The Superiority of Panel SPSM-KSS Fourier Univariate Unit Root Test towards Problematic PFI Time Series Data

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Abstract— This paper aims at investigating the properties of problematic time series data with outliers and missing values problems by applying the Sequential Panel Selection Method (SPSM) using Panel KSS unit root test with a Fourier Function. The problematic time series data refer to the real-industrial-data which comprise of the Malaysian construction materials price indices monthly data from January 1980 to December 2013, with base 100 in year 1980 covering four states of Malaysian Peninsular central region; Wilayah Persekutuan Kuala Lumpur, Selangor, Melaka and Negeri Sembilan. The method used in this study is powerful to classify the whole panel using structural breaks as well as nonlinearity control, and determines which series in the panel are stationary processes. The empirical results found that the series of Aggregates, Sand and Roof Materials price indices are all stationary even though there exist different severity of outliers problem and interpolated missing values in the data. The missing values interpolation techniques with respect to this study are nearest neighbor, linear, piecewise cubic spline, shape-preserving piecewise cubic, and their significance based on bootstrap p-values are also shown in this paper. This initial test is important to be considered before any further attempts of time series or forecast modeling can be implemented on the data. The findings are important for the policy makers, contractors as well as subcontractors to further forecast the future prices of construction materials and soon assist them in tender bidding before any agreements on construction projects are made.

Key-Words: - Outliers, missing values, time series, SPSM, KSS Fourier univariate unit root

1 Introduction

Stationary test of output shocks in time series properties has been the interest by many researches because it is significant in evaluating the policy implications on the macroeconomic programs stability, especially in the prediction and modelling tasks [1][2].

In the real world scenario, Private Financial Initiatives (PFI) is just about to germinate and an essential macroeconomic program in Malaysia, which resonates with the government's aim to invite more private sectors' participation in delivering and upholding the remarkable reputation of public services. The most important contributor of PFI is value for money (VFM), implying that PFI projects are expected to provide and cater for the clients' satisfactions that are in tandem with their investments. VFM is also seen in light of the maximum integration of whole-life expenses, benefits, risks, and success or contributing factors towards the fulfilment of clients' requirements with other added values, like the best quality outcome and the lowest possible price. Therefore, VFM performance should be maximized throughout all PFI implementations.

In fact, tolerable risk allocation between the public and private agencies is key to the act of realizing VFM on PFI projects. One of the principal embedded in project-related risks is the design and construction risks that should always be transferred under PFI projects [3]. Under this risks, fixed price is an integral characteristic of the PFI structure in risk-transfer to the PFI contractor, where the unitary charge should be decided up-front, to avoid from the contractor passing-on cost overruns. Therefore, it is important to calculate on material prices along PFI constructions to make sure that overspending, especially in the long-run, will not take place. Since the construction works and services delivery are primary endeavours in the Malaysian PFI, we attempt to analyze the time series properties of the construction material price indices in Malaysia.

It was widely circulating that cement's controlled price has been abolished by the Malaysian government, which was effective on 5 June 2008 [4]. Since then, there has been a drastic increase of the price of cement in June 2008 by 23.3% in Peninsula Malaysia, while 6.5% had been reported in Sabah and 5.2% in Sarawak [4]. This scenario is also applicable to the rest of the construction materials- steel, ready mix concrete, brick, aggregate, sand, mild steel round bar, high tensile deformed bar and others [5][6].

This unrestrained increment in the prices of construction materials is said to explain important financial struggles for suppliers, subcontractors, contractors and owners [7] or relevant parties that might not have the slightest idea what they were about to embark on. Owners and practitioners also are propelled to brave many new challenges at the expense of meeting their respective pricing goals [5][6]. Moreover, contributing factors that give the leeway to the latest material price hike in the industry have been named to be more than one, where they mainly manipulate the forces of both local and international market [8]. With regards to the uncertainty of construction material prices in Malaysia, we seek to probe into examining whether prices of construction materials in Malaysia are transitory or permanent according to certain region or territory.

The critical part as well as the main novelty of the study is the implementation of the nonlinear SPSM-KSS with a Fourier function on the problematic Malaysian construction materials price indices data consisting outliers and missing values simultaneously. Next, relevant literature shall be provided in section II, and the background of data used in this study is described in the following section, section III. Under section IV, the method overview is also given, with the method used to analyze the data is explained. Furthermore, the empirical results are presented well in section V. Finally, section VI concludes the study, whereby a recommendation for future endeavour is provided.

2 Review of Related Literature

Since 1982, [1] have put an interest on the importance of nonstationarity macroeconomic variables. This due to the reason that conventional lower power unit root test unperformed with compared to the stationary near-unit-root, and yielded less efficient estimations [2]. Therefore, there are many efforts done to support the problem in the unit root in real output levels.

One of the efforts is by increasing the power of unit root testing using panel data. The work that can be seen since year 1998 were by [9]-[13], and [2]. There was argument on the work done by [11], where their proposed test was uninformative to show the stationary processes of a number of series when the null hypothesis is rejected. It should be concluded that when the unit root null hypothesis is accepted, then all series in the panel are stationary, otherwise vice versa.

Traditionally, the conventional unit root test lose power when structural breaks are ignored in unit root testing, and in general practice, dummy variables are used to approximate the breaks [14][2]. This approach somehow suffers from detrimental pre-selection bias [15], power and size deformation [16]-[18] and sudden changes in trend when using dummies [2]. Even, the most used conventional unit root tests such, for example Augmented Dicker Fuller (ADF) test, are not efficient enough in detecting mean reversion in nonlinear macroeconomic variables [2].

Therefore, in 2014, [2] came out with an idea of a panel nonstationary test with nonlinear framework which is able to model any structural break of an unknown function via smooth process using Fourier approximation. Panel root testing is efficient in the mean-reversion of time-series data based on a nonlinear framework [19]-[21]. Smooth process using Fourier transformation has been successful by [22]-[24]. Moreover, the model by [2] is able to control for cross-sectional dependence in the panel data using Sequential Panel Selection Method (SPSM).

However, the study by [2] has not been applied to time series data with missing values and outliers problems. Here comes the novelty of this study.

3 Data Background

The data were sourced from three government bodies, namely Unit Kerjasama Awam Swasta (UKAS) of the Prime Minister's Department, Construction Industry Development Board (CIDB) and Malaysian Statistics Department which specifically deal with PFI construction materials price indices from central region of Peninsular Malaysia which consist of three states Wilayah Prsekutuan Kuala Lumpur, Selangor, Melaka and Negeri Sembilan. Monthly data of thirty-two years, 1980 to 2013 (1980=100) of fifteen different construction material price indices were adopted for analysis. The fifteen construction materials are ceiling materials, roof materials, timber, bricks and partition, glass, aggregate, plywood, sanitary fittings, floor and wall finishes, plumbing materials, steel and metal sections, sand, paint, steel reinforcement and ready mix concrete.

In practice, the input price index is adopted to measure any changes in the transaction price of the building material input to the construction process by having the active transaction prices of Malaysian manufactured and CIF (Cost Insurance Freights) imported building materials tracked and studied. Through this, the materials cost factor for the specific building types can be efficaciously supervised [25].

4 Methodology

In 2014, [2] proposed a nonlinear SPSM-KSS unit root test with a Fourier function which had been proved to be successful in testing the mean reversion of data series with consideration of structural breaks. The system by [2] is;

$$Y_{i,t} = \alpha_i + \beta_i t + \Gamma_i X_{i,t-1}^3 + \sum_{j-1}^{k} \gamma_{i,j} \Delta X_{i,t-j} + m_{i,1} \sin\left(\frac{2k\pi t}{T}\right) + n_{i,1} \cos\left(\frac{2k\pi t}{T}\right) + \varepsilon_{i,t} \quad (1)$$

where t=1,2,3,...,T,k is the rate of approximation, m and n represents the amplitude and displacement of the rate component, sin (.) and cos (.) are the Fourier expression to approximate integrable functions. Further discussions on the Fourier approximation can be seen in [2]. And further step on SPSM can be referred in [26].

The hypotheses to be established for unit root testing are as follows:

H_0:Γ_i =0, for all i (stationarity)

H_a: $\Gamma_i \neq 0$, for some i (nonstationarity)

The stationary of the series are based on the asymptotic p-values by means of Bootstrap simulation of 5000 replications [2]. The significance level of the study is 1%. The maximum lag has been set to be 8 [2]. Fourier (k) is determined by min sum square of errors for Fourier function. OU statistics is as proposed by [20]. Furthermore, missing values interpolation methods are as suggested by MathWorks [27] which are;

i. Nearest neighbor interpolation
ii. Linear interpolation
iii. Piecewise cubic spline interpolation
iv. Shape-preserving piecewise cubic interpolation

5 Results and Discussions

Table 1 shows the summary statistics of the variables of interest. The total N=408 (12 months x 34 years) from January 1980 to 2013 (base 1980=100). The mean of timber is the highest (212.7055), followed by steel reinforcement (199.2349) and sand (198.6965). It can be concluded that the price of timber is the most expensive compared to the other materials, followed by steel reinforcement and sand. Timber also shows the highest in terms of standard deviation which is 104.01141, followed by steel reinforcement (97.18053) and sand (68.49616). On the other hand, the variable with the lowest mean and standard deviation values is aggregate, (mean=113.7727, std.dev=7.63394).

Ceiling materials, bricks and partition, aggregate, sanitary fittings, sand and steel reinforcement are positively skewed which are 0.972, 1.347, 1.409, 1.225, 0.143 and 1.278 respectively. Meanwhile, roof materials, timber, glass, plywood, floor and wall finishes, plumbing materials, steel and metal sections, paint and ready mix concrete are negatively skewed which are -0.321, -0.497, -0.761, -0.772, -1.196, -0.776, -0.487, -0.811 and -0.814 respectively.

However, based on the Jarque-Bera test for normality, all three variables are highly significant at 95% confidence interval; ceiling materials (J-B=0.574, p-value=0.000), roof materials (J-B=0.786, p-value=0.000), timber (J-B=0.831, p-value=0.032), bricks and partition (J-B=0.623, p-value=0.000), glass (J-B=0.644, p-value=0.000), aggregate (J-B=0.873, p-value=0.000), plywood (J-B=0.731, p-value=0.000), sanitary fittings (J-B=0.673, p-value=0.043), floor and wall finishes (J-B=0.891, p-value=0.000), plumbing materials (J-B=0.784, p-value=0.000), steel and metal sections (J-B=0.845, p-value=0.000), sand (J-B=0.828, p-value=0.031), paint (J-B=0.769, p-value=0.029), steel reinforcement (J-B=0.817, p-value=0.000) and ready mix concrete (J-B=0.736, p-value=0.044).

From Table 1, all the three variables suffer from missing values and outliers problems. Here comes the novelty of the study, the panel SPSM-KSS univariate unit root test by [2] has never been tested on time series data with missing values and outliers before. In addition, based on Table 1, each variable consist of 11 missing values, which is 2.7% (11/408 x 100) of the overall data. In the meanwhile, the degree of outliers is different between the fifteen variables; ceiling materials, bricks and partition, aggregate as well as ready mix concrete consist of 3.9% outliers, sand roof materials consist of 8.1% outliers, and the other variables do not contain any outliers. This means that roof materials consist of the greatest number of outliers. This can be proven by the box plots of the variables as shown in Figure 1.

Table 2 reports the best results of Panel SPSM-KSS unit root test with a Fourier function (with both constant and trend) on ceiling materials, roof materials, timber, bricks and partition, glass, aggregate, plywood, sanitary fittings, floor and wall finishes, plumbing materials, steel and metal sections, sand, paint, steel reinforcement and ready mix concrete price indices data of Malaysian context. In the table, the columns represent list of interpolation method for missing values, the sequences of the Panel KSS statistics with the bootstrap p-values, the individual minimum KSS statistic, the best frequency for the model with trend function, and the stationary series identified by the procedure.

As can be seen in Table 2, regardless the different missing values interpolation methods and severity of outliers problems in the data, the method proposed by [2] still perform well. The results are parallel among all four interpolation methods.

The variable of ceiling materials is found to be stationary with minimum KSS values range between -4.3486 to -4.3499 (p-value=0.000). Same goes to the other variables which are stationary using the panel KSS unit root test method. The minimum KSS values for roof materials range between -2.0866 to -2.0871 (p-values <0.05), timber -3.1962 (p-values <0.05), bricks and partitioning -2.9171 (p-values <0.05), glass -0.3451 to -0.3453 (p-values <0.05), aggregate -2.0729 (p-values <0.05), plywood -1.9823 (p-values <0.05), sanitary fittings -3.9759 to -4.0102 (p-values <0.05), floor and wall finishes -2.7115 (p-values <0.05), plumbing materials -5.8163 (p-values <0.05), steel and metal sections -2.0477 to -2.0486 (p-values <0.05), sand -2.0729 (p-values <0.05), paint -2.8743 (p-values <0.05), steel reinforcement -1.0052 (p-values <0.05) and ready mix concrete -4.2864 to -4.3317 (p-values <0.05).

The procedure was done until the last sequence. We found that the panel KSS statistics failed to reject the unit root null hypothesis for the whole sequences.

6 Conclusions and Recommendations

As a conclusion, the panel KSS univariate unit root with Fourier function and trend performs well even when the time series data exist missing values and outliers problems. Regardless the use of any missing values interpolation methods, the test is still applicable. This preliminary test is suggested to be tested any the time series data before further forecasting attempt can be done. This is due to the highly non-linear behavior of real-world time series data with changing volatility and many micro- and macroeconomic determinants [28-31].

. In the near future, it is suggested that the study should be extended to the other regions in Malaysia simultaneously, which are south, east coast, north as well as Sabah and Sarawak.

Moreover, even though it is known that panel KSS unit root with Fourier function and trend is the best unit root test method until now [2], it is believed that results should be compared to the results of panel KSS unit root with trend, panel KSS unit root with no trend, and panel KSS unit root with Fourier and no trend altogether for clearer proof and explanation [2].

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Table 1. Summary statistics of the construction materials price indices data of the study

No.	Variables	Notation	N	Range	Min	Max	Mean	Std. Dev	Skewness	Kurtosis	J-B	Outliers	Missing values
1.	Ceiling Materials	CM	408	66.36	0	166.36	134.8539	15.29938	0.972	2.416	0.574**	16 (3.9%)	11 (2.7%)
2.	Roof Materials	RM	408	50.04	0	150.04	131.6040	8.21334	-0.321	3.508	0.786**	33 (8.1%)	11 (2.7%)
3.	Timber	TM	408	381.37	88.60	469.97	212.7055	104.01141	-0.497	2.822	0.831*	0 (0%)	11 (2.7%)
4.	Bricks and Partition	BP	408	51.69	0	150.49	120.4754	12.53569	1.347	3.552	0.623**	16 (3.9%)	11 (2.7%)
5.	Glass	Glass	408	91.00	0	191.00	152.1925	20.36691	-0.761	1.989	0.644**	0 (0%)	11 (2.7%)
6.	Aggregate	Agg	408	41.43	0	140.63	113.7727	7.63394	1.409	2.803	0.873**	16 (3.9%)	11 (2.7%)
7.	Plywood	Ply	408	156.94	91.30	248.24	156.5302	49.25800	-0.772	4.138	0.731**	0 (0%)	11 (2.7%)
8.	Sanitary Fittings	SF	408	120.66	0	220.66	181.9332	41.20417	1.225	3.482	0.673*	0 (0%)	11 (2.7%)
9.	Floor and Wall Finishes	FWF	408	50.00	0	150.00	127.4829	9.33190	-1.196	2.964	0.891**	0 (0%)	11 (2.7%)
10.	Plumbing Materials	PM	408	57.23	0	152.83	121.3968	18.71001	-0.776	3.892	0.784**	0 (0%)	11 (2.7%)
11.	Steel and Metal Sections	SMS	408	84.97	0	175.57	122.7532	25.79626	-0.487	2.634	0.845**	0 (0%)	11 (2.7%)
12.	Sand	Sand	408	187.88	100.00	287.88	198.6965	68.49616	0.143	-1.730	0.828*	0 (0%)	11 (2.7%)
13.	Paint	Paint	408	120.00	0	220.00	165.0305	36.98542	-0.811	3.198	0.769*	0 (0%)	11 (2.7%)
14.	Steel Reinforcement	SR	408	303.93	88.60	392.53	199.2349	97.18053	1.278	2.393	0.817**	0 (0%)	11 (2.7%)
15.	Ready Mix Concrete	RMC	408	134.34	0	234.34	148.5644	23.29786	-0.814	2.584	0.736*	16 (3.9%)	11 (2.7%)

Note: * and **indicate significance at the 5% and 1% levels respectively.

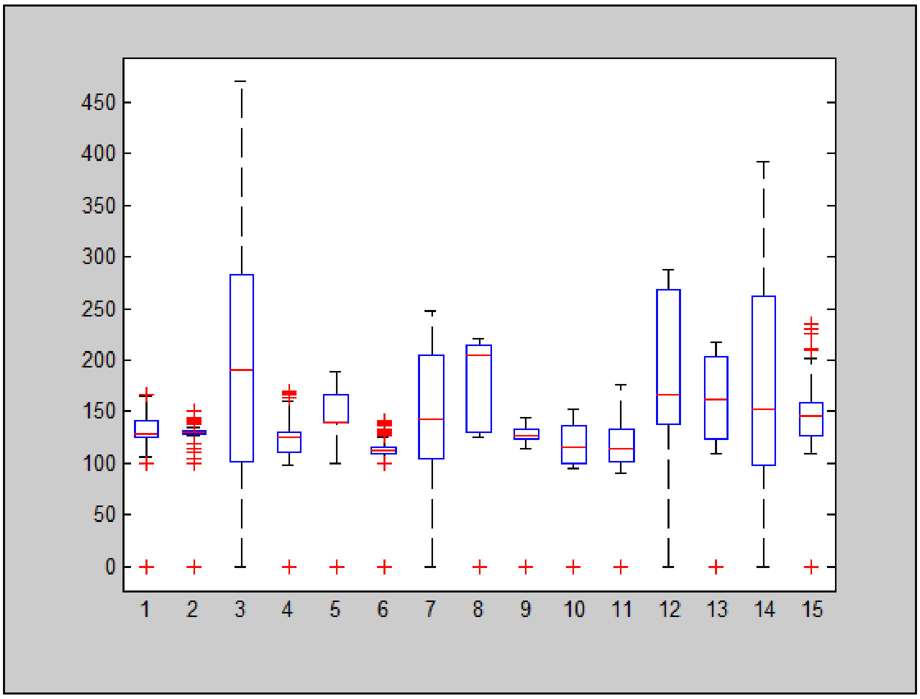

Fig. 1. Box plot for each variable

Table 2. Panel KSS unit root test with a Fourier function and trend

No.	Interpolation Method	Sequence	OU Statistics (p-value)	Min. KSS	Fourier	Series
1	**Nearest Neighbor**	1	-3.2167 (0.0234)	-4.3486	5	CM**
		2	-2.7696 (0.0185)	-2.0866	5	RM**
		3	2.3119 (0.0343)	-3.1962	5	TM **
		4	-3.2744 (0.0328)	-2.9171	5	BP**
		5	-2.6692 (0.0336)	-3.0451	5	Glass**
		6	2.4996 (0.0191)	-2.0729	5	Agg**
		7	3.2967 (0.0000)	-1.9823	5	Ply**
		8	-2.8263 (0.0445)	-4.0059	5	SF **
		9	2.5686 (0.0293)	-2.7115	5	FWF**
		10	-4.3214 (0.0000)	-5.8163	5	PM**
		11	-5.1660 (0.0368)	-2.0477	5	SMS**
		12	2.4996 (0.0191)	-2.0729	5	Sand**
		13	-3.2981 (0.0012)	-2.8743	5	Paint**
		14	-1.8153 (0.0085)	-1.0052	5	SR**
		15	4.3296 (0.0421)	-4.3317	5	RMC**
2	**Linear**	1	-3.2167 (0.0234)	-4.3486	5	CM**
		2	-2.7696 (0.0185)	-2.0866	5	RM**
		3	2.3119 (0.0343)	-3.1962	5	TM **
		4	-3.2744 (0.0328)	-2.9171	5	BP**
		5	-2.6691 (0.0336)	-3.0453	5	Glass**
		6	2.4996 (0.0191)	-2.0729	5	Agg**
		7	3.2967 (0.0000)	-1.9823	5	Ply**
		8	-2.8263 (0.0445)	-4.0059	5	SF **
		9	2.5686 (0.0293)	-2.7115	5	FWF**

		10	-4.3214 (0.0000)	-5.8163	5	PM**

Cont...

		11	-5.1665 (0.0368)	-2.0486	5	SMS**
		12	2.4996 (0.0191)	-2.0729	5	Sand**
		13	-3.2981 (0.0012)	-2.8743	5	Paint**
		14	-1.8153 (0.0085)	-1.0052	5	SR**
		15	4.3296 (0.0421)	-4.3317	5	RMC**
3		1	-3.2177 (0.0234)	-4.3499	5	CM**
		2	-2.7696 (0.0185)	-2.0866	5	RM**
		3	2.3119 (0.0343)	-3.1962	5	TM **
		4	-3.2744 (0.0328)	-2.9171	5	BP**
		5	-2.6692 (0.0336)	-3.0451	5	Glass**
		6	2.4996 (0.0191)	-2.0729	5	Agg**
	Piecewise Cubic Spline	7	3.2967 (0.0000)	-1.9823	5	Ply**
		8	-2.8267 (0.0445)	-4.0102	5	SF **
		9	2.5686 (0.0293)	-2.7115	5	FWF**
		10	-4.3214 (0.0000)	-5.8163	5	PM**
		11	-5.1660 (0.0368)	-2.0477	5	SMS**
		12	2.4996 (0.0191)	-2.0729	5	Sand**
		13	-3.2981 (0.0012)	-2.8743	5	Paint**
		14	-1.8153 (0.0085)	-1.0052	5	SR**
		15	4.3296 (0.0421)	-4.3317	5	RMC**
4		1	-3.2167 (0.0234)	-4.3486	5	CM**
		2	-2.7696 (0.0185)	-2.0871	5	RM**
		3	2.3119 (0.0343)	-3.1962	5	TM **
		4	-3.2744 (0.0328)	-2.9171	5	BP**
		5	-2.6692 (0.0336)	-3.0451	5	Glass**
		6	2.4996 (0.0191)	-2.0729	5	Agg**
	Shape-Preserving Piecewise Cubic	7	3.2967 (0.0000)	-1.9823	5	Ply**
		8	-2.7453 (0.0445)	-3.9759	5	SF **
		9	2.5686 (0.0293)	-2.7115	5	FWF**
		10	-4.3214 (0.0000)	-5.8163	5	PM**
		11	-5.1660 (0.0368)	-2.0477	5	SMS**
		12	2.4996 (0.0191)	-2.0729	5	Sand**
		13	-3.2981 (0.0012)	-2.8743	5	Paint**
		14	-1.8153 (0.0085)	-1.0052	5	SR**
		15	4.3188 (0.0421)	-4.2864	5	RMC**

Note: * and **indicate significance at the 5% and 1% levels respectively.

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