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Quantifying the Linkages among Agricultural, Manufacturing and Service Sectors Associated with GDP Growth in Thailand

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Abstract: This paper analyzes the linkages among three economic sectors in Thailand, namely manufacturing, agricultural, and service sectors, as well as their contributions to Thailand's GDP growth using the quantile vector autoregression (QVAR) model. We have a special concern about a variety of distributions across quantiles and propose the multivariate skewed distributions for the QVAR model. Our empirical results find that service sector plays a crucial role to support other economic sectors while the impacts of the manufacturing and agricultural sectors turn out to be negative on the service sector. In addition, this analysis finds that during the expansion phrase, the manufacturing and service sectors play a significant role in boosting up the Thai economy. But in the recession, the service sector is the only significant engine that remains and drives the economy.

Keywords: Quantile vector autoregression, Scale mixtures of normal distributions, GDP sector compositions, Economic growth

1. INTRODUCTION

Thailand is a newly industrialized country, which was marked as a tiger economy with the rapid economic growth rate around 10% during 1985 and 1996. The Thai economy grew at a fast pace until it went through the Asian Financial Crisis of 1997-98. The Thai economy suffered greatly from this crisis before recovered in a few years later, and took almost 10 years to get back to the 1996 GDP level (Bosworth, 2005). Since then, the Thai economy grew at the moderate rate, but later the growth became slower again due to the unstable domestic politics and again the global financial crisis of 2008-09.

Presently, Thai Gross Domestic Product in the year 2015 was 395.17 USD Billion. It was contributed by three major sectors of the Thai economy: manufacture, agriculture, and service. Manufacturing sector is highly important accounting for 26.92 percent of the GDP while agriculture is producing only 9.14 percent of the GDP. Recently, the share of manufacturing sector in GDP has become larger whereas the role of agriculture in the Thai economy has become less important, as shown in Figure1. Services play a crucial role in propelling the Thai economy. It accounted for 55.14 percent of the GDP in 2015, and averagely more than 50 percent over the last 20 years.

The process of economic development results in a transformation of the country into a newly industrialized nation. In the early stage, Thailand had a traditional agro-economy in which agriculture played an important role to propel the economy and employed more than 60% of Thailand's workforce (Pipitpojanakarn et al., 2016). However, the impact of agriculture on Thailand's economy has gradually declined as the country developed. The growth of other sectors, especially manufacturing, has increased over the years, as shown in Figure1. Similar trend is also evident in service sector but with a greater GDP share which has increased from 45 percent in 1960 to 55 percent in 2015, paralleling with that of manufacturing. This means service sector is also an important source of economic growth in Thailand. We, thus, witness the Thai economy's transformation taking place with a large decline in the share of agriculture, and the growing dominance of both manufacturing and service sectors.

This experience violates the common pattern of economic structural change in the past. As shown in the literature, there is a sequence of economic development in which agriculture, industry, and services sectors are developed successively (Singariya and Naval, 2016). On the contrary, the service sector in Thailand as well as in many other developing countries has already become large in parallel with the manufacturing. This raises several questions: i) Is there an intersectoral linkage between manufacturing and services in Thailand's economy? ii) How does the growth in both manufacturing and service sectors affect the agricultural sector? And how do these three economic sectors contribute to Thailand's economic growth?

To quantify the intersectoral linkages and the contribution of these economic sectors to economy, the literatures show that vector autoregression (VAR) model is the most suitable method. This model

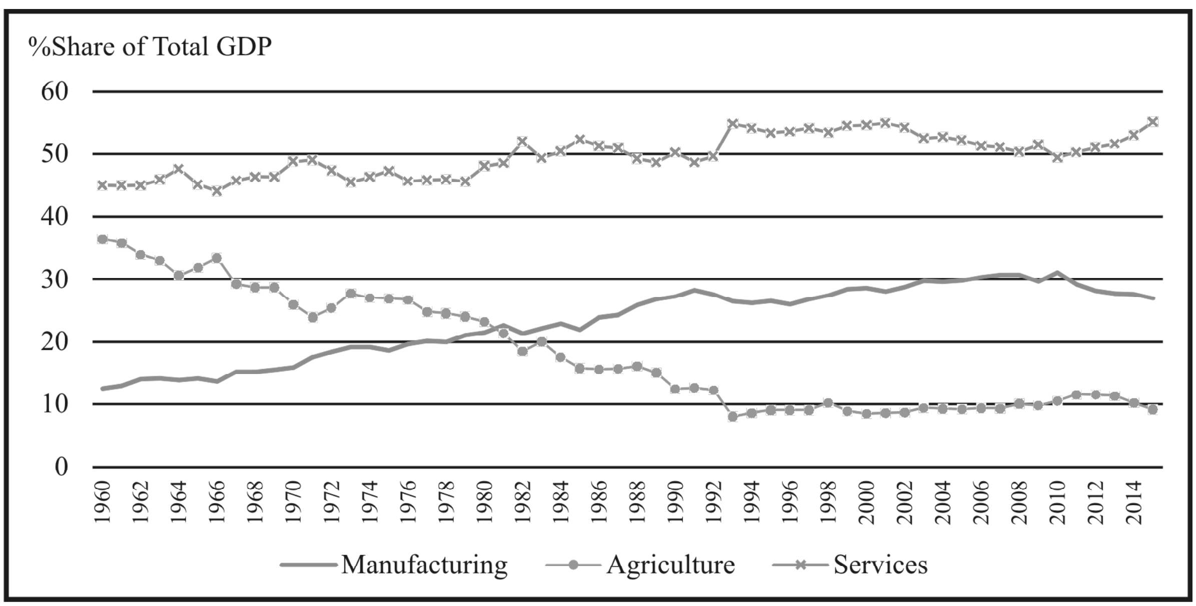


Figure 1: GDP by Sector as % Share of Total GDP (1960-2015)

Source: World Bank, 2016

allows us to summarize the information contained in the data and to conduct certain types of policy experiments, which is useful for macroeconomic view. There are plenty studies employing VAR model to quantify the interrelationship among economic sectors, for example, the study of Singariya and Naval (2016). The authors used VAR model to study the intersectoral linkages and economic growth in India. Similarly, Subramaniam and Reed (2009) used this algorithm to identify the pattern of changes in sectoral composition and the contribution to Poland's and Romania's economic growth, as well as the study of Uddin (2015) in the case of Bangladesh. However, the interpretations of the linkages under these studies are stuck to the average state of the economy. Therefore, to make the interpretation more realistic, we need to analyze the asymmetry of the economy. Schüler (2014) and Pastpipatkul et al. (2017) suggested applying quantile to the VAR model to identify the real state of economy. For example, in the case of GDP growth in lower quantile, it can be attributed to recession while the growth in higher quantile can characterize boom or expansion. All of these studies have made useful contributions in terms of both understanding the linkages between economic sectors and economic growth, and the suitable econometric model. Hence, this paper attempts to find the intersectoral linkages and their contributions to economic growth to answer our three research questions by using the quantile vector autoregression (QVAR) model.

The remainder of this paper is organized as follows. Section 2 provides the basics for understanding the quantile vector autoregression (QVAR) model and introduces the multivariate skewed distribution families for QVAR. Section 3 presents the data description and variables used in this paper. Next, the empirical study and results will be discussed in Section 4. Section 5 is conclusion.

2. METHODOLOGY

This paper employs the quantile vector autoregression (QVAR) model to quantify the linkages among three economic sectors and to identify their contributions to Thailand's economic growth. Therefore, the beginning of this section will provide the basics of QVAR model, and then we will introduce the multivariate skewed distribution families for QVAR model.

2.1. Quantile Vector Autoregression (QVAR) Model

Quantile vector autoregression (QVAR) model allows for the analysis of the linkages among economic variables across the full conditional distribution of the dependent variable. As we mentioned, this study is an attempt to analyze the relationship among the three economic sectors: agriculture, manufacturing and services, and Thailand's GDP growth with a special concern about asymmetry of the economy, such as recession, expansion, and intermediate growth. In order to address this problem, we employ QVAR model as introduced by Cecchetti and Li (2008). The authors provided a simple QVAR process of order p as follows.

Consider the p^{th} order autoregression for the M dimensional endogenous variables vector $\mathrm{Y}_t = (y_{1t},....,y_{Mt})^{'}, t = 1,.....,T$, can be written in general form as:

$$Y_t \ = A_0^\tau + A_1^\tau Y_{t-1} + ... + A_p^\tau y_{t-p} + u_t^\tau , \tag{1}$$

where A_0^τ is $(M \times 1)$ vector of intercepts at any quantile $\tau = [0,1]$, A_p^τ is a $(M \times M)$ matrix lagged coefficients at quantile τ and u_t is a $(M \times 1)$ vector of error terms, which is assumed to have an asymmetric distribution with time invariant covariance matrix (Σ). For example, consider a bivariate QVAR(1) model equation

$$\begin{pmatrix} y_{1t} \\ y_{2t} \end{pmatrix} = \begin{pmatrix} A_{10}^{\tau} \\ A_{20}^{\tau} \end{pmatrix} + \begin{pmatrix} A_{11}^{\tau} & A_{12}^{\tau} \\ A_{21}^{\tau} & A_{22}^{\tau} \end{pmatrix} \begin{pmatrix} y_{1t-1} \\ y_{2t-1} \end{pmatrix} + \begin{pmatrix} u_{1t}^{\tau} \\ u_{2t}^{\tau} \end{pmatrix}, \tag{2}$$

where the structure error term can be written as

$$\Sigma = \begin{bmatrix} u_{1t}^{\tau}u_{1t}^{\tau} & u_{1t}^{\tau}u_{2t}^{\tau} & \cdots & u_{1t}^{\tau}u_{Mt}^{\tau} \\ u_{2t}^{\tau}u_{1t}^{\tau} & \ddots & & \vdots \\ \vdots & & \ddots & \vdots \\ u_{Mt}^{\tau}u_{1t}^{\tau} & \cdots & \cdots & u_{Mt}^{\tau}u_{Mt}^{\tau} \end{bmatrix}, \tag{3}$$

where $u_{1t}^{\tau}u_{1t}^{\tau} = \sigma_{11} = Var(u_{1t})$, $u_{it}^{\tau}u_{jt}^{\tau} = Cov(u_{jt}^{\tau}u_{jt}^{\tau})$, $u_{Mt}^{\tau}u_{Mt}^{\tau} = Var(u_{Mt}^{\tau}) = \sigma_{MM}$.

2.2. The Multivariate Skewed Distribution Families for QVAR Model

In this study, we employ a Maximum likelihood Estimator (MLE) to estimate all unknown parameters in QVAR model. From this point of view, Schüler, Y. S. (2014) used the multivariate asymmetric Laplace distribution (ALD), which permits the joint treatment of multiple equation regression quantiles. They suggested that the Laplace distribution behaves to the quantile loss function as the Gaussian distribution behaves to the squared loss function. However, Wichitaksorn, Choy, and Gerlach (2014) argued that Laplace distribution has a strong assumption in order to set the quantile model through MLE. Although, it has the zero quantile property and useful stochastic representation, it is not differentiable at zero, which brings about numerical instability problems. Therefore they introduced a generalized class of skew densities (SKD) to the quantile loss function. This family of distributions includes skew of the Normal, Student's t, Laplace, Slash and Contaminated Normal distributions. Therefore, in this study, we extend a univariate class of SKD to a multivariate SKD that can be used for our QVAR model. In this section, we explain the fundamental concept of the multivariate SKD family of distributions.

To construct the multivariate setting, following Bandyopadhyay, Lachos, Castro, and Dey (2012) and Wichitaksorn*et al.* (2014), the characteristic function of a general multivariate SKD is defined as

1) Multivariate skew-normal distribution: Skew normal distribution is the asymmetrical class of SKD distributions. It has the lowest heavier tail when compared with the skew-t, the skew-slash, and the skew-contaminated normal distributions. Here u is a location parameter, Σ_{τ} is scale parameter, and $\tau \in (0,1)$ is skewness or quantile level. The probability density function (pdf) can be written as

$$f_n(\cdot) = \frac{4\tau(1-\tau)}{\sqrt{2\pi\left|\Sigma^{\tau}\right|}} \exp\left(-2\rho_{\tau}^{2}\left(\frac{Y-u}{\Sigma^{\tau}}\right)\right), \tag{4}$$

where ρ_τ is the check or loss function defined by $\rho_\tau = u(\tau - \mathrm{I}\{u < 0\}$. Σ^τ is $(M \times M)$ nonnegative definite symmetric matrix and may be decomposed to yield

$$\Sigma^\tau = S^\tau R S^\tau,$$

where R denotes the correlation matrix with ones on the diagonal and $S^\tau = diag(\sigma_1^\tau, ..., \sigma_M^\tau)$.

2) Multivariate skew-t distribution: Skew-t distribution was proposed to solve the problem of the skew-normal distribution. It can handle a thick-tailedness, however it suffers from certain moment intractability (Jones and Faddy, 2003). The pdf of skew-t is given by

$$f_t(\cdot) = \frac{4\tau(1-\tau)\Gamma\left(\frac{v+1}{2}\right)}{\Gamma\left(\frac{v}{2}\right)\sqrt{2\pi\left|\Sigma^\tau\right|}}\left(\frac{4}{v}\rho_\tau^2\left(\frac{Y-u}{\Sigma^\tau}\right)+1\right)^{-\frac{v+1}{2}}, \tag{5}$$

where v is degree of freedom and Γ is gamma distribution.

3) Multivariate skew-laplace distribution: In the case of the skewed Laplace distribution, the check function is linearly being not differentiable at zero. The distribution has a thick-tailedness and has the highest kurtosis when compared with the others. The pdf of skew-laplace is given by

$$f_L(\cdot) = \frac{4\tau(1-\tau)}{\left|\Sigma^\tau\right|}\exp\left(-2\rho_\tau^2\left(\frac{Y-u}{\Sigma^\tau}\right)\right) \tag{6}$$

4) Multivariate skew-slash distribution: The skew-slash distribution has the ability to even handle (possible) bi-modality of random effects, with the CN being the most flexible one at the expense of an additional parameter

$$f_s(\cdot) = v\int_0^1 u^{v-1} f_n(Y\left|u, u^{-1/2}\Sigma^\tau, \tau\right)du, \tag{7}$$

where $f_n(\cdot)$ is the probability density function of skew-normal.

5) Multivariate skewed contaminated normal distribution: This distribution is similar to skew-slash distribution but its kurtosis is higher. The pdf is given by

$$f_{cn}(\cdot) = vf_n(Y\left|u, \gamma^{-1/2}\Sigma^\tau, \tau\right) + (1-\mathrm{v})\, f_n(Y\left|u, \Sigma^\tau, \tau\right), \tag{8}$$

Where γ represents a scale factor for the contaminated normal distribution. Note that the SKD family of distributions behaves to the quantile loss function in some way similar as the Gaussian distribution to the squared loss function in Ordinary Least Square (OLS). Therefore, the relationship between the quantile loss function and this family of distributions can be used to reformulate the QVAR model within the likelihood framework. To estimate all unknowns of the QVAR model, the maximum likelihood estimator is employed.

$$\widehat{\Theta}_{MLE}^\tau = \underset{\Theta^\tau}{\arg\max}\, L(\Theta^\tau \left|Y_t\right.) \tag{9}$$

3. DATA

In this study, we used quarterly data of Thailand's Gross Domestic Product (GDP), the GDP from agricultural sector (AGR), the GDP from manufacturing sector (MANU), and the GDP from service sector (SER). The data are spanning from the first quarter of 1993 to the fourth quarter of 2015, covering 95 observations. We collected the data from Thomson Reuter DataStream. We first performed the stationary test using the Augmented Dickey-Fuller (ADF) unit roots test with the variables. In this section we do not provide the results but we found that the data are not stationary, so we transformed the data into the growth rate to obtain the stationary data. The descriptive statistics of the variables are presented in Table 1.

Table 1
Descriptive Statistics

	AGRI	*MANU*	*SER*	*GDP*
Mean	0.0547	0.0186	0.0154	0.0171
Median	-0.0833	0.0087	0.0153	0.0146
Maximum	0.8416	0.2977	0.2613	0.1353
Minimum	-0.3136	-0.2045	-0.9994	-0.0930
Std. Dev.	0.2998	0.0691	0.1290	0.0381
Skewness	1.0384	0.7147	-5.0657	0.0304
Kurtosis	2.6386	6.2263	41.7039	3.2956
Jarque-Bera	17.5905	49.292	6335.8740	0.3607
Probability	0.0001	0.0000	0.0000	0.8349
ADF (prob.)	0.0000	0.0000	0.0000	0.0000

Source: Calculation.

4. EMPIRICAL RESULTS

Prior to the determination of our sectoral growth model, we will use AIC and BIC to obtain the optimal lag length for the QVAR model as well as a distribution that suits the data in each quantile. Therefore, the beginning of empirical results is about the lag length and asymmetric distribution selections. Next, we will present the estimated parameters and discuss about the intersectoral linkages and the contributions of economic activities to Thailand's economic growth. The last part will present the impulse response and variance decomposition analysis.

4.1. Lag Length Selection and Asymmetric Distribution Selection

Table 2 displays the various computed values for all lags. The minimum values based on AIC and BIC can identify the optimum lag length. The result shows that lag 1 with the AIC value of -153.3573 and BIC value of -59.6443 is the appropriate lag length. So we will use lag 1 to estimate the QVAR model.

The same criterions are used to select the best-suited distribution for the data in each particular quantile. In this paper, we consider the family of distributions consisting of skewed Normal, skewed Student's t, skewed Laplace, skewed Slash and skewed contaminated Normal distributions, and the minimum value of the criterions will show the appropriate distribution. Table 3 shows that the skewed contaminated normal is optimal for the low quantile level, i.e. 0.25, while the skewed normal distribution is optimal for the higher quantile levels, i.e. 0.5 and 0.75.

Table 2
Lag length selection for QVAR model

Lag selection	*AIC*	*BIC*
1	-153.3573	-59.6443
2	-153.1813	-59.2171
3	-153.1815	-59.3793
4	-153.1092	-59.0991

Source: Calculation

Note: We perform the lag length selection through QVAR model at the 0.5-quantile.

Table 3
Asymmetric distribution selection for QVAR(1) model

	τ = 0.25		τ = 0.5		τ = 0.75	
Distribution	*AIC*	*BIC*	*AIC*	*BIC*	*AIC*	*BIC*
Skewed Normal	-126.85	-50.87	-153.35	-73.16	-142.65	-66.6
Skewed Student-t	-89.35	-10.84	-148.73	-67.16	-82.01	-3.50
Skewed Laplace	-111.22	-35.24	-139.66	-63.56	-101.00	-25.02
Skewed Slash	-66.30	12.21	-122.89	-44.38	-66.35	12.16
Skewed Contaminated Normal	-182.96	-100.96	-129.16	-48.19	-75.51	5.54

Source: Calculation

4.2. The Estimates of the QVAR(1) Model

This section illustrates the relationships among economic sectors and the GDP growth in Thailand. We analyze these relationships under the asymmetry of the economy in which the lower quantile (τ = 0.25) is supposed to be the economy in a recession and the higher quantiles (τ = 0.5, 0.75) are supposed to be the economy in an expansion and boom respectively. The coefficients presented in Table 4 indicate the responses of the dependent variables to the changes in previous period of the independent variables.

The results show that during the recession phrase, the service sector in Thailand is influenced significantly by the changes in manufacturing sector, the GDP growth, and service sector itself. The positive signs of the service sector and the GDP growth imply that an increase in these two factors in the previous period will affect the service sector positively. On the contrary, the influence of the manufacturing sector on the services is found to be negative. This is probably because most of the jobs in service sector cannot be replaced by machinery, so this situation leads to the struggle for human resources. As the manufacturing grows, the demand for manufacturing output will attract more resources from the service sector, and this eventually creates a negative impact on the service sector. However, the contribution of the service sector to manufacturing is found to be positive. The manufacturing progress depends much on the service activity such as computer software and programming, so manufacturing should be able to benefit from the growing service sector, for example, through better technology and improved labor productivity.

During the expansion phrase the results show that agricultural sector depends negatively on the manufacturing. This is due to the transfer of labor from agriculture to manufacturing. The expansion of manufacturing requires more and more labor from the agricultural sector where there is a plentiful supply of cheap or low-cost labor. Therefore, this situation leads to a competition for labor, thereby a negative effect. On the other hand, the results also show that during the expansion phrase the agricultural sector can positively contribute to the manufacturing. Agriculture is important for the manufacturing sector since it creates demand for industrial goods. Therefore, the growing agricultural sector implies higher demand for the industrially produced goods, such as higher demand for agricultural equipment, fertilizers and other chemical products.

Table 4
Parameter estimation from QVAR (1) model under the skewed normal and the skewed contaminated normal distributions

	Quantile	*0.25*	*0.5*	*0.75*
Dependent Variable	*Independent Variable*	*Estimated*	*Estimated*	*Estimated*
SER	SER(-1)	1.1079*	0.1959	1.1718***
		(0.5731)	(0.1079)	(0.3247)
	MAN(-1)	-2.5556**	-0.1736	-2.9596***
		(1.2943)	(0.2465)	(0.9391)
	AGR(-1)	-0.3075	-0.0171	-0.4335*
		(0.2387)	(0.0418)	(0.2404)
	GDP(-1)	3.8122*	-0.5839	3.7378
		(2.1269)	(0.5294)	(2.5586)
	Constant	-0.0798***	0.0352	-0.1090
		(0.0145)	(0.2245)	(0.1000)
MAN	SER(-1)	0.5016**	-0.0447	0.2588
		(0.2472)	(0.0778)	(0.3294)
	MAN(-1)	-0.7994	-0.5206**	-0.5918
		(1.2740)	(0.1779)	(0.9050)
	AGR(-1)	0.1084	0.1101***	0.1063
		(0.2292)	(0.0302)	(0.1638)
	GDP(-1)	0.4940	0.4810	0.4800
		(2.3542)	(0.3821)	(0.3545)
	Constant	-0.0925***	0.0160**	-0.0438**
		(0.0278)	(0.0058)	(0.0222)
AGR	SER(-1)	0.8975	2.3926***	0.9924*
		(0.3348)	(0.3258)	(0.5206)
	MAN(-1)	-0.4404	-3.2132***	-0.3619
		(0.9700)	(0.7444)	(1.8912)
	AGR(-1)	-0.1355	-0.7119***	-0.1841
		(0.1219)	(0.1264)	(0.3009)
	GDP(-1)	-0.5089	3.9382*	-0.4441
		(1.6229)	(1.5987)	(4.7278)
	Constant	0.0184	0.0242	-0.1794***
		(0.0222)	(0.0244)	(0.0634)

contd. table 4

	Quantile	*0.25*	*0.5*	*0.75*
Dependent Variable	*Independent Variable*	*Estimated*	*Estimated*	*Estimated*
GDP	SER(-1)	0.2456*	0.1431**	0.1733
		(0.1348)	(0.0485)	(0.1662)
	MAN(-1)	-0.4599	0.4007***	-0.3659
		(0.8628)	(0.1108)	(0.4323)
	AGR(-1)	0.0539	0.0107	0.0321
		(0.1479)	(0.0188)	(0.0805)
	GDP(-1)	0.3105	0.3092	0.3003
		(0.2561)	(0.2379)	(0.2256)
	Constant	-0.0308***	0.0153***	-0.0103
		(0.0075)	(0.0036)	(0.0092)

Source: Calculation

Note: "*", "**" and "***" denote rejections of the null hypothesis at the 10% and 1% significance levels, respectively. The values in brackets are the standard deviations.

During a booming economy, the contributions of manufacturing and agricultural sectors to the service sector are surprisingly more negative than in the recession. This is probably because the economic boom is a period that the whole economic system is better and all economic sectors are growing in terms of rising demand for goods, sales increases, income increases, and productivity improvements. However, this situation may lead to a stronger competition for labor between the manufacturing, agricultural and service sectors. The manufacturing and agricultural sectors can use both machinery and labor to mechanize the work while the service is a labor intensive sector, requiring a large amount of labor to produce its goods. Therefore, the growing manufacturing and agricultural sectors result in the intense struggle for labor, and thereby the negative impacts on the service sector.

Now, this section comes to contributions of these three sectors to Thailand's GDP growth. We find that the contributions are different across quantiles. During the expansion phrase, the manufacturing and service sectors play a significant role in boosting up the economic growth in Thailand. However, our empirical results show that during the recession phrase where the economy is temporary in slowdown and the economic activities are postponed, the service sector is the only significant engine that remains and drives the Thai economy. This result is in line with what the Bank of Thailand has suggested, that is, the service sector can always provide a good substitution for the Thai economy when we face the unsmooth economic activities. The service sector is highly diverse, starting from street vendors to professional sectors, but the major engine that can indeed drive the Thai economy –even in the recession phrase- is tourism and travel-related activities, including hotels, travel agents, airlines and other passenger transport services, and restaurants.

4.3. Impulse Response and Variance Decomposition Analysis

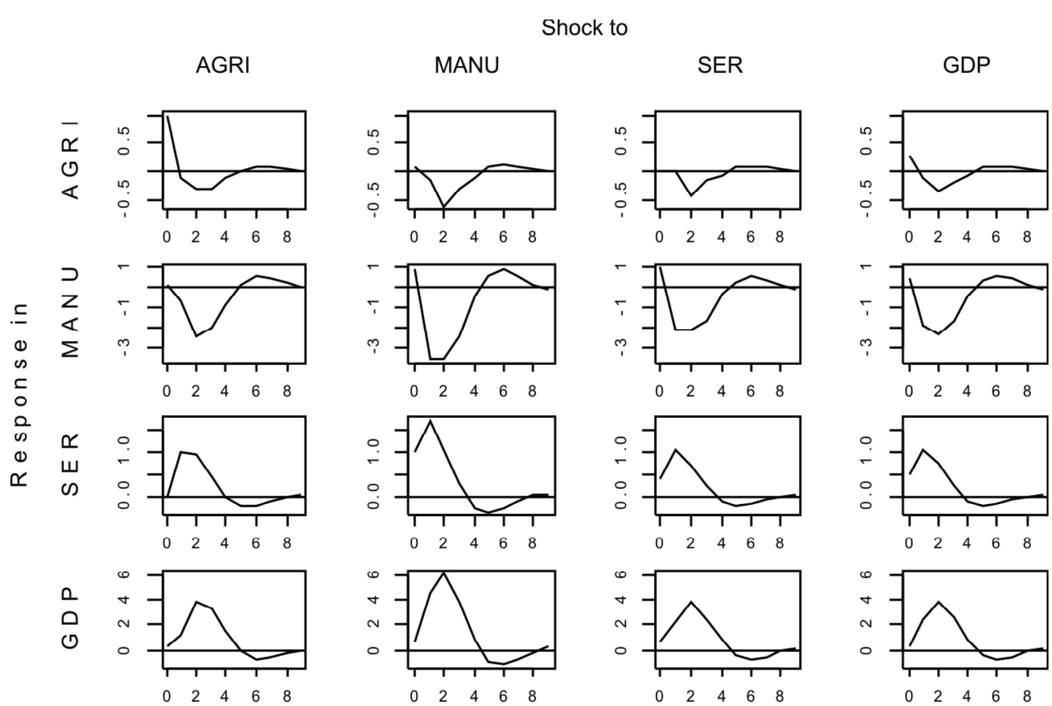
After investigating the linkages among three economic sectors and their contributions to Thailand's economic growth, this section will make use of the VAR model and present the impulse response analysis and variance decomposition analysis in order to examine the dynamic interaction among the variables.

Impulse Response Analysis

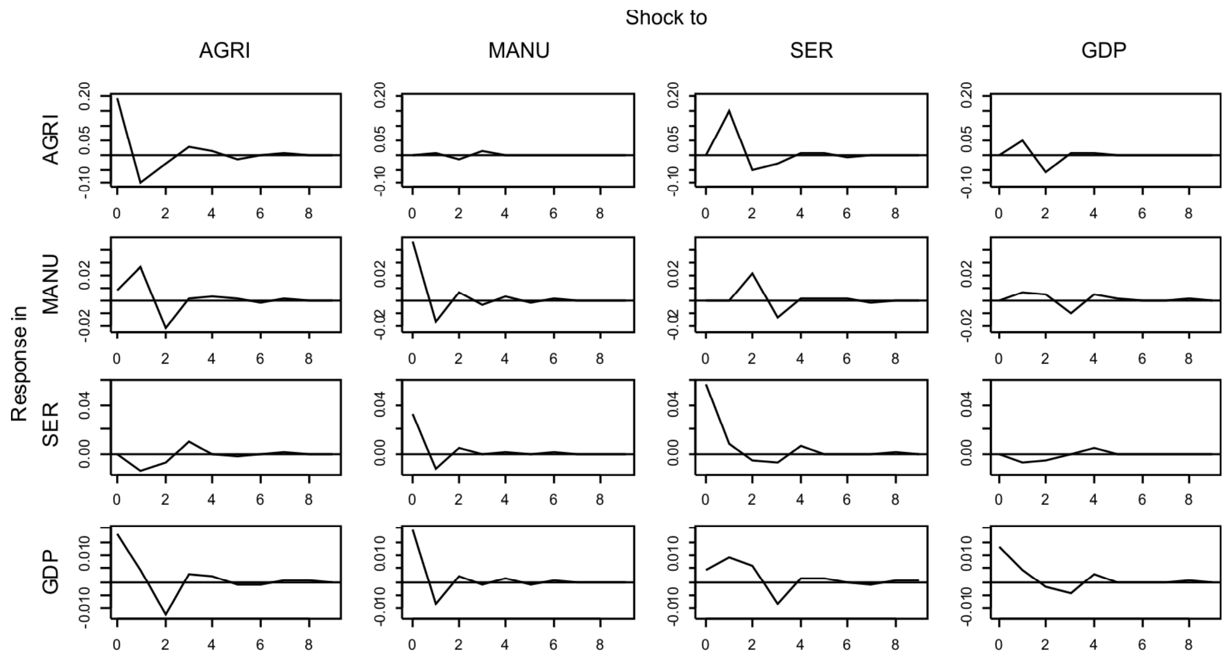
The impulse response function is estimated here to analyze the responsiveness of the three economic sectors and the Thai economy, in terms of GDP, to the shocks (a one standard deviation shock) of variables. We present the impulse response for the specification of the QVAR model with three different quantiles (τ = 0.25, 0.5, and 0.75). Figure 2 reports the impulse responses of the QVAR model for quantiles 0.25, 0.5, and 0.75, respectively. Each panel displays the deviation in percent for the series entered in difference for every endogenous variable. The feedback of the economic sectors differs considerably between quantiles. At the 0.25-quantile, a shock in agricultural sector (denoted by AGR) results in a great and persistent negative effect on the manufacturing sector (denoted by MAN). It then falls sharply and reaches the steady state within 4 quarters. However, AGR creates a positive sharp-shaped response in the GDP and the service sector (denoted by SER) dies out in about 2 months. In this quantile, AGR is more likely to affect the Thai economy than other sectors, followed by MAN and SER respectively. At the 0.5-quantile, as shown in Figure 2, it illustrates the shocks to AGR, MAN, and GDP cause other variables to fall after about 1 to 2 quarters. However, the shocks of SER establishes response different from those of AGR, MAN, and GDP; that is, it causes other variables to rise after about 1 to 2 quarters, except the response in SER itself that is found to fall about 2 quarters. Although they initially deviate from equilibrium, they will return to the equilibrium within 3 to 4 quarters. In this regime, SER and AGR are more likely to affect the Thai economy than the manufacturing sector.

Finally, at the 0.75-quantile, as shown in Figure 2, we present the impulse response function for the changes in the Thai economy after the shocks of its components in a boom phrase. The similar results are obtained in this quantile. All variables are observed to have negative effects on the agricultural and manufacturing sectors. In this regime, AGR is more likely to affect the Thai economy than other sectors.

a) At the 0.25-quantile



b) At the 0.5-quantile



c) At the 0.75-quantile

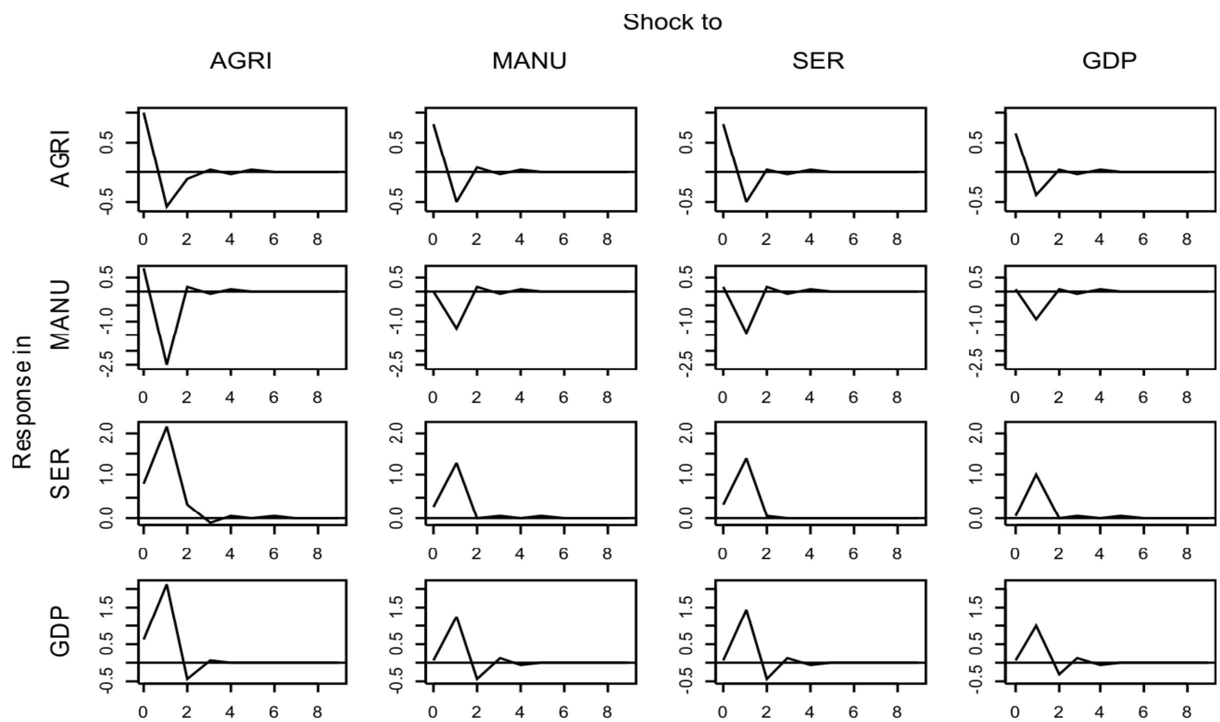


Figure 2: Impulse Response of Agricultural, Manufacturing, and Service sectors, and Thailand's GDP Growth to Various Shocks

Note: The vertical axis is the size of impact and the horizontal axis is the time trend (in quarter).

Forecast Error Variance Decomposition Analysis

We employ our QVAR (1) model to generate the forecast error variance decomposition (FEVDs) in each quantile, in order to characterize the dynamic behavior of the Thai economy when the shocks in each economic sector happen.

Table 5 presents the results of the FEVDs for the 0.25-quantile (left column), the 0.5-quantile (middle column), and the 0.75-quantile (right column). Each entry in the table denotes the percentage of forecast error covariance of each considered variable. In the 0.25-quantile, it appears that the variance of all variables are significantly explained by their own variance, which accounts for more than 70 percent in the 1st quarter and about 40 percent in the 10th quarter. Consider the GDP growth, apart from its own shock, manufacturing sector accounts for the largest share of the shock to GDP, amounting to about 54.3375 percent, followed by the agricultural sector (3.1786 percent) and the service sector (0.0075 percent) since the 2nd quarter. At the 0.5-quantile, Table 5 shows the FEVDs of the GDP, SER, MAN, and AGR for the expansion phrase (middle column). Similar results were obtained in this quantile level. We find that the variance of all variables is significantly explained by their own variance. When compared to the 0.25-quantile, the shares of their own shocks are increasing, except for MAN. We also find some interesting result in this quantile that the GDP has its own shock contribution exactly 100 percent in the 1st quarter; moreover, the manufacturing sector accounts for the largest share of shock to GDP, amounting to 92.8139 percent in the 10th quarter period.

Finally, consider the variance decomposition at the 0.75-quanitle, the heterogeneous results are found at this quantile level. Only AGR and SER can be explained strongly by their own variances in the 1st quarter. Consider GDP and MAN, we find that other sectors create a large share of the shock to them in the 1st quarter. However, when time passes to the 10th quarter period, the share of their own shocks will increase to 53.0699 percent for the GDP and 32.6540 percent for MAN.

These results indicate that the changes in Thailand's economy are mainly explained by its own shock according to our analysis. Apart from its own shock, the manufacturing sector accounts for the largest share of shock to other sectors. This finding, therefore, implies that the manufacturing sector contributes a large shock to the Thai economy while other sectors are not likely to have direct substantial effects on the Thai economy.

5. CONCLUSION

We have analyzed the linkages among three economic sectors in Thailand, i.e. the manufacturing, the agricultural, and the service sectors, as well as their contributions to Thailand's GDP growth. To obtain the linkages, we employ the quantile vector autoregression (QVAR) model with a special concern about a variety of distributions across quantiles. Hence, this paper proposes the multivariate skewed distributions for the QVAR model. This paper assumes 3 different quantiles (0.25, 0.5, and 0.75) to indicate the states of economy, i.e. recession, expansion, and boom. The empirical result can prove our assumption on the distributions across quantiles. We find that the skewed contaminated normal is optimal for the low quantile level, i.e. 0.25, while the skewed normal distribution is optimal for the higher quantile levels, i.e. 0.5 and 0.75.

Our analysis shows that the service sector plays an important role to support other economic sectors. It creates a positive impact on agricultural and manufacturing sectors in recession, expansion, and boom,

Table 5
Forecast Error Variance Decomposition

	Variance Decomposition of SER											
Quantile	*0.25*				*0.5*				*0.75*			
Period	*SER*	*MAN*	*AGR*	*GDP*	*SER*	*MAN*	*AGR*	*GDP*	*SER*	*MAN*	*AGR*	*GDP*
1	99.8465	0.1321	0.0214	0.0000	99.5218	0.0000	0.0000	0.4781	75.2942	23.8215	0.8843	0.0000
10	42.2789	49.4272	2.2243	6.0694	11.3212	2.0483	85.9477	0.6826	38.9610	31.2954	13.8218	15.9217
	Variance Decomposition of MAN											
Quantile	*0.25*				*0.5*				*0.75*			
Period	*SER*	*MAN*	*AGR*	*GDP*	*SER*	*MAN*	*AGR*	*GDP*	*SER*	*MAN*	*AGR*	*GDP*
1	0.6213	78.6981	0.0000	20.6805	29.3685	59.9361	0.0000	10.6952	65.7797	28.1913	0.0002	6.0288
10	0.4879	61.4713	0.4537	37.5871	27.3728	54.0224	8.6792	9.9254	38.0218	32.6540	13.6648	15.6592
	Variance Decomposition of AGR											
Quantile	*0.25*				*0.5*				*0.75*			
Period	*SER*	*MAN*	*AGR*	*GDP*	*SER*	*MAN*	*AGR*	*GDP*	*SER*	*MAN*	*AGR*	*GDP*
1	9.2149	0.0000	98.6935	1.2143	0.0000	0.1762	99.0569	0.7665	1.5619	0.0001	97.2512	1.1867
10	0.1375	6.0257	64.3371	29.4997	0.7467	2.3131	96.0225	0.9177	3.1077	2.2738	78.7125	15.9060
	Variance Decomposition of GDP											
Quantile	*0.25*				*0.5*				*0.75*			
Period	*SER*	*MAN*	*AGR*	*GDP*	*SER*	*MAN*	*AGR*	*GDP*	*SER*	*MAN*	*AGR*	*GDP*
1	0.0000	73.4405	4.7129	21.8466	0.0131	0.0000	0.0000	100	0.0000	50.5946	15.5701	33.8352
10	0.0075	54.3375	3.1786	42.4084	0.0834	92.8139	2.4550	3.1186	0.0410	35.6065	11.2826	53.0699

Source: Calculation

Note: "SER", "MAN", and "AGR" denote the service, manufacturing, and agricultural sectors, respectively.

while the impacts of the manufacturing and agricultural sectors on the service sector are mostly negative. This is due to the limitation of resources in Thailand resulting in a competition for labor between the manufacturing, agricultural and service sectors. The manufacturing and agricultural sectors can use both machinery and labor to mechanize the work while the service is a labor intensive sector, requiring a large amount of labor to produce its goods. From this view, the growing manufacturing and agricultural sectors therefore create the negative impacts on the service sector.

Moreover, our analysis finds that during the expansion phrase, the manufacturing and service sectors play a significant role in boosting up the economic growth in Thailand. But in the recession phrase, the service sector is the only significant engine that remains and drives the Thai economy. However, the service sector in Thailand is just in the first stage of the development; therefore, the government should find ways to improve efficiency, productivity, and quality of the service products to strengthen the service sector.

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