INTRODUCTION

The coefficient of variation was defined by dividing σ by μ-$\kappa = \sigma/\mu$ where σ was the population standard deviation, and μ was the population mean. Given the random variable X was normal distribution, the represented sample estimate of κ, depends on a sample size n. The statistic was $\hat{\kappa} = s/\bar{x}$, where s was the standard deviation, and $\bar{x}$ was the sample mean. The sample coefficient of variation, $\hat{\kappa}$ was measured as a point estimate of κ. And it's used measurement for variability of data.

Researchers have many measures of the variability of agricultural production. One method was the confidence intervals for coefficient of variation by considering the width of range as the indicative of environment suitable for agricultural production (Taye & Njuho, 2008). This article presents the new approximation method of confidence intervals for coefficient of variation (Saelee, 2011) and comparison with different methods: Miller's method, Vangel's method and two types of Mahmoudvand and Hassani's methods by Monte Carlo simulation. Later the examination of variability of agricultural products in different regions by using the new approximation method of confidence intervals for coefficient of variation was proposed.

CONFIDENCE INTERVALS FOR COEFFICIENT OF VARIATION METHOD

Previous approximation of confidence intervals for coefficient of variation

There have been several approximation methods, for example, Miller (1991) proposed the following:

$$\mathrm{CI1} = \frac{S}{\bar{x}} \pm Z_{\frac{\alpha}{2}} \sqrt{\nu^{-1}\left(\frac{S}{\bar{x}}\right)^2 \left[0.5 + \left(\frac{S}{\bar{x}}\right)^2\right]} \quad \text{...(1)}$$

Where ν= n-1, Z_α was statistic values of standardize normal distribution at (1- α) 100% (Miller, 1991; Ng, 2005).

Vangel (1996) presented new confidence interval for coefficient of variation by modifying confidence interval for coefficient of variation of Mckay (1932). It was called the modified confidence interval of Mckay, which proposed alternatively employed the new function θ that $\theta = \frac{\nu}{\nu+1}\left[\frac{2}{\chi^2_{\nu,\alpha}} + 1\right]$ thus new confidence interval is as follow,

$$\mathrm{CI2} = \left(\hat{\kappa}\left[\left(\frac{\chi^2_{\nu,1-\alpha/2}+2}{\nu+1} - 1\right)\hat{\kappa}^2 + \frac{\chi^2_{\nu,1-\alpha/2}}{\nu}\right]^{-1/2}, \hat{\kappa}\left[\left(\frac{\chi^2_{\nu,\alpha/2}+2}{\nu+1} - 1\right)\hat{\kappa}^2 + \frac{\chi^2_{\nu,\alpha/2}}{\nu}\right]^{-1/2} \right)$$

or

$$\mathrm{CI2} = \left(\hat{\kappa}\left[\left(\frac{u_1+2}{\nu+1} - 1\right)\hat{\kappa}^2 + \frac{u_1}{\nu}\right]^{-1/2}, \hat{\kappa}\left[\left(\frac{u_2+2}{\nu+1} - 1\right)\hat{\kappa}^2 + \frac{u_2}{\nu}\right]^{-1/2} \right) \quad \text{.....................................(2)}$$

(Vangel, 1996)

Mahmoudvand, and Hassani (2009) suggested two new confidence intervals for the coefficient of variation in a normal distribution, which were:

$$\text{CI3}=\left(\frac{\hat{\kappa}}{2-c_n+z_{1-\alpha/2}\sqrt{1-c_n^2}},\frac{\hat{\kappa}}{2-c_n-z_{1-\alpha/2}\sqrt{1-c_n^2}}\right)\text{ ....(3)}$$

and

$$\text{CI4}=\left(\hat{\kappa}-\frac{\hat{\kappa}}{2-c_n}z_{1-\alpha/2}\sqrt{(1-c_n^2)+\frac{\hat{\kappa}^2}{n}}\ ,\ \hat{\kappa}+\frac{\hat{\kappa}}{2-c_n}z_{1-\alpha/2}\sqrt{(1-c_n^2)+\frac{\hat{\kappa}^2}{n}}\right)\text{ ......(4)}$$

(Mahmoudvand and Hassani, 2009)

Previous research used Miller's formula in case of $n \le 10$ and appropriate when $0.33 \le \kappa \le 0.67$; Vangel's formula used better than Miller's formula by modify function θ and two-type of Mahmoudvand and Hassani's method had like results Miller's method when n had bigger value.

Therefore, the new method of approximation confidence interval was used in order to the choice for researcher for dropping errors of previous methods. This article demonstrate the new approximation method of estimate confidence interval (CI5) compared the results with Miller's method (CI1), Vangel's method (CI2), and two types of Mahmoudvand and Hassani's method, (CI3 and CI4) by coverage probabilities and expected lengths of 90% and 95%.

The new approximation confidence intervals for coefficient variation

Mean and variance of coefficient of variation for normal distribution were considered. An asymptotically unbiased estimator for κ was introduced. The new approximation confidence interval for coefficient variation was followed:

$$\hat{\kappa}-z_{\frac{\alpha}{2}}\sqrt{\left(\frac{4n+3}{8n^2}\right)\hat{\kappa}^2+\left(\frac{8n^2-4n-3}{8n^3}\right)\hat{\kappa}^4}<\kappa<\hat{\kappa}+z_{\frac{\alpha}{2}}\sqrt{\left(\frac{4n+3}{8n^2}\right)\hat{\kappa}^2+\left(\frac{8n^2-4n-3}{8n^3}\right)\hat{\kappa}^4}$$

Or

$$\text{CI5}=\left(\hat{\kappa}-z_{\frac{\alpha}{2}}\sqrt{\left(\frac{4n+3}{8n^2}\right)\hat{\kappa}^2+\left(\frac{8n^2-4n-3}{8n^3}\right)\hat{\kappa}^4}\ ,\ \hat{\kappa}+z_{\frac{\alpha}{2}}\sqrt{\left(\frac{4n+3}{8n^2}\right)\hat{\kappa}^2+\left(\frac{8n^2-4n-3}{8n^3}\right)\hat{\kappa}^4}\right)\text{........(5)}$$

(Saelee, 2011)

RESULTS

In this study, data were simulated with Monte Carlo simulation in computer. Visual Basic 2008 Express Edition was used, repeated for 50,000 times. Compared the coverage probability and average width of the confidence interval of the method to estimate confidence intervals for the coefficient of variation, of a new approximate method (CI5) with Miller's method (CI1), Vangel's method (CI2), and Mahmoudvand and Hassani's method (CI3, CI4) . The sample sizes were 10, 15, 25, 30, 50 and 100, and the coefficients of variation of population were 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 at the confidence levels of 90% and 95%.

Comparison of the methods form simulation

The results of using Monte Carlo simulations to examine the coverage probabilities of the confidence intervals CI1, CI2, CI3, CI4 and CI5 and their average width of confidence intervals are presented in Tables 1 and Table 2. Both for $n \geq 30$ with all coefficients of variation population and for $n < 30$ with coefficients of variation population of 0.5-0.9, the new method (CI5) confidence interval is nearer to nominal level than the Miller's method (CI1), the type 2 of Mahmoudvand and Hassani's method (CI4) and the Vangel's method (CI2) in the majority cases. The new method (CI5) also has average width slightly smaller than the Miller's method (CI1), the type 2 of Mahmoudvand and Hassani's method (CI4) and the Vangel's method (CI2) in most cases. For $n <30$ with the coefficient of variation population of 0.1-0.4, the Miller's method (CI1) and the type 2 of Mahmoudvand and Hassani's method (CI4) have the coverage percentage close to the new method(CI5). But the Vangel's method (CI2) confidence interval is nearer to nominal level than the new method (CI5). The Vangel's method (CI2) has average width slightly bigger than the new method (CI5). For $n < 30$, the type 1 of Mahmoudvand and Hassani's method (CI3) has the coverage percentage nearer to nominal level than the new method (CI5) in mostly case when coefficient of variation population is 0.1-0.2 . But for $n < 30$, with coefficient of variation population of 0.3-0.9 and $n \geq 30$, with all coefficient of variation population, the new method (CI5) has the coverage percentage nearer to nominal level than the type 1 of Mahmoudvand and Hassani's method (CI3) in mainly cases. The new method (CI5) has average width slightly smaller than the type 1 of Mahmoudvand and Hassani's method (CI3) in some cases.

Table 1 Average width and coverage percentage (in brackets) for $1 - \alpha = 0.90$.

Method	κ								
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
n = 10									
Miller	0.076(0.854)	0.158(0.856)	0.251(0.857)	0.358(0.856)	0.458(0.847)	0.526(0.818)	0.616(0.914)	0.667(0.926)	0.716(0.946)
Vangel	0.090(0.898)	0.190(0.899)	0.312(0.900)	0.476(0.906)	0.662(0.948)	0.806(0.939)	0.996(0.999)	1.124(0.999)	1.260(0.999)
New Method	0.075(0.850)	0.155(0.851)	0.244(0.852)	0.346(0.851)	0.441(0.882)	0.506(0.899)	0.590(0.900)	0.638(0.903)	0.684(0.905)
Method 1 M & H	0.089(0.899)	0.178(0.891)	0.269(0.876)	0.359(0.858)	0.435(0.884)	0.484(0.901)	0.547(0.999)	0.581(0.999)	0.611(0.999)
Method 2 M & H	0.076(0.854)	0.158(0.855)	0.249(0.856)	0.353(0.855)	0.450(0.845)	0.516(0.884)	0.603(0.909)	0.652(0.915)	0.699(0.925)
n = 15									
Miller	0.062(0.875)	0.128(0.875)	0.202(0.876)	0.288(0.877)	0.389(0.877)	0.490(0.871)	0.585(0.908)	0.651(0.908)	0.705(0.910)
Vangel	0.069(0.900)	0.143(0.900)	0.231(0.901)	0.343(0.904)	0.497(0.911)	0.689(0.947)	0.895(0.990)	1.053(0.999)	1.196(0.999)
New Method	0.061(0.871)	0.126(0.872)	0.199(0.889)	0.282(0.883)	0.379(0.893)	0.476(0.896)	0.568(0.901)	0.631(0.900)	0.682(0.899)
Method 1 M & H	0.068(0.899)	0.136(0.889)	0.204(0.874)	0.274(0.853)	0.343(0.830)	0.406(0.829)	0.461(0.948)	0.497(0.948)	0.526(0.946)
Method 2 M & H	0.062(0.874)	0.127(0.874)	0.201(0.875)	0.286(0.875)	0.384(0.876)	0.482(0.869)	0.576(0.904)	0.639(0.904)	0.692(0.904)
n = 25									
Miller	0.048(0.884)	0.098(0.884)	0.155(0.886)	0.219(0.887)	0.295(0.889)	0.384(0.891)	0.467(0.900)	0.570(0.908)	0.663(0.914)
Vangel	0.051(0.898)	0.105(0.899)	0.167(0.899)	0.242(0.902)	0.339(0.905)	0.471(0.911)	0.605(0.969)	0.826(0.984)	1.086(0.999)
New Method	0.047(0.882)	0.097(0.882)	0.153(0.884)	0.217(0.884)	0.291(0.896)	0.378(0.897)	0.458(0.897)	0.558(0.905)	0.650(0.909)
Method 1 M & H	0.050(0.896)	0.100(0.887)	0.150(0.871)	0.201(0.849)	0.252(0.824)	0.304(0.794)	0.348(0.826)	0.396(0.829)	0.437(0.872)
Method 2 M & H	0.048(0.884)	0.098(0.884)	0.154(0.885)	0.218(0.886)	0.293(0.887)	0.381(0.889)	0.462(0.898)	0.563(0.907)	0.655(0.911)
n = 30									
Miller	0.043(0.908)	0.089(0.904)	0.140(0.902)	0.199(0.899)	0.265(0.900)	0.341(0.899)	0.426(0.897)	0.521(0.899)	0.625(0.904)
Vangel	0.046(0.919)	0.094(0.915)	0.149(0.914)	0.215(0.911)	0.296(0.923)	0.399(0.942)	0.531(0.962)	0.712(0.970)	0.982(0.983)
New Method	0.043(0.906)	0.089(0.902)	0.139(0.900)	0.197(0.896)	0.262(0.898)	0.337(0.896)	0.420(0.895)	0.513(0.896)	0.614(0.901)
Method 1 M & H	0.045(0.917)	0.090(0.902)	0.135(0.883)	0.180(0.859)	0.225(0.838)	0.270(0.819)	0.314(0.803)	0.358(0.790)	0.401(0.782)
Method 2 M & H	0.043(0.908)	0.089(0.903)	0.140(0.901)	0.198(0.897)	0.264(0.899)	0.339(0.897)	0.423(0.896)	0.516(0.898)	0.619(0.902)
n = 50									
Miller	0.033(0.894)	0.069(0.894)	0.108(0.896)	0.153(0.897)	0.205(0.898)	0.264(0.902)	0.331(0.909)	0.406(0.907)	0.488(0.906)
Vangel	0.034(0.899)	0.070(0.897)	0.110(0.899)	0.157(0.902)	0.214(0.906)	0.284(0.914)	0.370(0.928)	0.477(0.950)	0.611(0.955)
New Method	0.033(0.893)	0.069(0.893)	0.108(0.894)	0.152(0.895)	0.204(0.895)	0.262(0.900)	0.328(0.907)	0.402(0.905)	0.483(0.905)
Method 1 M & H	0.034(0.898)	0.068(0.887)	0.102(0.873)	0.137(0.851)	0.171(0.824)	0.205(0.796)	0.239(0.772)	0.273(0.749)	0.306(0.731)
Method 2 M & H	0.033(0.894)	0.069(0.894)	0.108(0.895)	0.153(0.896)	0.204(0.897)	0.263(0.901)	0.330(0.908)	0.404(0.906)	0.485(0.905)
n = 100									
Miller	0.024(0.899)	0.049(0.899)	0.076(0.900)	0.108(0.901)	0.144(0.902)	0.185(0.902)	0.233(0.902)	0.287(0.903)	0.348(0.904)
Vangel	0.024(0.901)	0.049(0.901)	0.077(0.901)	0.109(0.904)	0.148(0.907)	0.195(0.912)	0.253(0.918)	0.324(0.925)	0.412(0.934)
New Method	0.024(0.898)	0.048(0.898)	0.076(0.899)	0.107(0.900)	0.143(0.901)	0.185(0.901)	0.232(0.901)	0.285(0.902)	0.346(0.902)
Method 1 M & H	0.024(0.899)	0.047(0.889)	0.071(0.874)	0.095(0.852)	0.119(0.825)	0.142(0.795)	0.166(0.761)	0.191(0.728)	0.215(0.695)
Method 2 M & H	0.024(0.899)	0.049(0.899)	0.076(0.900)	0.107(0.900)	0.144(0.901)	0.185(0.901)	0.232(0.901)	0.286(0.902)	0.347(0.903)

Table 2 Average width and coverage percentage (in brackets) for $1 - \alpha = 0.95$.

Method	κ								
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
n = 10									
Miller	0.091(0.894)	0.188(0.893)	0.299(0.893)	0.418(0.889)	0.507(0.889)	0.596(0.962)	0.647(0.973)	0.692(0.992)	0.738(0.999)
Vangel	0.113(0.949)	0.239(0.949)	0.402(0.950)	0.622(0.975)	0.823(0.971)	1.037(0.999)	1.178(0.999)	1.325(0.999)	1.504(0.999)
New Method	0.089(0.910)	0.184(0.920)	0.291(0.928)	0.404(0.945)	0.489(0.943)	0.574(0.952)	0.621(0.954)	0.664(0.955)	0.707(0.944)
Method 1 M & H	0.114(0.951)	0.229(0.945)	0.346(0.934)	0.456(0.941)	0.532(0.962)	0.607(0.999)	0.646(0.999)	0.680(0.999)	0.712(0.999)
Method 2 M & H	0.091(0.894)	0.188(0.893)	0.297(0.892)	0.412(0.888)	0.499(0.867)	0.586(0.958)	0.634(0.965)	0.678(0.975)	0.722(0.992)
n = 15									
Miller	0.074(0.914)	0.152(0.914)	0.241(0.914)	0.343(0.912)	0.457(0.909)	0.554(0.897)	0.643(0.956)	0.698(0.959)	0.744(0.968)
Vangel	0.084(0.950)	0.177(0.950)	0.288(0.950)	0.436(0.953)	0.646(0.969)	0.867(0.974)	1.093(0.999)	1.253(0.999)	1.403(0.999)
New Method	0.073(0.922)	0.150(0.932)	0.237(0.941)	0.336(0.948)	0.446(0.946)	0.539(0.949)	0.625(0.950)	0.677(0.949)	0.722(0.951)
Method 1 M & H	0.084(0.950)	0.169(0.943)	0.255(0.932)	0.341(0.916)	0.425(0.908)	0.489(0.952)	0.547(0.999)	0.580(0.999)	0.607(0.999)
Method 2 M & H	0.074(0.914)	0.152(0.914)	0.239(0.914)	0.340(0.911)	0.452(0.908)	0.546(0.896)	0.633(0.954)	0.686(0.955)	0.732(0.960)
n = 25									
Miller	0.057(0.928)	0.117(0.928)	0.241(0.914)	0.262(0.926)	0.352(0.925)	0.456(0.924)	0.553(0.955)	0.662(0.957)	0.728(0.953)
Vangel	0.061(0.949)	0.127(0.948)	0.288(0.950)	0.298(0.952)	0.424(0.953)	0.604(0.960)	0.790(0.999)	1.109(0.999)	1.314(0.998)
New Method	0.056(0.937)	0.116(0.936)	0.237(0.941)	0.258(0.938)	0.347(0.943)	0.449(0.941)	0.543(0.953)	0.649(0.953)	0.713(0.949)
Method 1 M & H	0.061(0.948)	0.122(0.941)	0.255(0.932)	0.245(0.913)	0.308(0.892)	0.370(0.870)	0.424(0.959)	0.478(0.972)	0.509(0.960)
Method 2 M & H	0.057(0.928)	0.117(0.928)	0.239(0.914)	0.260(0.925)	0.349(0.924)	0.452(0.923)	0.547(0.954)	0.655(0.955)	0.719(0.950)
n = 30									
Miller	0.052(0.933)	0.106(0.933)	0.168(0.932)	0.238(0.932)	0.319(0.930)	0.414(0.929)	0.504(0.951)	0.618(0.955)	0.707(0.954)
Vangel	0.055(0.951)	0.114(0.951)	0.182(0.951)	0.265(0.953)	0.372(0.956)	0.520(0.958)	0.675(0.996)	0.956(0.999)	1.237(0.999)
New Method	0.051(0.952)	0.106(0.951)	0.166(0.941)	0.235(0.940)	0.316(0.949)	0.409(0.947)	0.497(0.949)	0.608(0.953)	0.695(0.951)
Method 1 M & H	0.055(0.950)	0.110(0.943)	0.165(0.931)	0.220(0.913)	0.276(0.894)	0.332(0.868)	0.381(0.923)	0.435(0.917)	0.475(0.950)
Method 2 M & H	0.052(0.933)	0.106(0.932)	0.167(0.932)	0.237(0.931)	0.317(0.930)	0.411(0.928)	0.500(0.950)	0.612(0.954)	0.700(0.952)
n = 50									
Miller	0.040(0.943)	0.082(0.952)	0.129(0.954)	0.182(0.956)	0.242(0.956)	0.312(0.953)	0.390(0.952)	0.478(0.950)	0.575(0.955)
Vangel	0.040(0.951)	0.084(0.963)	0.132(0.971)	0.189(0.981)	0.257(0.984)	0.342(0.984)	0.449(0.987)	0.588(0.989)	0.770(0.999)
New Method	0.040(0.942)	0.082(0.952)	0.128(0.953)	0.181(0.955)	0.241(0.955)	0.309(0.952)	0.387(0.951)	0.474(0.948)	0.569(0.953)
Method 1 M & H	0.041(0.952)	0.082(0.956)	0.123(0.951)	0.164(0.944)	0.205(0.932)	0.246(0.909)	0.287(0.891)	0.327(0.867)	0.367(0.861)
Method 2 M & H	0.040(0.943)	0.082(0.952)	0.128(0.954)	0.181(0.956)	0.241(0.956)	0.310(0.952)	0.388(0.952)	0.476(0.949)	0.571(0.954)
n = 100									
Miller	0.028(0.946)	0.058(0.946)	0.091(0.946)	0.128(0.946)	0.171(0.946)	0.221(0.946)	0.277(0.945)	0.342(0.945)	0.414(0.945)
Vangel	0.028(0.951)	0.058(0.952)	0.092(0.952)	0.131(0.953)	0.178(0.955)	0.236(0.958)	0.307(0.962)	0.395(0.967)	0.508(0.971)
New Method	0.028(0.946)	0.058(0.946)	0.091(0.946)	0.128(0.946)	0.171(0.949)	0.220(0.945)	0.276(0.945)	0.340(0.944)	0.412(0.944)
Method 1 M & H	0.028(0.950)	0.057(0.943)	0.085(0.930)	0.114(0.914)	0.142(0.892)	0.171(0.867)	0.199(0.839)	0.228(0.809)	0.257(0.777)
Method 2 M & H	0.028(0.946)	0.058(0.946)	0.091(0.946)	0.128(0.946)	0.171(0.946)	0.220(0.945)	0.277(0.945)	0.341(0.945)	0.413(0.945)

Examination of variability of agricultural products

At 90% and 95% confidence levels, the new method had efficiency more than other methods when sample size was large. Then the new method was used in the examination of variability of agricultural products. It was found that cassava yield, the northeast region has smallest width range, which means that the most stable across environments in Thailand for cassava. Rubber yield, the southern region has smallest width range, which means that the most stable across environments in Thailand for rubber. Maize yield, the eastern region has smallest width range, which means that the most stable across environments in Thailand for maize. Main rice yield, the northeast region has smallest width range, which means that the most stable across environments in Thailand for main rice, see Table 3.

Table 3 Width range of the new method at 90% and 95% confidence level by regions of cassava rubber maize and main rice.

Regions	Cassava	Rubber	maize	Mainrice
Confidence level 90%				
Northern	0.0330	0.0802	0.0327	0.0247
Northeast	0.0191	0.0357	0.0340	0.0199
Central	0.0302	0.0834	0.0263	0.0349
Eastern	0.0464	0.0535	0.0216	0.0719
Western	0.0403	0.1262	0.0474	0.0744
Southern	0	0.0198	0	0.0343
Confidence level 95%				
Northern	0.0393	0.0956	0.0390	0.0295
Northeast	0.0228	0.0425	0.0405	0.0238
Central	0.0359	0.0994	0.0314	0.0416
Eastern	0.0553	0.0638	0.0257	0.0857
Western	0.0481	0.1504	0.0564	0.0886
Southern	0	0.0236	0	0.0409

At 90% and 95%, the approximation confidence intervals for coefficient of variation was used, the examination the variable of agricultural products found that cassava was more stable across environments than maize, rubber, and main rice, see Table 4.

Table 4 Variability of agricultural product 2006 to 2010 using by the new approximation confidence intervals for coefficient of variation at 90% and 95% confidence level.

Crop type	Number of data	Point estimation	90% confidence level			95% confidence level		
			L	U	R	L	U	R
Cassava	226	0.0930	0.0857	0.1003	0.0145	0.0843	0.1017	0.0173
Rubber	282	0.1570	0.1459	0.1682	0.0223	0.1437	0.1703	0.0266
Maize	200	0.1070	0.0981	0.1159	0.0178	0.0964	0.1176	0.0212
Main rice	380	0.2927	0.2738	0.3116	0.0378	0.2702	0.3153	0.0451

Note. L is Lower limit, U is Upper limit, R = U-L

CONCLUSION

The new approximate confidence interval for coefficient of variation was used, for situation where data were normal distribution. The results showed that $\hat{\kappa}$ is asymptotically unbiased estimate of κ, which was the sample coefficient of variation. The comparison results indicated that the new approximate confidence intervals for coefficient of variation are as good as or better than current methods estimate to κ for sample size $n \geq 30$. The examination the variable of agricultural products found that the northeast region was the best stable across environments in Thailand for cassava and main rice. The southern region was the best stable across environments in Thailand for rubber. The eastern region was the best stable across environments in Thailand for maize. And the examination the variation of agricultural products found that cassava was more stable across environments than maize rubber and main rice.

ACKNOWLEDGEMENTS

The authors would like to thank the Office of the Higher Education Commission, which provided scholarships at the doctoral level for the main authors. The author thanks the editor and the referees for their constructive comments. Gratefulness belongs to the advisor, Assistant Professor Dr. Suchada Kornpetpanee (Dean of the College of Research Methodology and Cognitive Science, Burapha University) for insightful suggestions.

REFERENCES

Mahmoudvand, R.,& Hassani, H.(2009).Two new confidence intervals for the coefficient of variation in a normal distribution. *Journal of Applied Statistics, 36*(4), 429–442.

McKay, A. T. (1932). Distribution of the Coefficient of Variation and the Extended "t" Distribution. *Journal of the Royal Statistical Society, 95*(4), 695-698.

Miller,E.G. (1991). Asymptotic test statistics for coefficient of variation. *Comm.Stat Theory & Methods, 20*(10), 3351-3363.

Ng, C.K.(2005). *Performance of three methods of interval estimation of the coefficient of variation***.** Department of Management Sciences City, University of Hong Kong.

Saelee, V.(2011). New Approximate Confidence Intervals for Coefficient of Variation. *Journal of Science Ladkrabang*, *20*(2).

Taye, G. & Njuho P., (2008). Monitoring Field Variability Using Confidence Interval for Coefficient of Variation. *Journal of Communications in Statistics—Theory and Methods, 37*, 831–846.

Vangel, M. G. (1996, February). Confidence Intervals for a Normal Coefficient of Variation. *Journal of the American Statistician, 50*(1), 21-26.