4 Reassessing the Nexus between Insurance Activities and Economic Growth in China Through Quantile Approaches

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Abstract

This study reexamines the relationship between insurance activities and economic growth in China, employing both the Quantile approach and the Quantile-on-Quantile approach, which have rarely been used in the previous studies. It is identified that economic growth generally contains causal impacts on life/non-life insurance activities, and a feedback causal relation is identified at 0.1~0.5 quantiles. Results from Quantile_on_Quantile approach give more details about the causal relation of the nexus and find the relation varying at different quantiles. Furthermore, interest rate is found to affect the causal relations significantly. Our empirical results contain important implications for insurance policy making and insurance firm management in China.

Key words: Insurance activities; economic growth; quantile approach; Quantile_on_Quantile approach; Granger causality.

JEL Classification: C22

1. Introduction

Strong interaction between financial activities and economic growth was identified in most economies around the world (see Choong and Chan, 2011; Nyasha and Odhiambo, 2015 for a review). However, the role of insurance activities usually was ignored or underestimated in previous studies. Insurance industry provides coverages for various loss exposures to business

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firms and households, it also invests huge amount of funds (usually called reserves) onto infrastructure projects or other industries, thus contributes to the national output growth. At the same time, insurance development seems to benefit from other economic activities. Even though strong relation between insurance activities and national output is widely believed to exist, the interaction pattern between these two variables is not clear yet. China's insurance industry grew along with the economic marketization process starting from 1980s (Pan *et al.* 2014). High-speed growth of both insurance industry and national output of China allow us a very good opportunity to examine the insurance activities-economic growth nexus in more details, including how the interaction pattern evolves along with the changing scenarios of interest rate, a factor which may impact both variables, and contribute to the existing literature.

2. Literature Review

2.1. Causal Relation between Insurance Activities and Economic Growth

In general, four theories emerged in previous literature about the relation between economic growth and insurance activities. The first theory is termed the "Supply-Leading Hypothesis" (SLH), positing that economic growth ensues from the advancement of insurance. According to SLH, the growth of insurance activities contributes essential services and funds that foster economic development, leading to an increased level of output. A strand of literature provides the evidences (for instance, Arena (2008), Han *et al.* (2010), Su *et al.* (2013), and Pradhan *et al.* (2015)). The second perspective is referred to as the "Demand-Following Hypothesis" (DFH), suggesting that economic growth increases the demand for insurance coverages, establishing a causal relationship from national output to insurance activities. Much literature supports this idea (see Beck and Webb (2003), Petkovski and Kjosevski (2014), Pradhan *et al.* (2015, 2016), and Su *et al.* (2013) for reference). The third proposition is the "Feedback Hypothesis" (FBH), asserting that national output and insurance activities mutually reinforce each other, and the causal relation is bi-directional rather than one-way (Kugler and Ofoghi (2005), Pradhan *et al.* (2016)). The fourth perspective is the "Neutrality Hypothesis" (NEH), which believes that the insurance activities and economic growth are independent of each other and no causal relation exists between these two economic variables (Hu *et al*., 2013; Pradhan *et al*., 2015).

2.2. Influence of Interest Rate on Insurance Activities

Interest rate risk is always a concern for financial firms, variation of interest rate can have major impacts on the value of financial institutions. Insurance firms are none of exception. Among various insurance firms, life insurers seem to be more vulnerable to interest rate shock because life insurance firms sell long-term products whose present value depends on interest rates (Brewer *et al*, (2007); Becker & Ivashina, 2015). Life insurers are also exposed to interest rate risk through the behaviour of policyholders (Berends, *et al*., 2013; Jensen, *et al.* 2019). National Association of Insurance Commissioners (NAIC), a regulatory support organization, states in a publication that "Interest rate risk can materialize in various ways, impacting life insurers' earnings, capital and reserves, liquidity and competitiveness" (NAIC, 2016). For non-life insurers, the reserve an insurer should maintain, computed as the expected discounted claims, is also subject to interest rate risk through the variation in the discounting term (Barbarin *et al*., 2009).

2.3. Impact of Interest Rate on Economic Growth

In the macroeconomic literature, investment is one of the key determinants of economic growth. Interest rate affects residents' willingness to save and spend, and the capital costs of investment, thus impacting economic growth. Many researchers identified a negative relationship between interest rate and economic growth (for instance, Breeden, 1979; Cochrane, 1991; Kamara, 1997;

Low and Chan, 2017; Ozer and Karagol, 2018). Interest rate can affect economic growth directly or through some intermediary variables (Josifidis *et al.,* 2014; Shaukat *et al.* 2019).

This article contributes to the existing literature in two folds. Firstly, the relation between the insurance development and economic growth may vary during the growth process of an economy (Enz, 2000; Zheng *et al*., 2008), but this issue has rarely been examined within a framework yet. This article uses quantile methods to explore the causal relation at various quantile values and capture the characteristics. Secondly, causal relation might change when some external factors project influence on both variables under study. For instance, Lee, *et al.* (2016) identifies that institutional environments shape the relation between insurance activities and economic growth. Consideration of the role of interest rate in this article will add monetary policy implications in the causal relation analysis.

3. Data

This paper uses data of life insurance, non-life insurance, interest rate and Gross Domestic Product (GDP) during 1999Q1-2020Q4 in China to study the links between insurance activities and economic growth with interest rate as a control variable. Data are obtained from Statistic Book of China (various issues) and website of China Banking and Insurance Regulatory Commission (CBIRC). Table 1 reports summary statistics of data studied, and we find all the data sets are non-normal except for interest rate. All data are seasonally adjusted at its source. Based on Koenker and Bassett (1978), quantile regression performs better than traditional OLS regression if data distribution is non-normal, this is one of the reasons why we use Quantile approach in our study. Furthermore, due to its independence from mean-based estimates, quantile regression is less susceptible to the influence of outliers, offering a more precise depiction of the data structure. Additionally, it furnishes a more comprehensive perspective on the relationship between variables. Quantile regression can be adapted to model nonlinear relationships more flexibly than OLS regression. It proves particularly advantageous in fields such as economics, finance, and medical research, where gaining insights into the impact of variables across various points of the distribution is paramount.

Table 1. Descriptive Statistics

	GDP	*life insurance*	*non-life insurance*	*interest rate*
Mean	26828.5	217.3	171.9	5.9
Median	18321.4	181.4	107.8	5.9
Maximum	101598.6	1163.1	589.7	7.7
Minimum	1927.4	13.4	12.5	4.8
Std. Dev.	24138.0	221.4	164.2	0.8
Skewness	1.2732	2.507	0.962	0.243
Kurtosis	3.9179	10.343	2.694	2.578
Jarque-Bera	26.866***	289.992***	13.922***	1.524
Probability	0.000	0.000	0.000	0.466
Shapiro-Wilk Test	0.978**	0.950**	0.982**	0.988**

*Notes: *** and ** indicate significance at the 1 and 5% levels, separately.*

4. Methodology – Quantile Approach and Quantile_on_Quantile Approach

4.1. Quantile Approach (QA)

While it is acknowledged that the conventional Granger causality test (Granger, 1969) falls short in offering insights into tail causal relations or nonlinear causalities, the quantile causality approach offers a more intricate and adaptable evaluation of causal relationships. This study employs the Bootstrap Toda-Yamamoto Granger causality test through quantile regression (referred to as BTY-QG (p) hereafter), as introduced by Cheng *et al.* (2021), to examine the interconnection between insurance activities and economic growth in China. The following two Quantile equations are obtained.

$$EGrowth_t(\tau) = C_{10} + \sum_{i=1}^{p-1} \theta_{11}(\tau) EGrowth_{t-i} + \sum_{i=1}^{p+d} \delta_{12}(\tau) InsuranceA_{t-i} + \sum_{i=1}^{p+d} r_{13}(\tau) InterestR_{1t-i} + \varepsilon_{1t} \quad (1)$$

$$InsuranceA_t(\tau) = C_{20} + \sum_{i=1}^{p-1} \theta_{21}(\tau) InsuranceA_{t-i} + \sum_{i=1}^{p+d} \delta_{22}(\tau) EGrowth_{t-i} + \sum_{i=1}^{p+d} r_{23}(\tau) InterestR_{2t-i} + \varepsilon_{2t} \quad (2)$$

Where *EGrowth* is economic growth, *InsuranceA* is insurance activities, and *InterestR* is interest rate to serve as a control variable. We can test Granger causality running from insurance activities to economic growth at different quantiles under the null hypothesis of $\delta_{12}(\tau_1) = \delta_{12}(\tau_2) = \cdots = \delta_{12}(\tau_p) = 0$ in Equaton (1) and Granger causality from economic growth to insurance activities at different quantiles under the null hypothesis of $\delta_{22}(\tau_1) = \delta_{22}(\tau_2) = \cdots = \delta_{22}(\tau_p) = 0 \; in \; Equation \; (2)$. The optimal lags (p*) of our model is selected based on Akaike Information Criterion (AIC). $R\beta(\tau) = 0$is the null hypothesis of no Granger causality in the following Wald statistic:

$$Wald = \left(R\beta(\tau)\right)' [R(Z'Z)^{-1} \otimes S]R')^{-1}](R\beta(\tau)) \quad (3)$$

Where *R* is an indicator matrix of the parameters, $\beta(\tau)$ is the column stack of *D*, *S* is the variance–covariance matrix of the unrestricted model, and $\otimes$ is the Kronecker product. Considering the possible issue of autoregressive conditional heteroskedasticity (ARCH) effects in data, we use the bootstrapping simulation technique based on Hatemi-J and Uddin (2012) for 10000 iterations to construct the 10%, 5%, and 1% critical values from the empirical distribution.

4.2. Quantile_on_Quantile Approach (Sim and Zhou, 2015, hereafter, QQA)

In this study, we also use the QQA proposed by Sim and Zhou (2015) to examine the comprehensive relationship between insurance activities and economic growth. This technique is mainly based on a combination of non-parametric estimation and quantile regression. Following Sim and Zhou (2015), the following non-parametric quantile regression model is used to examine the impact of different quantiles of insurance activities (or economic growth) on the various quantiles of economic growth (insurance activities): .

$$EGrowth_t = \beta^{\theta}(InsuranceA_t) + G(InterestR_t) + W(EGrowth_{t-1}) + u_t^{\theta} \quad (4)$$

and

$$InsuranceA_t = w^{\theta}(EGrowth_t) + G(InterestR_t) + W(InsuranceA_{t-1}) + e_t^{\theta} \quad (5)$$

Where $EGrowth_t$ represents economic growth, $InterestR_t$ is interest rate to serve as a control variable. We also incorporate $EGrowth_{t-1}$ and $InsuranceA_{t-1}$ into Equations (4) and (5) to deal with residuals series correlation problem. $InsuranceA_t$ is insurance activities in time *t, and* θ

denotes the θth quantile in the distribution of $EGrowth_t$. u_t^{θ} and e_t^{θ}represent quantile error term, where estimated θth quantile is equal to zero. Moreover, $\beta^{\theta}(*)$ and $w^{\theta}(*)$ are unknown since no information is available on the relationship between $EGrowth_t$ and $InsuranceA_t$. The key advantage of this specification lies in its flexibility, as it does not impose any hypotheses regarding the functional form of the relationship between $InsuranceA_t$ and $EGrowth_t$. To reveal the relation between the θth quantile of $EGrowth_t$ and the τth quantile of $InsuranceA_t$, denoted by $InsuranceA^{\tau}$, a first-order Taylor expansion around a quantile of $InsuranceA^{\tau}$ $(or\ EGrowth^{\tau})$ is used as in Eq (6) and (7):

$$\beta^{\theta}(InsuranceA_t) = \beta^{\theta}(InsuranceA^{\tau}) + \beta^{\theta'}(InsuranceA^{\tau})(InsuranceA_t - InsuranceA^{\tau}) \quad (6)$$

and

$$w^{\theta}(EGrowth_t) = w^{\theta}(EGrowth^{T}) + w^{\theta'}(EGrowth^{\tau})(EGrowth_t - EGrowth^{\tau}) \quad (7)$$

Where $\beta^{\theta'}$ is the partial derivative of $\beta^{\theta}(InsuranceA_t)$ with respect to $InsuranceA_t$, $w^{\theta'}$ is the partial derivative of $w^{\theta}(EGrowthA_t)$ with respect to $EGrowth_t$, which is also called marginal effect, similar to the slope coefficient in a linear regression model. A remarkable feature of Equation (6) is that the parameters $\beta^{\theta}(InsuranceA^{\tau})$ and $\beta^{\theta'}(InsuranceA^{\tau})$ are doubly indexed in θ and τ. Unlike the standard conditional quantile function, this expression reflects the relation between the θ th quantile of $EGrowth_t\ (or\ InsuranceA_t)$ and the τth quantile of $InsuranceA_t\ (or\ EGrowth_t)$. Moreover, a linear relation is not assumed between the quantiles of the variables under study. Consequently, Equation (7) estimates the overall dependence structure between $EGrowth_t$ $(InsuranceA_t)$and $InsuranceA_t$ $(EGrowth_t)$ at their respective quantile distributions.

The Quantile Quantile Adjuster (QQA) can be interpreted as a technique that breaks down the estimations of the standard quantile regression model, facilitating the acquisition of specific estimates for various quantiles of the explanatory variable. Exploiting this inherent decomposition property of the QQA, it becomes feasible to utilize the QQA estimates for the retrieval of standard quantile regression estimates. To be more precise, the quantile regression parameters, uniquely identified by θ, can be derived by averaging the QQA parameters across τ. For example, the slope coefficients of the quantile regression model, which measure the effect of $InsuranceA_t\ (or\ EGrowth_t)$on the distribution of $EGrowth_t\ (or\ InsuranceA_t)$ and is denoted by $\gamma_1(\theta)$, can be obtained as follows:

$$\gamma_1(\theta) \equiv \bar{\hat{\beta}}_1(\theta) = \frac{1}{S}\sum_{\tau} \hat{\beta}_1(\theta, \pi) \quad (8)$$

$$\gamma_1(\theta) \equiv \bar{\hat{w}}_1(\theta) = \frac{1}{S}\sum_{\tau} \hat{w}_1(\theta, \pi) \quad (9)$$

where S =19 is the number of quantiles when $\tau = [0.05, 0.10 \ldots, 0.95]$ considered. A simple way of checking the validity of the QQA is to compare the estimated quantile regression parameters with the τ-averaged QQA parameters. We illustrate both QA and the averaged QQA estimates of the slope coefficients, demonstrating that the fundamental characteristics of the quantile regression model can be reconstructed by consolidating the richer information embedded in the QQA estimates.

5. Empirical Results

To avoid spurious regression results, several conventional unit root tests such as ADF, PP and KPSS are used to examine the unit root in the variables studied. We select the lag order of the test on the basis of the recursive t-statistic, as suggested by Perron (1989). For the second step we go for cointegration test. Bayer and Hanck (2013) introduced a novel cointegration methodology referred to as the combined cointegration approach. This approach integrates outcomes from preceding cointegration methods (such as Phillips and Ouliaris, 1990; Boswijk, 1994; Johansen, 1995; Banerjee, 1998) and furnishes Fisher F-statistics, enhancing the conclusiveness and reliability of empirical results. Consequently, we utilize the combined cointegration test proposed by Bayer and Hanck in our research. Interested readers can refer to Bayer and Hanck (2013) for details about Fisher F-statistics. Finally, both QA and QQA approaches are conducted to analyse the links between insurance activities and economic growth and all the empirical results are reported as follows:

5.1. Results from Traditional Unit Root Tests

Results from the ADF, PP and the KPSS tests are reported in Tables 2, both the ADF and PP tests fail to reject the null hypothesis of non-stationary at 5% significance level in GDP, life insurance, non-life insurance and interest rate for China. But after taking difference, these variable become stationary, thus these variables are confirmed as I(1) order.

Table 2. Unit root test results

	ADF	*PP*	*KPSS*	*ADF*	*PP*	*KPSS*
		Level			first difference	
GDP	*-1.929*	*-6.026*	*1.360****	*-2.066*	*-32.15****	*0.076*
life insurance	*-2.427*	*-2.757**	*1.135****	*-5.348****	*-35.015****	*0.245*
non-life insurance	*-1.360*	*-1.557*	*1.202****	*-2.796**	*-19.891****	*0.249*
interest rate	*-2.394*	*-2.074*	*0.499**	*0.000****	*-4.922****	*0.065*

Notes: ***and * indicate significance at the 1 and 10 % levels, respectively.

5.2. Results from the Bayer-Hack Combined Cointegration Test (Bayer and Hanck, 2013)

Table 3 reports the results from Bayer-Hanck (BH) combined cointegration tests, and we find BH cointegration test fails to reject the null hypothesis of no cointegration at the 10% significance level. This means cointegration did exist between insurance activities and economic growth in China, therefore, the Bootstrap Toad-Yamamoto Quantile Granger causality (BTY-QG(p+1)) will be used in our Granger causality test.

Table 3. Bayer-Hanck Combined Cointegration Test

Variables	*EG-JOH*	*EG-JOH-BO-BDM*	*lags*	*Cointegration*
life insurance and GDP	70.463***	77.861***	2	Yes
non-life insurance and GDP	66.515***	77.72***	2	Yes
Significance level				
1%	17.304	33.969		
5%	11.229	21.931		
10%	8.678	16.964		

*Notes: ***, ** and * indicate significance at the 1, 5 and 10 % levels, separately.*

5.3. Granger Causality Test Results based on Bootstrap QA

Following Cheng *et al.* (2021), Granger causality test results with Wald test statistics in Quantile model are reported in both Table 4 (without interest rate as a control variable) and Table 5 (with interest rate as a control variable). Based on the AIC value we find the optimal lags of p* is 2 for both equations (1) and (2). Therefore, we use the Bootstrap Granger causality in Quantile in the next step. Results in Table 4 indicate Granger causality running from life/non-life activities to economic growth at 0.1~0.5/0.6 quantiles, respectively and from economic growth to insurance activities at all quantiles. These empirical results demonstrate strong evidence in favour of a feedback between insurance activities and economic growth at lower quantiles of insurance activities in China. Table 5 demonstrates the results with interest rate as a control variable and we find similar results as those in Table 4, except that the causal relation running from economic growth to non-life insurance only exist at high quantiles (0.4-0.9).

Table 4. Quantile Causality Test - GDP, Life and Non-life insurances without Interest Rate

	GDP = f (life insurance)				life insurance = f (GDP)			
quantile.	Wald test.	CV10%	CV 5%	CV 1%	Wald test.	CV10%	CV 5%	CV 1%
0.1	166.6(+)***	19.801	27.633	41.787	26.72(+)***	12.837	15.388	23.436
0.2	131.8(+)***	21.103	25.773	36.727	29.04(+)***	11.728	14.606	19.647
0.3	114.0(+)***	19.423	24.283	35.267	27.44(+)***	10.163	13.039	17.359
0.4	76.64(+)***	17.096	19.560	28.545	21.34(+)***	9.1717	11.822	14.982
0.5	46.64(+)***	15.080	16.955	25.014	19.82(+)***	8.9110	10.533	16.509
0.6	0.530065	15.403	18.726	24.758	28.80(+)***	9.0359	11.262	17.255
0.7	0.459622	17.619	20.822	26.239	42.70(+)***	8.0398	10.868	16.776
0.8	0.654669	19.988	24.594	31.305	95.16(+)***	9.1820	12.004	19.895
0.9	0.729454	23.175	27.983	39.334	160.2(+)***	11.173	15.528	24.126

	GDP = f (non-life insurance)				Non-life insurance = f (GDP)			
quantile.	Wald test.	CV10%.	CV 5%.	CV 1%.	Wald test.	CV10%.	CV 5%.	CV 1%.
0.1	768.2(+)***	21.722	27.503	46.318	26.08(+)***	14.511	18.491	29.833
0.2	509.5(+)***	26.823	35.731	59.758	20.31(+)***	14.301	18.176	23.446
0.3	423.3(+)***	28.378	35.452	53.607	26.35(+)***	14.069	16.706	23.653
0.4	251.9(+)***	28.277	34.257	48.834	30.95(+)***	13.380	16.494	23.231
0.5	172.7(+)***	29.152	34.773	47.729	54.88(+)***	12.927	16.823	20.921
0.6	104.6(+)***	31.961	36.888	47.670	97.44(+)***	13.029	15.838	22.004
0.7	1.044509	36.016	42.171	56.952	165.0(+)***	13.513	16.183	25.313
0.8	0.972731	43.608	47.500	61.497	200.3(+)***	13.505	17.178	27.384
0.9	1.495167	51.308	56.979	73.915	271.8(+)***	12.993	17.601	26.070

Notes: The data frequency is monthly, and the critical values of statistical significance at 10%, 5%, and 1% levels are denoted as CV10%, CV5%, and CV1%, respectively. Symbols (***) signify rejection at the 1% levels or more stringent.

Table 5. Quantile Causality Test - GDP, Life and Non-Life insurances with Interest Rate

	GDP = f (life insurance, interest rate)				life insurance = f (GDP, interest rate)			
quantile.	Wald test	CV10%	CV 5%	CV 1%	Wald test	CV 10%	CV 5%	CV 1%
0.1	135.6(+)***	18.141	23.9127	33.074	23.38(+)***	12.343	15.385	21.06
0.2	114.2(+)***	19.927	24.675	37.254	28.02(+)***	10.908	13.734	19.877
0.3	103.9(+)***	18.065	22.821	30.341	23.97(+)***	9.354	11.509	16.625
0.4	69.57(+)***	16.258	18.662	24.178	18.63(+)***	8.698	11.262	17.185
0.5	41.45(+)***	15.332	16.875	21.911	23.73(+)***	8.009	10.217	16.214
0.6	0.592	15.267	17.609	25.796	39.74(+)***	7.616	10.660	16.522
0.7	0.522	15.950	18.090	24.962	41.34(+)***	8.577	11.018	18.064
0.8	0.689	17.432	20.220	26.539	97.21(+)***	9.580	11.525	16.141
0.9	0.864	21.182	24.727	32.049	162.8(+)***	10.495	14.462	20.458
	GDP = f (non-life insurance, interest rate)				non-life insurance = f (GDP, interest rate)			
quantile.	Wald test	CV10%	CV 5%	CV 1%	Wald test	CV 10%	CV 5%	CV 1%
0.1	1076.0(+)***	19.324	23.028	42.010	17.91205	15.140	19.632	34.628
0.2	688.2(+)***	26.633	32.363	47.213	23.34852	14.4192	18.442	30.468
0.3	486.8(+)***	26.036	31.069	45.598	23.41770	14.512	18.003	25.097
0.4	409.0(+)***	25.703	31.984	43.608	27.53(+)***	14.160	18.093	25.146
0.5	335.0(+)***	28.013	33.174	41.164	107.9(+)***	13.889	17.709	24.359
0.6	226.9	30.926	34.867	46.480	109.4(+)***	15.146	17.562	27.799
0.7	0.714	35.616	40.428	49.381	136.2(+)***	14.640	18.232	25.978
0.8	0.958	41.980	47.022	60.065	158.5(+)***	14.769	18.357	26.877

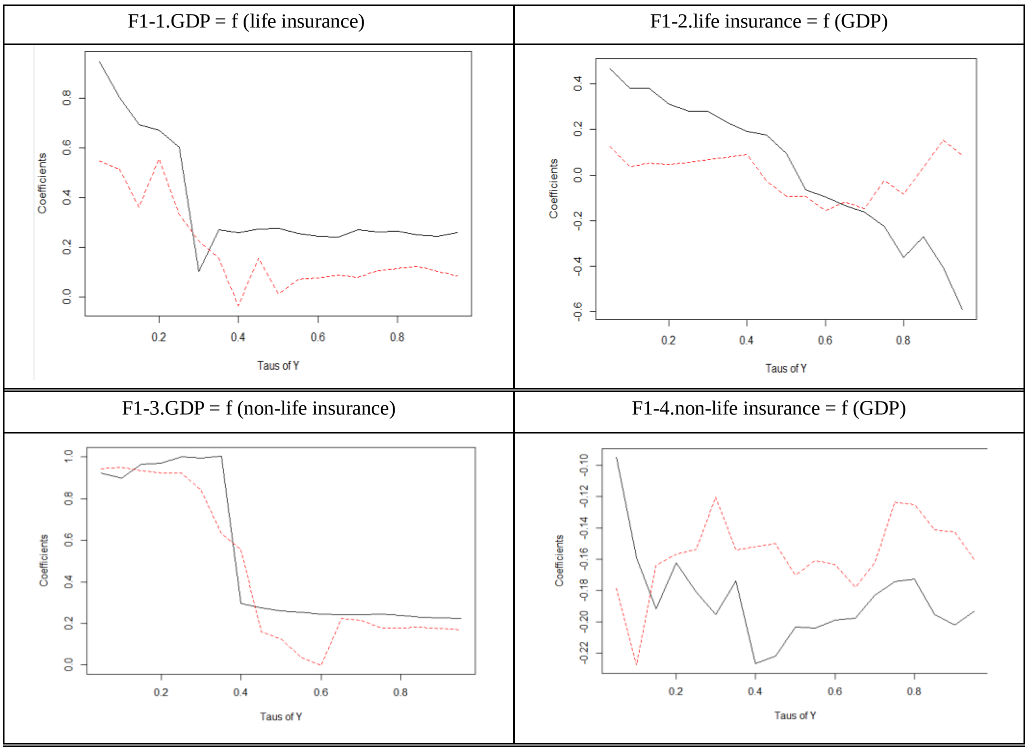
0.9	1.329	50.139	54.671	64.335	259.2(+)***	13.377	19.682	30.530

Notes: The data frequency is monthly, and the critical values of statistical significance at 10%, 5%, and 1% levels are denoted as CV10%, CV5%, and CV1%, respectively. Symbols (***) signify rejection at the 1% levels or more stringent.

5.4. Empirical Results from QQA

To further examine the comprehensive relationship between insurance activities and economic growth for China, we also use the QQA proposed by Sim and Zhou (2015). First of all, we check the validity of the QQA. Both QA and averaged QQA estimates of the slope coefficients are plotted (see Figure 1), the graphs from Figure 1-1 to Figure 1-4 (without interest rate as a control variable) indicate that the QQA estimates of the slope coefficient closely resemble those of the standard quantile regression.

Figure 1. Comparison between Quantile Regression and Quantile-on-Quantile Regression Estimates with GDP, Life and Non-life insurance



5.4.1. QQA Results for Life Insurance Activities and Economic Growth (GDP)

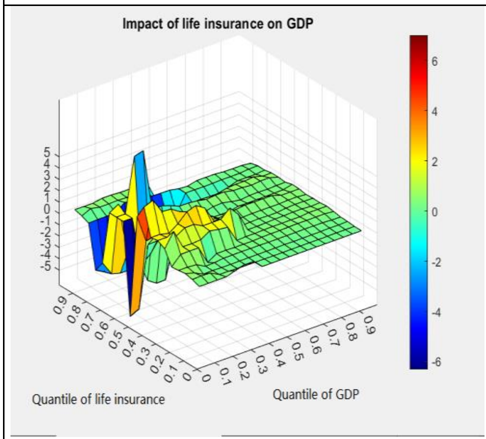
A 3-D QQA estimates are plotted in Figure 2-1 to Figure 2-4 (without interest rate as a control variable), through the plot we can see the links between insurance activities and economic growth vary at different quantiles. Figure 2-1 shows that the impact of life insurance activities at 0.05 ~ 0.25 and 0.8 ~ 0.95 quantiles do not show causal impacts on economic growth (at all quantiles). Whereas the causal impact of life insurance activities at 0.3 ~ 0.75 quantiles on economic growth at 0.05 ~ 0.45 quantiles are significant and quite volatile. Figure 2-2 show the reverse links where we treat life insurance activities as a dependent variable, we observe that the influence of economic growth on life insurance activities is notably robust and exhibits volatility.

5.4.2. QQA Results for Non-life Insurance Activities and Economic Growth (GDP)

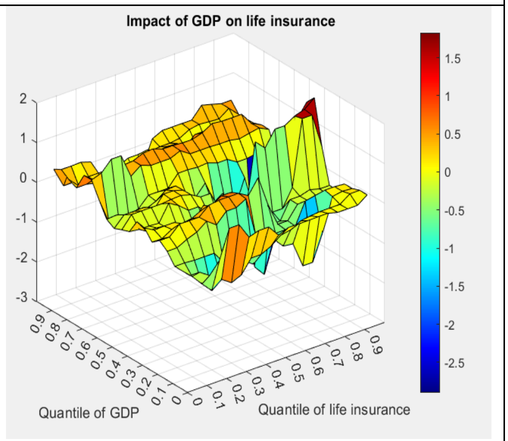
In Figure 2-3 we can see that non-life insurance activities (under all quantiles) affect economic growth (at 0.05 ~ 0.50 quantiles) and these effects disappear when economic growth is at 0.55 ~ 0.95 quantiles. Figure 2-4 shows that the effects of economic growth on non-life insurance activities are quite strong and volatile at all quantiles.

Figure 2. Quantile-on-Quantile (QQ) estimates of the slope coefficients without control of interest rate

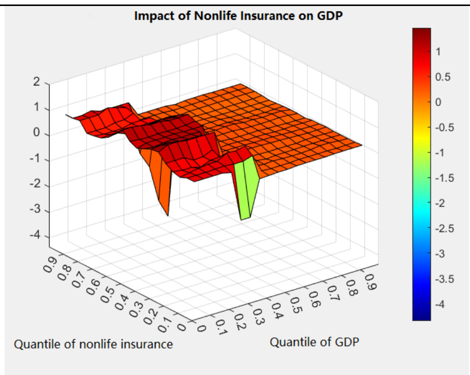
F2-1.GDP = f (life insurance)



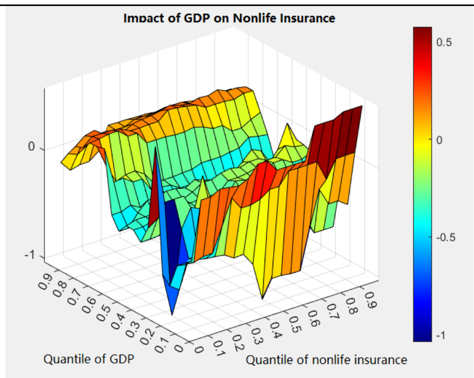
F2-2.life insurance = f (GDP)



F2-3.GDP = f (non-life insurance)



F2-4.non-life insurance = f (GDP)

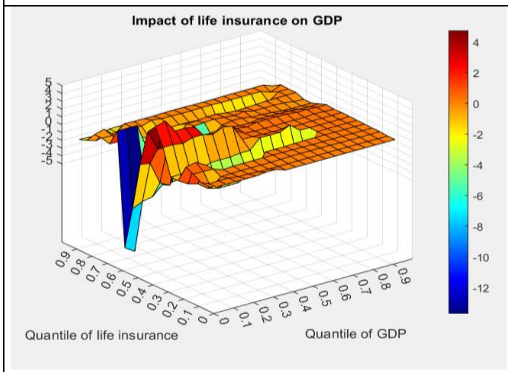
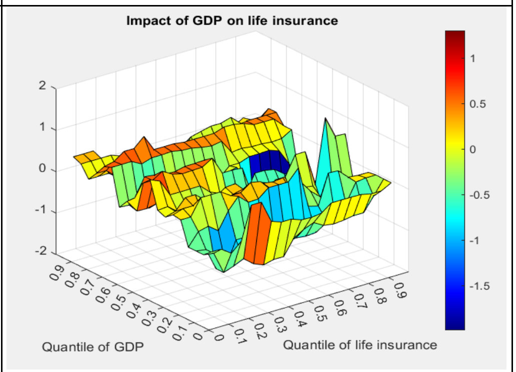
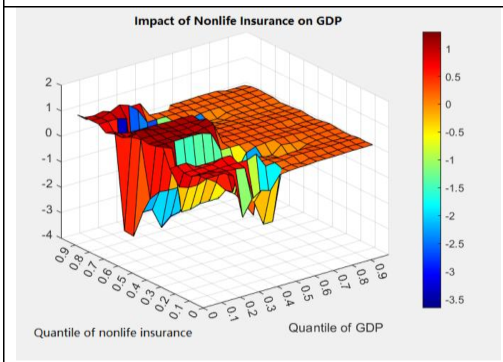
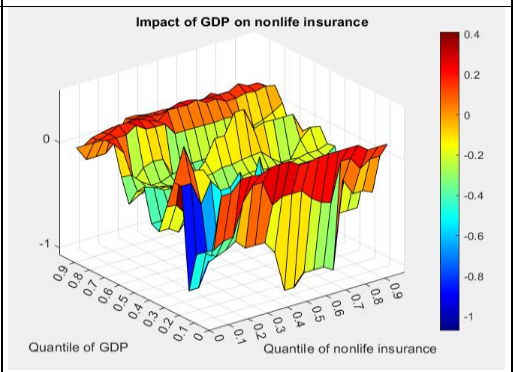


5.4.3. QQA Results with Control of Interest Rate

To investigate the role played by the interest rate for the link of economic growth and insurance activities, we also incorporate interest rate in our model, the empirical results are plotted in Figure

3-1 to Figure 3-4. With interest rate as a control variable we can see that the links between Insurance activities and economic growth also vary under different quantiles and empirical results are similar to those found in Figure 2-1 to Figure 2-4. However, the links become more volatile when interest rate is serving as a control variable.

Figure 3. Quantile-on-Quantile (QQ) Estimates of the Slope Coefficients with Control of Interest Rate

F4-1.GDP = f (life insurance, interest rate)	F4-2.life insurance = f (GDP, interest rate)
	
F4-3.GDP = f (non-life insurance, interest rate)	F4-4.non-life insurance = f (GDP, interest rate)
	

5.5. Economic and Policy Implications

Firstly, both life and non-life insurance appear to stimulate economic growth at lower quantiles, yet this effect diminishes as insurance activities reach higher quantiles. Our results are supported by many previous studies, such as Arena (2008), Si *et al*.(2018), and Singh(2020), in which life or/and non-life insurance are found to promote economic growth. Moreover, our study goes one step further to reveal that insurance sectors play better roles at lower quantiles. This might indicate that the Chinese insurance industry fails to meet higher-level demands of the economy and society. Radical changes occurred in various economic fields in the past decades, but insurance industry still appears to be too conservative to change accordingly. For instance, many Chinese non-life insurance firms still rely heavily on the traditional auto insurance products which take up more than two thirds of the business. More innovation in Chinese insurance industry is greatly desired in the future.

Secondly, economic growth has always been seen as a positive impetus for life/non-life insurance activities in general, as identified in Bayar *et al*.(2021), Petkovski and Kjosevski (2014), Pradhan *et al.* (2015, 2016), and Su *et al*.(2013), while this impact was subject to change across various quantiles according to our results. QQA results exhibit highly volatile causal relations running from GDP to both life and non-life insurance, which indicates that insurance sectors are widely affected by economic growth due to its wide range of business connected to various fields of economy, and the mechanism could be complex.

Thirdly, interest rate shows strong impacts on the relationship between insurance activities and economic growth. The most prominent impact is on the causal effect of economic growth on non-life insurance activities. When the interest rate is controlled, the QA results show that the causal effects become insignificant at lower quantiles (0.1 ~ 0.3). Furthermore, we observe that the results from QQA show more volatile relationship between insurance activities and economic growth when interest rate is considered, which indicates that sometimes interest rate helps shape the relationship of the insurance activities-economic growth nexus. Our findings are in accordance with NAIC (2016) and Barbarin *et al.* (2009) which stress the material impact of interest rate on insurance industry.

Some important policy implications can be drawn from the above discussion. Firstly, both life and non-life insurance sectors should be encouraged to innovate according to the changing economic scenarios, so that their contributions to the economic growth can be more significant. Secondly, the role of interest rate is worthy of attention because it may affect the causal relation of the insurance activities-economic growth nexus, and the insurance regulatory policy making should keep an eye on monetary policy change.

Conclusion

This study re-investigates the link between insurance activities and economic growth for China during 1999Q1~2020Q4 using both Quantile and Quantile_on_Quantile approaches which have rarely been shown in previous studies. It is identified that insurance activities and economic growth reinforce each other at lower quantiles (0.1 ~ 0.5), and economic growth causally affects insurance activities at all quantiles (0.1~0.9). It indicates that the macroeconomy always has impacts on insurance industry, while the contributions of insurance activities to the economic growth are not without condition, insurance industry needs more innovations to serve the society and support the economy when the development of insurance industry is at a higher level. These conclusions are further supported with more detailed results from Quantile_on_Quantile approach (QQA). When we incorporate interest rate as a control variable we notice the link between insurance activities and economic growth change and the causal relations become even more volatile. This result shows the important role of interest rate in moderating the link between insurance activities and economic growth in China. These findings have important implications for policymakers and insurance firm operations in China. They suggest that insurance policies and firm strategies should be tailored to different stages of economic growth and development of the insurance sector. The study also implies that monitoring and responding to changes in macroeconomic factors like interest rates is crucial for the effective management and regulation of the insurance industry.

Our investigation into the interplay between insurance activities and economic growth in China provides noteworthy findings, albeit with several limitations. Firstly, our data spans from 1999Q1 to 2020Q4, which may overlook long-term trends and recent global phenomena like the COVID-19 pandemic. Secondly, given our specific focus on China, the insights may not be applicable to economies with dissimilar insurance structures and economic systems. Thirdly, the Quantile and Quantile_on_Quantile methodologies might not thoroughly encapsulate complex and dynamic relationships, and elucidating the associations at quantile levels can be demanding. Lastly, while we have factored in interest rates, other elements such as inflation and governmental policies might also significantly influence the insurance-economy interplay.

Future research could undertake several avenues of exploration. Utilizing more data, particularly more recent data, could enhance the findings. Cross-national studies may reveal different insurance-economy dynamics under diverse regulatory settings and market maturities. Concurrently, considering other pivotal macroeconomic factors, like fiscal strategies and the degree of openness, could be beneficial in dissecting the insurance-economy nexus.s

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