1.1	0.969	0.1576
Phase 1.2	0.532	0.0645
Phase 1.3	0.639	0.0006
Phase 2.1	-0.829	0.0413
Phase 2.2	0.938	0.0000

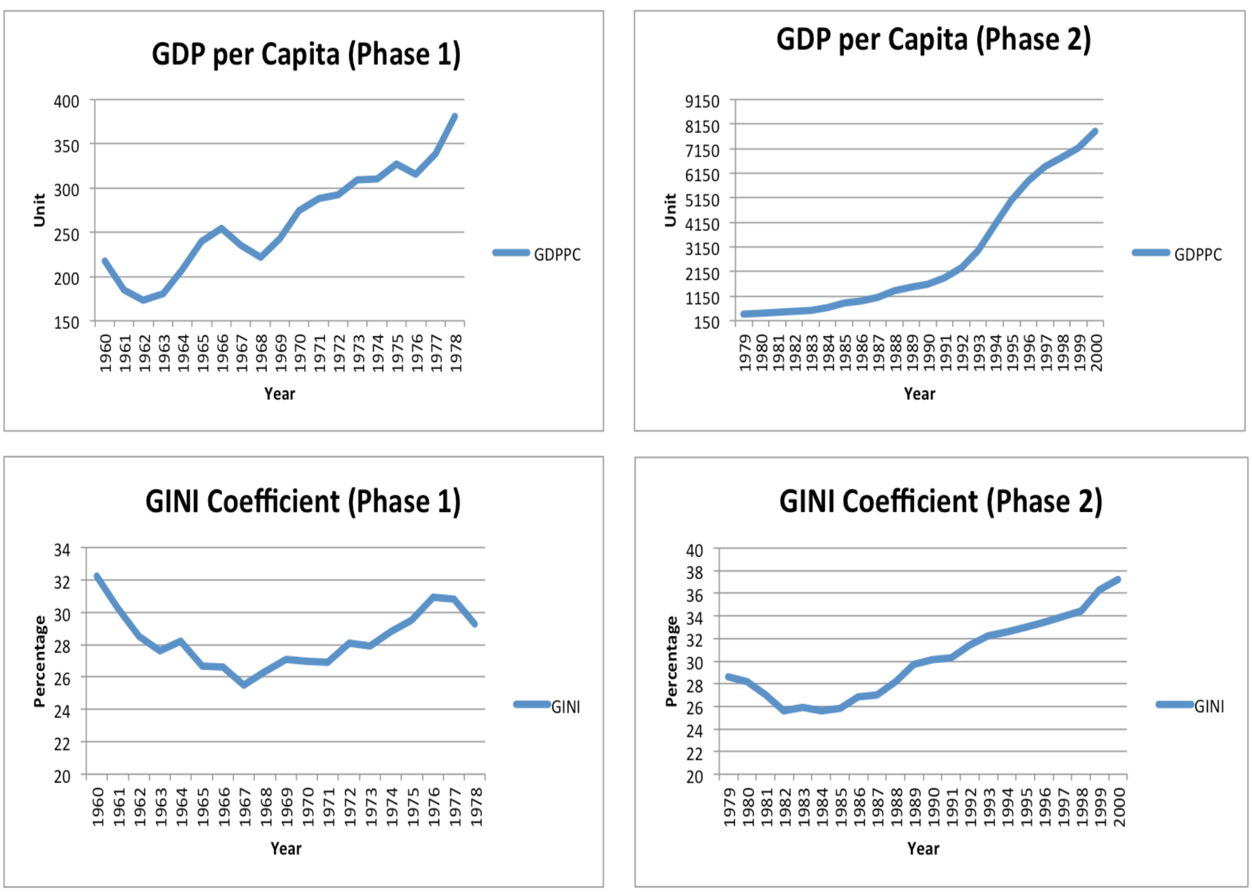

Figure 1. GDP per Capita and GINI Coefficient in each Phase 1 and Phase 2

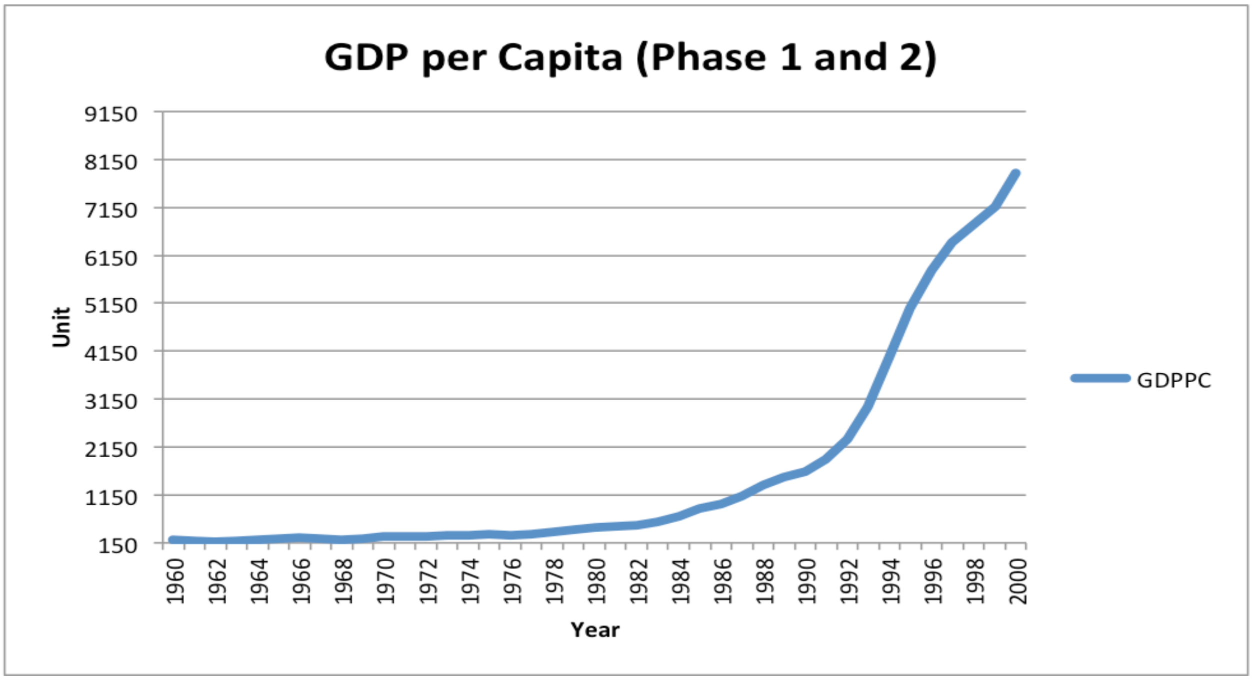

Figure 2. GDP per in whole phase

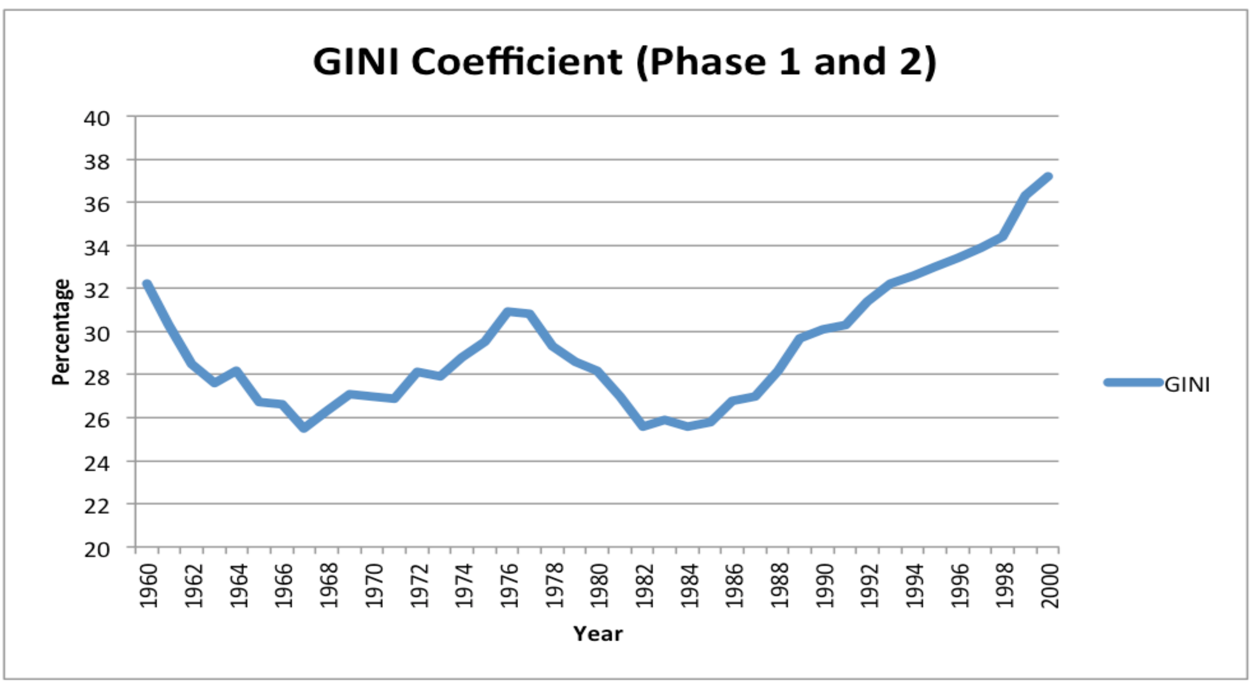

Figure 3. GINI coefficient in whole phase

Chapter 2
Literature Review

Chapter 2.2: Does Income Inequality Cause Economic Growth in China?

The relationship between economic growth and income inequality is an interesting topic that has been studied by many economists. For years, economists have been in a controversial dispute about whether income inequality directly causes economic growth and if, it is a negative or positive causality. Some studies including Alesina and Rodrik (1994) and Qin (2009), report that the inequality causes a negative economic growth. In contrast, Forbes (2000) and Risso at el (2012) conclude that the inequality causes the economic growth positively.

In order to enhance "the economic growth, to obtain equal income distribution, to attain national self-sufficiency, and to further socialist or communist ideals", China decided to change from Communist planned economy to economic reform in 1979 (Risso and Edgar, 2012). Since 1979, China carried out an economic reform toward market-based economy to increase productivity and living standards. Rural reform (Phase 2.1) is the period when China adopted the household responsibility system in agriculture. The system allowed the household to contract the land and capital from the organization. Household and organization set certain amount of profit that will go to the organization and then excessive profit goes to the household. By doing so, the productivity increased and thereby, increasing economic growth. Post-rural reform (Phase 2.2) opened up the trade and foreign direct investment, which increased the living standard and therefore increased the economic growth. As China desired and planned, China had experienced rapid economic growth since the economic reformation in 1979. Along with the increment in the economic growth, the income inequality started to increase during the post-reform (Risso and Edgar, 2012).

According to Benhabib (2003) and many other studies, the relationship between economic growth and income inequality must exist in Chinese history. If the relationship exists, then did income inequality directly cause the growth of Chinese economy? If so, does causality positive or negative? In this section I will discuss several studies that seek the answers to these questions.

Many studies suggest that the income inequality affects economic growth in China. However, whether the income inequality affects economic growth positively or negatively depends on the studies. For example, Risso and Carrera (2012) concluded that the relationship is positive, Qin et al (2009) concluded that the relationship is negative, and Benjamin concluded that income inequality does not affect the economic growth.

According to the study done by Risso and Carrera (2012), Risso proposed the relationship between inequality and growth as a positive relationship. Risso and Carrera (2012) used the Granger no-causality test with the log of income inequality and log per capita GDP to test the causality between income inequality and economic growth. Risso divided Chinese history into two phases and examined the causality in each phase, in addition to the whole phase. Risso and Carrera (2012) concluded that the income inequality affected economic growth positively in the short run during the pre-rural reform (Phase 1) and long run during the whole-Phase. However, Risso concluded that during post-rural reform (Phase 2) income inequality did not cause the economic growth (Risso and Carrera, 2012).

According to Benhabib (2003), theoretically, too much income inequality can hurt the economic growth due to the government interventions using rent seeking and appropriation.

However, with just about the right income inequality and policies, countries can take advantage of the productivity differences and optimize the economic growth. The economic growth increases modestly when the income inequality moves away from perfect equality. But economic growth starts to decrease when the income inequality increases further (Benhabib, 2003).

Unlike Risso and Carrera (2012) model, there is a study that illustrates the negative relationship between income inequality and economic growth in China. Qin created two types of income inequality measures in China: income inequality between urban and rural regions using ratio of per capita incomes with time-series data, and income inequality within urban and within rural areas. Using Theil's index as an inequality measure in his model, Qin incorporated Theil's index in the private consumption equation. Qin tests the different shocks, such as impulse shock, step shock, and trend shock to test the affect of the inequality to consumption. Qin concluded that income inequality "carry negative effect on macro-economic stability as they cause consumption and then investment to undulate" (Qin et al, 2009).

Theoretically, the potential rationale of how income inequality can affect the growth negatively are in the following ways: imperfect credit markets, imperfect factor markets, and political economy. According to Benhabib, "inequality coupled with borrowing constraints and financial market imperfections prevents the talented poor to undertake profitable investments in physical and human capital, thereby limiting the full potential for the growth of the economy" (Benhabib, 2003). When there exists the credit market imperfection, the poorest have the least amount of the resources when holding the average income fixed. This hinders the opportunity to grow. Therefore, with limited resources in imperfect credit market, the economic growth is impacted negatively. Imperfect factor market has similar affect to economic growth. Higher income, capital, labor, and land inequality can cause imperfect competition and slows down the factor market development that eventually limits the opportunity for the poor to trade. Lastly, political economy, such as tax regulation and education, can affect the growth negatively (Benjamin et al, 2011).

In China, all three cases existed in the beginning of the reformation that credit market and factor markets were poorly constructed and the migration was restricted by the hukou system, which is a household registration (Benjamin et al, 2011). Therefore, the high-income inequality caused credit and factor market imperfection and impeded the growth of economy. Yet, Benjamin et al (2011) created model that proposed interesting result. Benjamin has collected the data based on the household-level specification, which the data is from 1987 to present. Benjamin concluded that the inequality does not have casual impact on growth and higher inequality does not impede the growth of China.

The literature review above answers the questions that I have addressed at the beginning of this section. The effect of income inequality on economic growth can vary from study to study; the relationship can be positive, negative or none. Many of these studies demonstrated that income inequality indeed affects economic growth. So did income inequality really cause economic growth in China? In this paper, with the fact that Phase 1, Phase 2 and the whole-Phase have a positive correlation, I will demonstrate whether the causality existed from income inequality to the economic growth using empirical work.

The empirical work will be composed of time series regression. The model will be based on the Yamamoto Granger no causality test used in Risso and Carrera (2012). I will be redoing the work done by Risso and Carrera using Yamamoto Granger no causality test to check whether a causality exists and determine which direction the causality occurs. Since China locked all the data for the measurement of inequality, I will use the data provided by Risso and Careera. Since

Risso and Careera did not take account the serial correlation in the residual when they run the test, the empirical data will be set free from the serial correlation This empirical data will explore the existence of direct causality from income inequality to economic growth. Importantly, I will evaluate the conclusions provided by Risso and Carrera and then, determine whether the conclusion is robust by providing critical reasoning. In the next section, the methodology of Yamamoto Granger no causality test will be presented.

Chapter 3
Description of Methodology

To measure economic growth, I considered GDP per capita (GDPPC) from World Development Indicator. To measure income inequality, I considered Gini coeffiecnt (GINI). However, unlike GDP per captia of China, obtaining Gini from national census was unattainable due to the restricted information provided from China. Thus, I considered Gini coefficient from Kanbur and Zhang (2005). Both GDPGR and GINI are time series data from 1960 to 2000. For the better approximation of the regression, I considered logarithms of GDP per capital (lgGDPPC) and logarithms of Gini coefficient (lgGINI).

In order to examine the causality between income growth and income inequality, I decided to use the cointegration method. If economic growth and income inequality are cointegrated, then I can say that the true relationship between the growth and the inequality exist throughout the time. The two most famous methods to obtain cointegration are Engle-Granger Test and Johansen Test. However, I chose Johansen Test over Engle-Granger Test because the Engle-Granger test only examines one cointegrating relationship while the Johansen test allows testing more than one cointegrating relationship (Johansen, 1988). Therefore, with Johansen test, I can test all possible cointegrating relationship.

The first step of cointegrating method is to determine the stationarity of the variables, lgGDPPC and lgGINI, using augmented Dickey-Fuller (ADF) test. ADF test for a unit root in the time series and yields a negative number as the result. In other words, the more negative the result, then stronger the rejection of the null hypothesis. In ADF, the hypotheses are as follow:

H_0: The variable contains a unit root and the variable is non-stationary

H_1: The variable is stationary

If the variable rejects the null hypothesis, then the variable is perhaps stationary.

$$Y_t = \alpha + pY_{t-1} + u_t \tag{1}$$

Equation (1) represents autoregressive model represented by Dickey and Fuller (1979), where Y_t is the variable, which can be either be lgGDPPG or lgGINI in the time series. u_t is the independently and identically distributed zero-mean and variance σ^2 error term, and p is a real number. If $|p| < 1$, the variable Y_t converges to a stationary time series as t approaches infinity. If $|p| = 1$, Y_t is not stationary and variance becomes $t\sigma^2$. The variable Y_t is called a random walk when $|p| = 1$. If $|p| > 1$, then Y_t is not stationary and as t increases the variance rises exponentially. In Dickey-Fuller Test, the equation (1) is modified by fitting the model by ordinary least square.

$$Y_t = \alpha + pY_{t-1} + \delta t + u_t \tag{2}$$

However, this regression is likely to produce a serial correlation so I decided to use an augmented version of Dickey-Fuller test:

$$\Delta Y_t = \alpha + pY_{t-1} + \delta t + \zeta_1 \Delta Y_{t-1} + \zeta_2 \Delta Y_{t-2} + \ldots + \zeta_k \Delta Y_{t-k} + u_t \tag{3}$$

In equation (3), k is the number of the lag order. The advantage of equation (3) is the ability to add higher order autoregressive processes by adding lags of the order k. In this way, the serial correlations are minimized.

The number of optimal lags can be captured from Akaike information criterion (AIC). Using the number of lags examined from AIC, I can use ADF to find the order of integration. If the order of integration of lgGDPPC and lgGINI are equal, then I can proceed with the cointegrating test so checking the order of integration using ADF is important. Then, I can set up a Vector autoregression model (VAR) without differencing the data and obtain the maximum lag length for the variables in VAR by using the AIC. At this point, I must make sure that there is no serial correlation in the residuals. I need to increase the number of lag in VAR until there is no serial correlation. Breusch-Godfrey test is used to check the existence of the serial correlation.

The VAR model can be represented by the following equation:

$$Y_t = \alpha + A_1 Y_{t-1} + \ldots + A_k Y_{t-k} + Bz_t + u_t \qquad (4)$$

Where Y_t is variables, such as lgGDPPC and lgGINI, and u_t is the residual time series that is normally and independently distribute. The equation (4) can be rewritten as the following:

$$Y_t = \alpha + \Pi Y_{t-1} + \Sigma^{k-1}_{i=1}\Gamma_i \Delta Y_{t-i} + Bz_t + u_t \qquad (5)$$

$$\text{Where } \Pi = \Sigma^{k}_{i=1} A_i - I \qquad (6)$$

$$\text{And } \Gamma_i = \Sigma^{k}_{j=i+1} A_j \qquad (7)$$

Where Y_t is the non-stationary variable and z_t is the deterministic variable. The matrix Π represents the long-run adjustments in change in Y_t. The rank of Π is the number of linearly independent and stationary linear combinations of the variables. The matrix Γ_i represents the short-run adjustments in change in Y_t. Using equation (5) I can obtain the cointegration.

The Existence of cointegration implies the presence of causality but not necessarily the direction of the causality. Therefore, Granger (1969, 1988) discovered Granger- Causality test to examine the causality between two variables. The test uses two VAR:

$$X_t = \Sigma^{n}_{i=1}\alpha_t Y_{t-i} + \Sigma^{n}_{j=1}\beta_j X_{t-j} + u_{1t} \qquad (8)$$

$$Y_t = \Sigma^{m}_{i=1}\theta_t X_{t-i} + \Sigma^{m}_{j=1}\eta_j Y_{t-j} + u_{2t} \qquad (9)$$

If the lagged Y affects X significantly in equation (8) and the lagged X affects Y significantly in equation (9), then there exists a Granger-Causality. If $\Sigma^{n}_{i=1}\alpha_t$ and $\Sigma^{m}_{i=1}\theta$ are jointly significantly different from zero, then causality exists. However, this Granger-Causality test has limitation. When time series variables are integrated, the F-test procedure is not applicable. So the standard Granger-Causality test are fail to correctly measures the causality in integrated system.

Therefore, I used Yamamoto Granger non-causality test, which is developed by Yamamoto (1995). When the variables are integrated, Yamamoto Granger non-causality test estimates VAR with (k+ d max) lags. Where k is the number of lag added into the VAR and d max is the maximum order of integration of variables. For example if variable X has order of the integration of I(0) and variable Y has the order of integration of I(1), then the d max is the maximum order of integration 1. So I can rewrite the equation (8) and (9) as the following:

$$X_t = \varphi + \Sigma^{k}_{i=1}\alpha_t X_{t-i} + \Sigma^{k+dmax}_{i=1}\alpha_t X_{t-i} + \Sigma^{k}_{i=1}\beta_i Y_{t-i} + \Sigma^{k+dmax}_{i=1}\beta_i Y_{t-i} + u_{1t} \quad (10)$$

$$Y_t = \varphi + \Sigma^{k}_{i=1}\theta_t Y_{t-i} + \Sigma^{k+dmax}_{i=1}\theta_t Y_{t-i} + \Sigma^{k}_{i=1}\eta_i X_{t-i} + \Sigma^{nk+dmax}_{i=1}\eta_i X_{t-i} + u_{1t} \quad (11)$$

Where X_t is economic growth and Y_t is income inequality. The null hypothesis of economic growth is H_o: $\beta_i = 0$, $\forall$ i=1,2,…, n, which means income inequality does not Granger-cause economic growth. The null hypothesis of income inequality is H_0 : $\eta_i = 0$, $\forall$ i=1,2,…, n , which means economic growth does not Granger-cause income inequality. Thus if the data rejects the null hypothesis, such as $\beta_i \neq 0$, then there exist the Granger causality.

Chapter 4
Empirical Results

As I mentioned in the previous sections, I tested three different phases: pre-rural reform (phase 1 using variables called lgGDPPCPH1 and lgGINIPH1), post-rural reform (phase 2 using lgGDPPCPH2 and lgGINIPH2), and whole-phase (using lgGDPPC and lgGINI). Recall that the first step of finding the cointegration and the Yamamoto Granger no-causality is to check the stationarity of the time series variables. Also recall that the more negative the Z(t) or coefficient, stronger the rejection of null hypothesis.

Chapter 4.1: Result of the ADF Test

The results of the ADF test of each phase in zero difference are recorded in Table 3. According to this table, in all three phases (phase 1, phase 2 and the whole phase) economic growth failed to reject the null hypothesis at a critical value of 5%, where the absolute value of test statistic, Z(t), is less than the absolute value of 5% critical value. This is true for all ADF with and without the trend & constant. In other words, economic growth of all phases have unit root at its level and they are indeed non-stationary. The p-value of economic growth in Z(t) is close to 1, indicating that the economic growth in all phases fails to reject the null hypothesis. The same results apply for income inequality. Again, the absolute value of the test statistic is less then the absolute value of 5% critical value for all three phases with and without trend & constant, demonstrating that income inequality fails to reject the null hypothesis. From this analysis, we can conclude that both, economic growth and income inequality are non-stationary at its level with zero difference.

Table 4 is the result of ADF for all three phases with first difference. According to this table, the first difference of the economic growth in all three phases rejects the null hypothesis at 5% level. This is true for with and without trend & constant. The absolute value of the test statistic in all phases is larger than the absolute value of the 5% critical value. Also p-value of the test statistic in all phases are smaller than 0.05; therefore, I can conclude that the economic growth and income inequality in first difference is indeed stationary. P-values are less than 0.05 that ΔlgGDPPC strongly rejects the null hypothesis. Table 2 and table 3 demonstrates that the first difference of economic growth and income inequality is stationary while in its level with zero difference are non-stationary. Based on this data, I can conclude that both, the economic growth and income inequality have an integration order of 1, which can be rewritten as I(1). Since economic growth and income inequality are in the same order, I can test the cointegration. As a result, the maximum order of integration from the variables is 1 (dmax = 1).

Chapter 4.2: Result of the Johanson Test

Recall that I have to figure out the number of maximum lags for the Vector autoregression model (VAR) before I run VAR because Johanson test for cointegration is sensitive to changes in the number of lags and can bring about opposite results. The number of lags chosen by AIC for all three phases are recorded in the table 5. According to this table, the maximum number of lags is '4' for phase 1, 4 for the phase 2 and '3' for the whole phase. Using this number of maximum lags, the result for the Johanson cointegration test is presented in Table 6. According to this table, the trace statistic is smaller than the 5% critical value at rank 1 in all three phases. Thus, a single cointegrating equation exists for the relationship between economic growth and income inequality. In other words, causality exits between economic growth and income inequality in the all three phases. However, as I mentioned in the previous section, existence of cointegration does not define the direction of the causality.

Chapter 4.3: Result of the Yamamoto Granger No-Causality Test

Table 7 illustrates the result of the Yamamoto granger no causality test. Recall that the number of lags used in Yamamoto granger no causality test is dmax plus the maximum number of lags from AIC. For Phase 1, using total of 5 lags (4 from AIC an 1 from dmax) p-value of income equality granger causes economic growth is smaller than 0.05; p-value is smaller than 5% significance level so reject the null hypothesis that income inequality does not granger cause economic growth. In other words, income equality caused economic growth in the Phase 1. Similar to the phase 1, the whole-Phase with total of 4 lags (3 from the AIC and 1 from dmax) has a p-value smaller than 0.05;thus, income inequality granger caused economic growth in the whole-Phase. However, according to the Table 7, the Phase 2 with a total of 5 lags has a p-value of 0.685, which is greater than 0.05; meaning causality does not exist from income inequality to economic growth.

Chapter 4.4: Result After Setting Free from the Serial Correlation

The results from chapter 4.1 to 4.3 are obtained from the same procedure that Risso and Edgar had demonstrated. Thus the results that I obtained from the data are analogous to that of Risso and Edgar. However, the cointegration test examined in previous chapters suffered from the serial correlation and the modification was not made in relations to the serial correlation. In order to set free from the serial correlation, the number of lags must be changed. Since the cointegration test is sensitive to the number of lags, changing the number of lags generates significant variations in the result. Thus, in order to obtain the correct result, the Vector autoregression model must be set free from the serial correlation by adding number of lags before the Granger no-causlity test is executed.

Breusch-Godfrey test (BG-test) was used to correct the serial correlation in all three phases. Phase 1 and the whole-phase did not suffer from the serial correlation. However, the phase 2 suffered from the serial correlation and the number of lags needed to set free from the serial correlation was ‘3’. According to Table 8, the total lags in Phase 2 is increased to 8 and the result is astonishing. The p-value in Phase 2 is corrected to 0.010, which is smaller than 0.05 (5% significance level) and thereby, rejects the null hypothesis that the income inequality does not granger cause the economic growth in the Phase 2.

Table 3. ADF Result of No Difference

	Z(t) (p-value)		Coefficient (p-value)	
	Without Trend & Const	Trend & Const	Without Trend & Const	Trend & Const
	(5% critical value: -3.000)	(5% critical value: -3.600)		
Economic Grwoth				
lgGDPPCPH1	-0.124(0.947)	-2.51(0.324)	-0.010(0.904)	-3.925(0.054)
lgGDPPCPH2	-0.564(0.879)	-2.516(0.319)	-0.009(0.583)	-0.415(0.270)
lgGDPPC (Whole)	1.700(0.998)	-1.037(0.939)	0.022(0.099)	-0.028(0.308)
Income Inequality				
lgGINIPH1	-1.247(0.653)	-1.989(0.705)	-0.243(0.236)	-0.341(0.072)
lgGINIPH2	0.158(0.969)	-3.070(0.114)	0.009(0.876)	-0.747(0.120)
lgGINI (Whole)	-0.307(0.925)	-1.242(0.902)	-0.018(0.760)	-0083(0.223)
* = Rejected null hypothesis at 5% significance level				

Table 4. ADF result of First Difference

	Z(t) (with p-value)		Coefficient (with p-value)	
	Without Trend & Const	Trend & Const	Without Trend & Const	Trend & Const
	(5% critical value: -3.000)	(5% critical value: -3.548)		
Economic Grwoth				
ΔlgGDPPCPH1	-3.775(0.003)*	-3.645(0.049)*	-3.561(0.007)*	-3.561(0.016)*
ΔlgGDPPCPH2	-3.666(0.006)*	-3.617(0.039)*	-0.938(0.004)	-1.020(0.007)*
ΔlgGDPPC (Whole)	-2.737(0.068)	-3.803(0.016)*	-0.379(0.010)*	-0.748(0.001)*
Income Inequality				
ΔlgGINIPH1	-3.664(0.007)*	-3.863(0.014)*	-1.015(0.003)*	-1.500(0.002)
ΔlgGINIPH2	-3.426(0.010)*	-3.774(0.029)*	-0.692(0.004)*	-0.674(0.023)*
ΔlgGINI (Whole)	-3.267(0.016)*	-3.485(0.041)*	-0.568(0.002)*	-0.693(0.001)*
* = Rejected null hypothesis at 5% significance level				

Table 5 Maximum Number of Lags Chosen by AIC

	Phase 1	Phase 2	Whole-phase
Lag	**AIC**	**AIC**	**AIC**
1	-4.02099	-7.42685	-6.56435
2	-6.45448	-7.91241	-6.87611
3	-7.00524	-8.33216	-7.05123*
4	-8.83158*	-8.94938*	-6.94647

Table 6. Johanson Test for Cointegration

	Phase 1	Phase 2	Whole-phase
Maximum Rank	**Trace Statistic**	**Trace Statistic**	**Trace Statistic**
0	34.0917	23.2236	16.8163
1	0.0173*	0.1109*	0.6244*
* = number of cointegrating equation chosen by the test			

Table 7 Yamamoto Granger Causality Test

Equation	Excluded	Total Lags	Chi2	Prob > Chi2
(Phase1)				
lgGDPPCPH1	lgGINIPH1	5	4.5784	0.032*
lgGINIPH1	lgGDPPCPH1	5	28.313	0.000*
(Phase 2)				
lgGDPPCPH2	lgGINIPH2	5	0.0663	0.797
lgGINIPH2	lgGDPPCPH2	5	391.77	0.000*
(Whole-Phase)				
lgGDPPC	lgGINI	4	4.8388	0.048*
lgGINI	lgGDPPC	4	44.553	0.000*
* = Causality exists from the variable in Excluded to the variable in Equation				

Table 8 Yamamoto Granger Test with Serial Correlation Correction

Equation	Excluded	Total Lags	Chi2	Prob > Chi2
(Phase1)				
lgGDPPCPH1	lgGINIPH1	5	4.5784	0.032*
lgGINIPH1	lgGDPPCPH1	5	28.313	0.000*
(Phase 2)				
lgGDPPCPH2	lgGINIPH2	8	6.6507	0.010*
lgGINIPH2	lgGDPPCPH2	8	302.39	0.000*
(Whole-Phase)				
lgGDPPC	lgGINI	4	4.8388	0.048*
lgGINI	lgGDPPC	4	44.553	0.000*
* = Causality exists from the variable in Excluded to the variable in Equation				

Chapter 5
Conclusion

I divided the Chinese history into three phases as I mentioned in the previous sections: Pre-rural reform (Phase 1), Post rural reform (Phase 2) and the entire period (whole-Phase). China showed a slow increase in economic growth and a low level of income inequality. Based on the empirical data, I can conclude that the income inequality and economic growth has positive relationship in Phase 1; income inequality caused economic growth during phase 1 with positive correlation in phase 1.2 and phase 1.3. This result is similar to Benhabib (2003) findings that China took advantage of the productivity difference to increase the economic growth with the income inequality not far away from the perfect inequality. During Phase 2, unlike Risso and Edgar, I can conclude that the income inequality and economic growth have a positive relationship; income inequality caused economic growth with positive correlation in Phase 2. Similar to the short-run in Phase 1 and Phase 2, the long-run income inequality caused economic growth and has the positive correlation. Thus, I conclude that all three phases have a positive relationship between income inequality and economic growth and that causality exists from income inequality to economic growth.

Based on my data of Phase 2, the result is astonishing because my result is different from Risso and Edgar, which my work is based on. Risso concluded that there is no causality from income inequality to economic growth in Phase 2, but these results suffered from the serial correlation. I set the lags of VAR by k plus dmax amount, where k is obtained from AIC and dmax is the order of integration. Unlike Risso and Edgar, I adjusted the number of lags so that VAR is free from the serial correlation. The change in number of lags of VAR brought significant modification to the result that now income inequality indeed caused an economic growth. In addition to this rapid economic growth in Phase 2, income inequality also increased by changing the policies from a communist planned economy to market-based economy. According to the empirical data, the increase in income inequality in Phase 2 positively affected the economic growth.

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The Pennsylvania State University, Schreyer Honors College **University Park, PA**
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- Awarded the Evan Pugh Scholar Award for being upper 0.5 percent of the respective classes
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WORK EXPERIENCE

Research Experiences for Undergraduates **University Park, PA**
Paid Research, Research member ***January 2015-May 2015***

- Conducted in-depth research on Roy model and analyzed the different aspect of the model to develop the relevant model for the instructor

Federal Reserve Bank of Boston (Education Department) **Boston, MA**
Summer Intern, Analyst ***July 2012- August 2012***

- Sorted out financially lowest 10 percent of a public elementary schools by each districts in Massachusetts using Microsoft Excel

Mogem Company (Mobile Keypad Production Department) **Seoul, South Korea**
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- Participated in the company's meeting with a buyer from Motorola as an interpreter to translate from English to Korean.

Boston Korean School **Boston, MA**
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LEADERSHIP EXPERIENCE

Federal Reserve Bank Community College Economics Challenge Team **Boston, MA**
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Korean Students for Christ **University Park, PA**
Band Leader, Director of Bible Study Group ***September 2012-Present***

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Columbia Mission Trip Team **Columbia**
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- Developed donation activities to fund various projects for missionaries in Columbia; resulted in $11,000 fund raised
- Photographed the important events for presentations and future references