Electricity Consumption, Industrial Production, and Entrepreneurship in Singapore

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Abstract

Within the context of a tri-variate vector autoregressive framework that includes entrepreneurship, this paper examines the link between electricity consumption and industrial production in Singapore's manufacturing sector. Unlike the existing studies, this paper focuses on one sector of the economy and utilises a unique monthly dataset. Empirical analysis based on Johansen's cointegration approach shows that the three variables are cointegrated – i.e., a stable long-run relationship exists among electricity consumption, output and entrepreneurship in Singapore's manufacturing sector. Empirical analysis based on data from Jan 1983 to Feb 2014 reveals that electricity consumption adjusts very slowly to shocks to industrial production and entrepreneurship. Furthermore, entrepreneurship Granger causes electricity consumption, which causes industrial production. As electricity consumption causes industrial output, the growth hypothesis concerning energy consumption and economic growth holds in Singapore's manufacturing sector and policies that restrict electricity production, without electricity imports， are likely to lead to a decline in the manufacturing output.

Keywords: Electricity consumption, industrial production, entrepreneurship, cointegration, Singapore

1. Introduction

Economic growth experienced by the world economy since early 1980s has led to vigorous debate among researchers concerning its determinants. It is generally believed that technological advancement, among other things, has resulted in a decrease in the cost of transportation and communication, which has contributed to an increase in international trade in goods and services. Growth in trade necessitated an increase in the production of goods and services, which is associated with increased pollution (especially in the developing countries). There is a direct link between production and demand for resources used in the production process. Based on the "growth hypothesis", energy can be viewed as an additional factor of production and hence a number of existing studies have attempted to explore the link between energy consumption and economic growth.[1] Early studies that consider the link between economic growth and energy consumption relied on a bivariate model. However, bivariate models suffer from omitted variables bias, which can render the results of statistical testing invalid. For example, using a bivariate model, Cheng and Lai (1997) considered the case of Taiwan. Using annual data from 1954 to 1993, they found that GDP causes energy consumption.

Most existing studies examine the relationship between energy consumptions and economic growth using highly aggregated data.[2] Some studies have found that the relationship between economic growth and energy consumption is statistically insignificant,

[1] See Yildirim, Sukruoglu and Aslan (2014) and references therein. Yildirim, Sukruglu and Aslan argue that unidirectional relationship from energy consumption to economic growth reflects the so-called growth hypothesis underlying growth-energy consumption nexus. This hypothesis suggest that energy saving could reduce economic growth. On the other hand, a unidirectional relationship from economic growth to energy consumption is described as energy conservation hypothesis. The feedback hypothesis reflects the two-way causation between economic growth and energy consumption.

[2] A good review of the existing literature can be found in Shahbaz et al. (2014) and Yildirim, Sukruoglu and Aslan (2014). In order to conserve space a separate literature review is not included in this paper. Some related studies include Abdullah and Morley (2014), Ahmad and Islam (2011), Alam, Begum and Buysse (2012), Ang (2007a), Ang (2008), Chen, Kuo and Chen (2007), Mozumder and Marathe (2007), Narayan, Narayan and Parsad (2008), Yoo and Kim (2006).

which is viewed as a confirmation of the "neutrality hypothesis" concerning the growth-energy consumption nexus. However support for this neutrality hypothesis does not imply that neutrality also exists at a disaggregated level and hence energy development and energy use polices are irrelevant. At the same time, support for non-neutrality does not imply that we do not need to worry about separate energy polices for different sectors. Indeed, not all sectors of any real economy are equally energy intensive. It would therefore be worthwhile to consider the link between energy consumption and economic growth at sectoral level. Such sectoral analysis could help one to identify industry specific issues that could lead to a more targeted and sharply focused energy policy.

This paper focuses on electricity consumption in Singapore's manufacturing sector. [3] While examining the link between manufacturing sector growth and electricity consumption, unlike other studies, this paper also takes into account the impact of domestic entrepreneurship. Using a unique monthly dataset that spans from January 1983 to February 2014, this paper examines the interrelationship among industrial production, electricity consumption and entrepreneurship in Singapore's manufacturing sector.[4]

This paper makes a number of distinct contributions to the existing literature. Only a handful of the existing studies have focused on Singapore and none of these studies appear to

[3] Singapore is used as a case study in this paper because it has not received much attention in the existing literature. However, monthly data on all relevant variable is now available from Singapore Department of Statistics. Singapore is a small open economy that has registered significant economic growth over the past few decades The Singapore economy grew from 2007 to 2013 at an average annual of 5.5%. Singapore is now included among the highest per-capita income countries. Manufacturing and services sectors are regarded as twin engines of Singapore's economic growth. Contribution of the manufacturing sector to GDP growth averaged over the period 1990-2007 was more than 1.63%. With rapid growth in the services sector in recent years, the share of manufacturing in Singapore's GDP has declined to around 18% in 2013 (Yearbook of Statistics, 2013).

[4] A number of studies, such as Wennekers and Thurik (1999), Thurik and Wennekers (2004), Van Stel, Carree and Thurik (2004), and Wong, Ho and Autio (2005), have highlighted the role of entrepreneurship in promoting economic growth.

have considered Singapore's manufacturing sector.[5] This is one of the first studies that uses relatively high frequency (i.e., monthly) data, which is more appropriate for econometric techniques such as cointegration analysis. Furthermore, while existing studies have explored other aspects of entrepreneurship, none of the existing studies have considered the impact of entrepreneurship in the context of growth-energy consumption nexus.[6] Conceptually, entrepreneurship plays an important role in the growth-energy consumption nexus. As an essential input, energy usage is an important decision variable, which has a direct bearing on production. Entrepreneurship captures a firm's decision making capacity. By explicitly including entrepreneurship as a variable in the model, we are able to statistically measure the impact of managerial decision making on growth-energy consumption nexus. The empirical results presented in this paper reveal that there is a long-run relationship among industrial production, electricity consumption and entrepreneurship in Singapore's manufacturing sector. This study also highlights the need for a sector specific energy policy.

2. Methodology and Data

In order to examine the interrelationship among manufacturing sector electricity consumption, output and entrepreneurship, this paper makes use of a Vector Autoregressive (VAR) model. VAR type models are particularly useful when sample size is large and the variables included in the model are not exogenous. The VAR model used in this paper is presented in equation (1) as follows:

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[5] Earlier studies on Singapore include Glasure and Lee (1997) and Chang and Wong (2001). Glasure and Lee's work is based on annual data over the period 1961 to 1990. Their empirical analysis based on a bivariate model suggests that GDP causes energy consumption in Singapore. Based on a bivariate model, Chang and Wong found that GDP causes energy consumption, which supports conservation hypothesis. This study utilises annual data from 1975 to 1995, which is a very small sample.

[6] For example, Anwar and Sun (2012) have explored the impact of foreign investment on entry and exit decision of domestic firms in China's manufacturing sector.

$$Y_t = C + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + ...+ \Pi_p Y_{t-p} + \varepsilon_t \quad (1)$$

$$Y_t = \begin{bmatrix} EM_t \\ IP_t \\ NF_t \end{bmatrix}$$

where EM_t is the electricity consumption in Singapore's manufacturing sector in Gigawatts per hour; IP_t is the index of manufacturing sector industrial production, which captures the fluctuations in manufacturing sector output; NF_t is a measure of entrepreneurship in Singapore's manufacturing sector; ε_t is a random variable which captures the effect of all omitted variables; and $\Pi_1, \Pi_2, ..., \Pi_p$ are the unknown population parameters.

Equation (1) consists of a tri-variate model, which allows one to examine the interrelationship among manufacturing sector electricity consumption, industrial production and entrepreneurship.[7]

Entrepreneurship (NF_t) can be measured in various ways (see OECD, 2014). In this paper, we constructed the entrepreneurship variable by subtracting the monthly cessation of companies form monthly formation. The net effect is the variable that captures the state of entrepreneurship in Singapore's manufacturing sector. Figure 1 shows the trend in entrepreneurship in Singapore's manufacturing sector from January 2000 to February 2014.

--- insert Figure 1 about here ---

Figure 1 shows that during the period of global financial crisis of 2008-2009 there was a net decline in the number of firms in Singapore's manufacturing sector. All variables are measured on monthly basis from January 1983 to Feb 2014. All data were downloaded

[7] Economic growth has created business opportunities in all sectors including Singapore's manufacturing sector. This had led to formation of new companies. At the same time, rapid globalisation has resulted in strong competitive pressures and some existing firms are forced to exit the domestic manufacturing sector. The net impact (i.e., the difference between formation of new companies and cessation of the existing companies) represents domestic entrepreneurship.

from the website of Singapore Department of Statistics (through subscription to STS Online). The basic characteristics of the data are described in Table 1.

--- insert Table 1 about here ---

The sample consists of 374 observations. The Augmented Dicky-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root testing procedures were used to test for stationarity. The results are reported in Table 2.

--- insert Table 2 about here ---

Table 2 shows that using all three testing procedures, at the 1% level of significance, Singapore's industrial production and electricity consumption are non-stationary in levels but stationary in first differences. However, the evidence concerning the entrepreneurship variable is mixed in that the ADF and PP tests suggest stationarity in levels but the KPSS test suggests non-stationarity at the 5% level of significance. Because the first differences of all variables are stationary, it is possible that a long-run cointegrating relationship exists among the three variables.[8]

3. Results

It is well known that Johansen's methodology, which utilises a multivariate approach, produces the best results, especially in large samples. This procedure requires all variables to be stationary in first differences. Based on the KPSS testing procedures it can be argued that the requirements of Johansen's cointegration procedure are satisfied.[9] The results of Johansen's cointegration approach are shown in Table 3.

--- insert Table 3 about here ---

[8] Cointegation analysis also allows one to separate short- and long- run relationship among variables and it can also be used to improve long-run forecast accuracy.

[9] An alternative to Johansen's methodology is Autoregessive Distributed Lag (ARDL) based bounds testing approach, which is particularly suitable in the case of small samples. Furthermore, the bounds testing approach developed by Pesaran, Shin and Smith (2001) does not require all variables to be non-stationary in levels. We also report the results of ARDL-based bounds testing approach.

The results presented in Table 3 suggest the presence of only one cointegrating vector at the 5% level of significance, which has a nice interpretation in that all the variables in the system move together towards the long-run equilibrium. The implication is that, even though all variables are individually non-stationary, a linear combination of the three variables is stationary (i.e., the three original non-stationary variables are cointegrated). Based on the empirical results reported in Table 3, it can be argued that there is a stable long-run relationship among electricity consumption, industrial production and entrepreneurship in Singapore's manufacturing sector.[10] The graph of this cointegrating relationship is shown in Figure 2.

--- insert Figure 2 about here ---

The existence of cointegration implies that the relationship among electricity consumption, industrial production and entrepreneurship in Singapore's manufacturing sector can be most efficiently represented by an error correction model. The Vector Error Correction Model (VECM) corresponding to equation (1) is as follows:

$$\Delta EM_t = \phi_0 + \phi_1 (EC)_{t-1} + \sum_{i=1} \phi_{21} \Delta IP_{t-i} + \sum_{i=1} \phi_{22} \Delta NF_{t-i} + \upsilon_t \qquad (2)$$

where EC_{t-1} is the lagged value of the corresponding error correction term; $\phi's$ are the population regression coefficients and υ_t is a random variable.

--- insert Table 4 about here ---

The estimated results based on equation (2) are reported in Table 4, which shows that both industrial output and entrepreneurship have a strong and statistically significant impact on electricity consumption in Singapore's manufacturing sector. An increase in industrial

[10] This conclusion also holds when a linear trend is included in the model.

production is positively related to electricity consumption but the relationship between entrepreneurship and electricity consumption is negative, which could be attributed to the use of relatively more energy efficient technologies by new firms and the exit of relatively less energy efficient firms. The negative relationship also implies substitution away from the use of electricity by the incumbent firms. The estimated error correction term indicates that energy consumption in Singapore's manufacturing sector adjusts to its long-run value at a fairly slow rate (approximately 2.9% per year). The estimated model was tested for the presence of autocorrelation in the residuals. The results of the Lagrange Multiplier (LM) test, presented in Table 5, suggest the absence of significant autocorrelation in residuals.

--- insert Table 5 about here ---

The estimated error correction model was found to be stable. The impulse response functions trace the time path of the effect of structural shocks to electricity consumption in response to a unit change in shock to industrial production and entrepreneurship. Figure 3 shows that a positive unit shock to industrial production contributes to an almost permanent increase in electricity consumption but a positive unit shock to entrepreneurship leads to a steady decline in electricity consumption, which appears to suggest increasing reliance on non-electricity energy sources.

--- insert Figure 3 about here ---

The reliability of the estimated model can also be evaluated by means of its forecasting accuracy. Based on the estimated model, the forecasted values of all three variables are plotted in Appendix 1a to 1c. The estimated values are close to the actual values of each of the three variables, which appears to confirm the reliability of the estimated model.

The test for cointegration developed by Johansen requires all variables to be integrated of order one. However, not all times series variables satisfy this condition. The results of ADF and PP testing procedures reported in Table 2 suggest that entrepreneurship is integrated of order zero whereas the electricity consumption and industrial production are integrated of order 1. It can therefore be argued that ARDL-based bounds testing approach to cointegration may be a good alternative to Johansen's approach.[11] The bounds testing approach, developed by Pesaran, Shin and Smith (2001), does not require all variables to be integrated of order one. In the following, we test for cointegration using the bounds testing approach.

3.1 ARDL Based Cointegration Analysis

ARDL procedure is based on the Wald or *F*-statistic in a generalized Dickey Fuller type regression used to test the significance of the lagged levels of relevant variables in a conditional unrestricted error correction model (ECM). Inferences are made by making use of two sets of asymptotic critical values corresponding to two extreme cases one assuming purely I(0) and the other assuming purely I(1), without the need to know the regressors' underlying order of integration. ARDL approach is based on the application of an *F*-test to establish the joint significance of the lagged level variables. This procedure involves estimating equations (3) as follows:

$$\begin{aligned}\Delta EM_t &= a + \sum_{k=1}^{n} b_k \Delta EM_{i,t-k} + \sum_{k=0}^{n} c_k \Delta IP_{i,t-k} + \sum_{k=0}^{n} d_k \Delta NF_{i,t-k} \\ &\quad + \lambda_1 EM_{i,t-1} + \lambda_2 IP_{i,t-1} + \lambda_3 NF_{i,t-1} + \varepsilon_{i,t}\end{aligned} \qquad (3)$$

In terms of equation (3), cointegration exists as long as $\lambda_1 = \lambda_2 = \lambda_3 = 0$. Pesaran, Shin and Smith (2001) also proposed a *t*-test that is used to test the significance of the coefficient of $EM_{i,t-1}$. In other words, cointegration exists if $\lambda_1 = 0$. The ARDL-based bound testing approach allows each variable to have different optimal lag. Using Schwarz Bayesian Criteria

[11] The ARDL technique has been used by a number of studies in different contexts. For example see Ang (2007b).

(SBC), we found the optimal lag length of (2, 3, 2). Using the optimal lag length, equation (3) was estimated. The estimated results are reported in Table 6. Use linear restrictions command, the null hypothesis of $\lambda_1 = \lambda_2 = \lambda_3 = 0$ was tested. The estimated value of the *F*-statistic (3, 359) was found to be 7.554, which is well above the upper bound of 4.73 provided in Pesaran, Shin and Smith (2001). This allows us to conclude electricity consumption, industrial production and entrepreneurship in Singapore's manufacturing sector are cointegrated.[12] This confirms our earlier results based on Johansen's approach. It can therefore be argued that our results are robust. It is well-known that an ARDL model can be re-parameterized to yield the ECM. The estimated results of this model are reported in Table 7.

--- insert Table 7 about here ---

The main difference is that the coefficient of the error correction term is relatively large but still quite small in absolute terms. The ARDL-based estimated long-run coefficients are presented in Table 8.

--- insert Table 8 about here ---

The estimated results presented in Table 8 are qualitatively similar to those reported in Table 4. The signs and the level of significance are consistent with Johansen's cointegration results. *LM* test for autocorrelation indicates the absence of significant autocorrelation - the estimated *F*-value of the test statistic is 5.41 with a *p*-value of 0.000). The estimated results are free from significant heteroscedasticity as indicated by the Chi-square test statistic value of 22.81 (with a *p*-value of 0.000). The functional form based on Ramsey's RESET test using the square of the fitted value is also appropriate (the estimated *F*-value is 9.60 with a *p*-value of 0.002).

[12] The results of the *t*-test also support this conclusion. The estimated *p*-value of λ_1 is zero in four decimal points, which also supports the view that the three variables are cointegrated.

The stability of the estimated model can be examined by means of Cumulative Sum of Recursive Residuals (CUSUM) test. The results of CUSUM test are shown in Figure 4. These results show that the estimated model is stable.

--- insert Figure 4 about here ---

4. Discussion

The existing studies on Singapore (Glasure and Lee, 1997 and Chang and Wong, 2001), using aggregate data, suggest that economic growth (as measured by GDP) causes energy consumption. Using a tri-variate model, where entrepreneurship has been taken into account, this paper finds that industrial production does not cause electricity consumption but electricity consumption in Singapore's manufacturing sector causes industrial production. This result suggests that the growth hypothesis is relevant in the case of Singapore's manufacturing sector. In other words, a decrease in the use of electricity, which could reduce environmental pollution, would lead to a decline in Singapore's manufacturing sector's industrial production. As shown in Table 9, at the 5% level of significance, there is a two-way causation between entrepreneurship and industrial production. However, the estimated results presented in Table 9 suggest a unidirectional causality between electricity consumption and entrepreneurship in Singapore's manufacturing sector. At the 1% level of significance, entrepreneurship causes electricity consumption. It can therefore be concluded that in the case of Singapore's manufacturing sector, entrepreneurship causes electricity consumption, which causes industrial production.

--- insert Table 9 about here ---

In summary, the empirical results presented in this paper suggest that electricity consumption Granger causes industrial production. But electricity consumption does not cause industrial production. In other words, growth hypothesis is relevant in the case of Singapore but energy conservation hypothesis is not supported by data. This implies that the feedback hypothesis that envisages a two-way causation between energy consumption and output growth is also not relevant in the case of Singapore's manufacturing sector. It is interesting to note that domestic entrepreneurship does not Granger cause electricity consumption. But domestic entrepreneurship does Ganger cause industrial production.

While the empirical analysis based on Johansen's methodology confirms the presence of cointegration, in order to evaluate the robustness of our empirical results, we also tested for cointegration using the ARDL based bounds testing procedure. The results of the bounds testing approach also confirm the presence of a common stochastic trend among the three variables. In other words, the empirical results presented in this paper are fairly robust.

5. Concluding remarks and policy implications

A number of existing studies have considered the link between energy consumption and economic growth. Early studies relied on a bivariate approach. While recognising the omitted variables bias issue, more recent studies have used a tri-variate approach. However, almost all existing studies use annual data aggregated data. We argue that the results based on aggregated data cannot be directly applied to all sectors of every economy and all sectors are not equally energy intensive. Furthermore, globalisation has resulted in new business opportunities and hence one should also take into account the impact of entrepreneurship.

Due to unavailability of data, a large number of studies use electricity use as a proxy for energy consumption. Some studies found that electricity consumption causes economic growth, which is known as the growth hypothesis. The growth hypothesis implies that a decrease in energy generation and hence consumption would reduce economic growth and hence environmental pollution can be reduced only if we sacrifice some economic growth. Another group of studies found that economic growth causes energy consumption, which is known as the conservation hypothesis. This hypothesis suggests that by controlling the economic growth rate and thereby conserving energy, environmental pollution can be reduced without too much sacrifice. Some studies found no causation between economic growth and energy consumption, which is known as the neutrality hypothesis. The neutrality hypothesis suggests that environmental policies do not have economic consequences. Finally, some studies found a two-way causation between economic growth and energy consumption, which is known as the feedback hypothesis.

Using a unique monthly dataset, which covers the period of January 1983 to February 2014, this paper focuses on Singapore's manufacturing sector. Statistical analysis using Johansen's cointegration methodology suggests that a statistically significant long-run relationship exists among electricity consumption, industrial production and entrepreneurship in Singapore's manufacturing sector. The estimated error correction model suggests that electricity consumption in Singapore's manufacturing sector adjusts very slowly to its long-run value in response to shocks to industrial production and entrepreneurship. While the existing studies, using aggregate annual data, have shown that economic growth, as measured by increase in gross domestic product (GDP) causes energy consumption, using monthly data from Singapore's manufacturing sector, this paper found a unidirectional causation from electricity consumption to industrial production. Furthermore, entrepreneurship is found to cause electricity consumption, which causes industrial production. The empirical results based on Johansen's methodology are confirmed by the autoregressive distributed lag (ARDL) based bounds testing approach.

The results presented in this paper have important policy implications. First, studies using aggregated data support conservation hypothesis concerning the growth-energy consumption nexus in Singapore. However, analysis of the disaggregated data reveals that growth hypothesis is relevant in the case of Singapore's manufacturing sector. This suggests that there is a need for manufacturing sector specific energy policy. Second, as growth in entrepreneurship is found to be an important determinant of electricity consumption in Singapore, there is a need for increased engagement with the industry. This will also allow relatively more accurate forecasting of energy demand in Singapore. Singapore cannot afford a decrease in its economic growth rate as it will hurt its manufacturing sector, an engine of its economic growth. Careful investment in renewable energy, including solar power, can increase electricity production without creating significant additional pollution. A recent report suggests long delays in approval of new renewable energy investment projects in Singapore (Finenko, 2014).

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Figure 1: Net formation on companies in Singapore's manufacturing sector

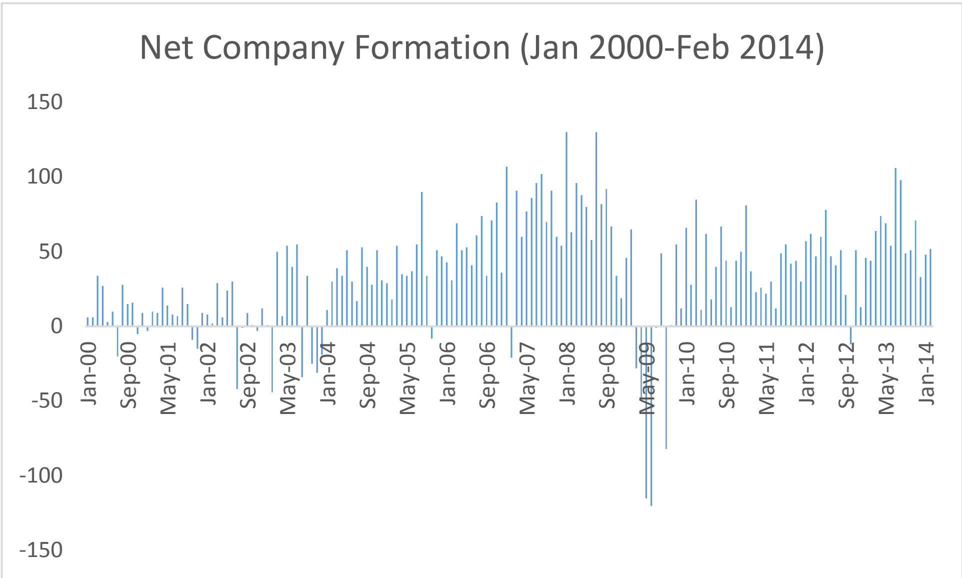


Figure 2: Cointegration Relationship (at the 5% level of Significance)

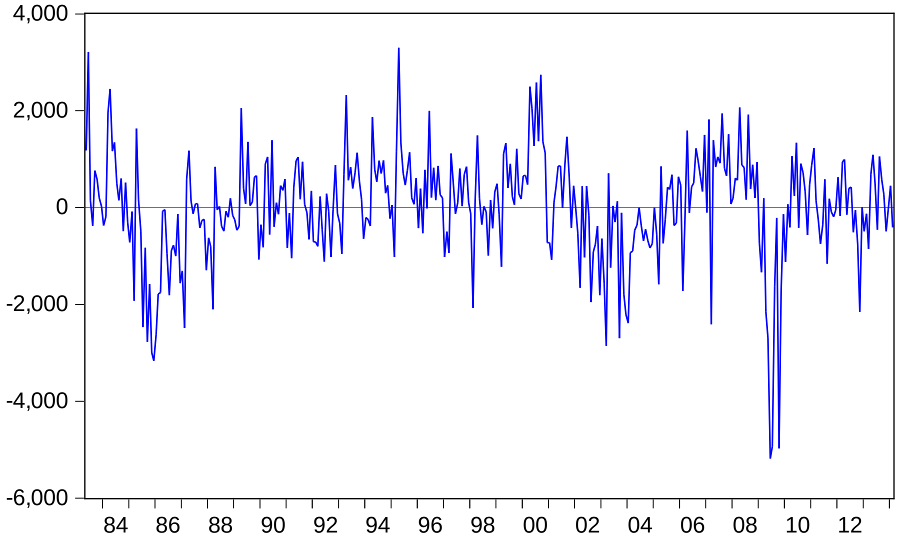
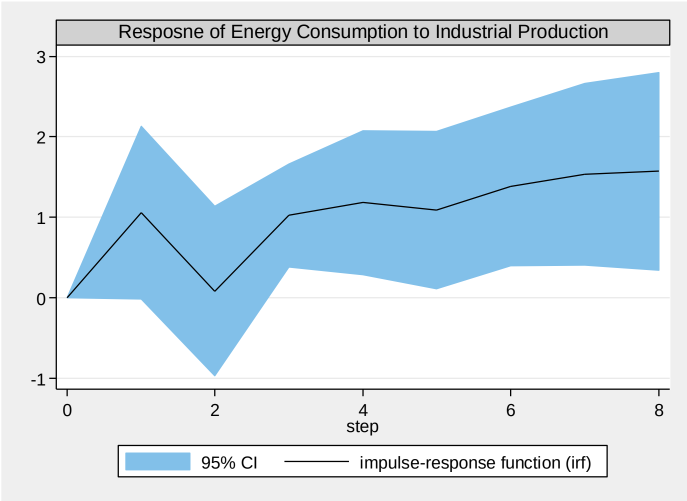


Figure 3: Impulse Response Functions



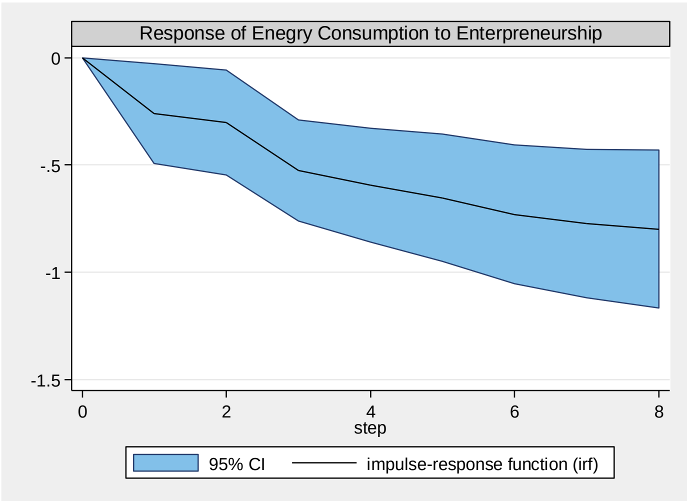
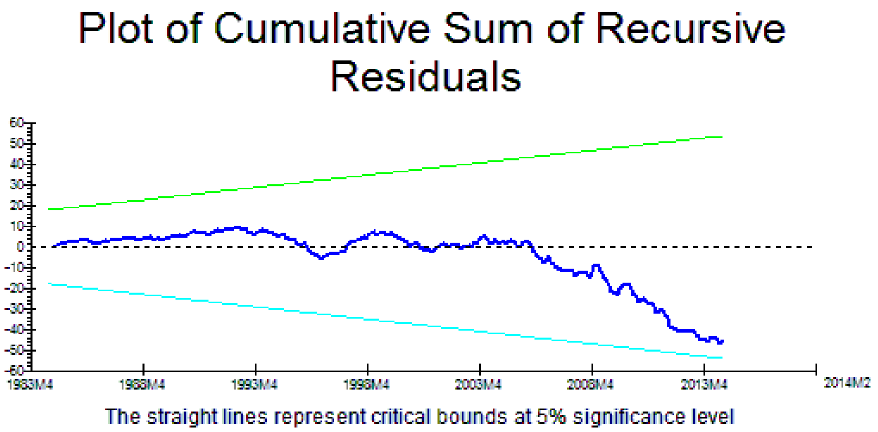
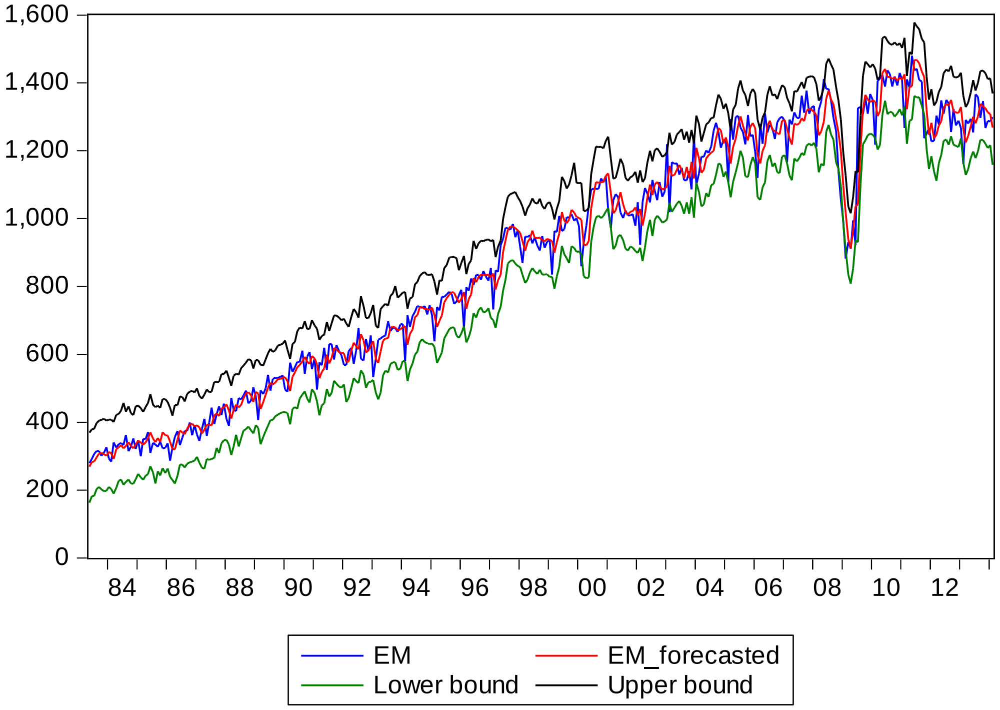


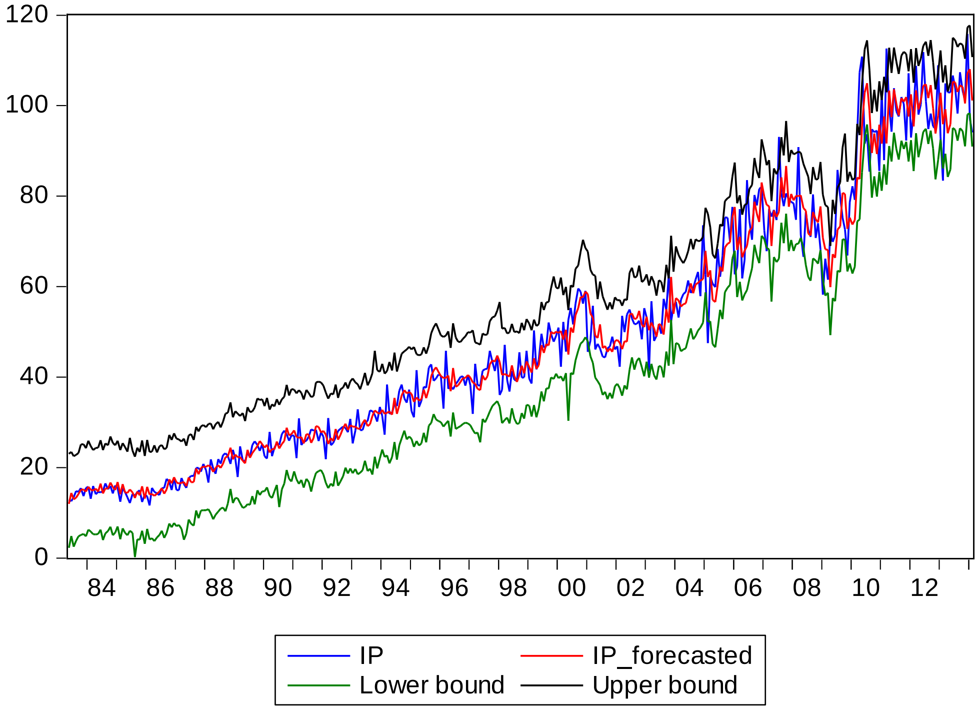
Figure 4: Model Stability (ARDL Approach)



Appendix 1a: Forecasted Values of Singapore's Manufacturing Sector Energy Consumption



Appendix 1b: Forecasted Values of Singapore's Manufacturing Sector Industrial Production



Appendix 1c: Forecasted Values of Entrepreneurship in Singapore's Manufacturing Sector

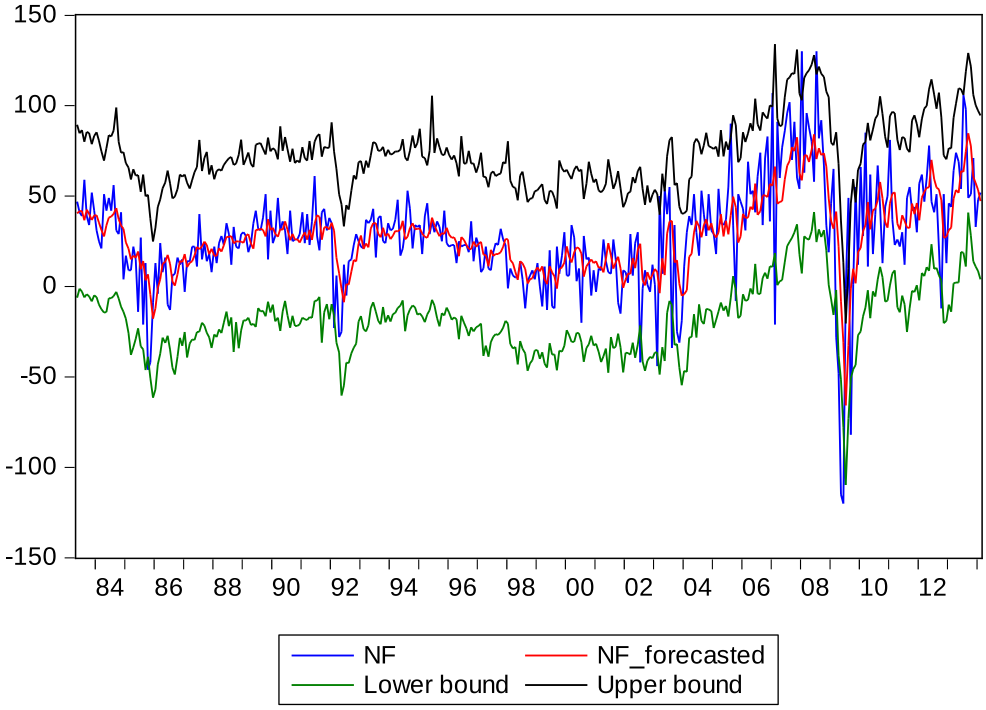


Table 1: Descriptive Statistics

	EM	IP	NF
Mean	879.5639	48.36179	81.96524
Median	931.2000	42.21000	89.50000
Maximum	1480.200	115.8300	252.0000
Minimum	228.9000	11.29000	-130.0000
Standard Deviation	361.6324	27.59226	55.62471
Skewness	-0.145733	0.612883	-0.436538
Kurtosis	1.660971	2.325197	3.563661
Observations	374	374	374

Table 2: Unit Root Testing

Variables	ADF in levels	ADF in First Differences	Phillips-Perron Test in Levels	Phillips-Perron Test in First Differences	KPSS in Levels	KPSS in First Differences
intercept and no trend						
EM	-1.1517 (0.6960)	-6.3746 (0.0000)	-1.4614 (0.5523)	-30.5021 (0.0000)	LM-stat: 2.3954*	LM-stat: 0.0274
IP	0.7196 (0.9925)	-11.2371 (0.0000)	-2.1710 (0.2174)	-78.5213 (0.00001)	LM-stat: 2.3163*	LM-stat: 0.1254
NF	-5.0908 (0.0000)	-21.4494 (0.0000)	-12.2999 (0.0000)	-64.8072 (0.0001)	LM-stat: 0.4850**	LM-stat: 0.2020

Note: *p*-values in parentheses; * represents significance at the 1% level;
** represents significance at the 5% level.

Table 3: Johansen's Cointegration Test

	Eigenvalue Test			Trace Test		
Number of Cointegrating Vectors	Max-Eigenvalue Statistic	0.05 Critical Value	*P*-values**	Trace Statistic	0.05 Critical Value	*P*-values**
None *	32.69	22.30	0.0013	45.23	35.19	0.0030
At most 1	8.08	15.89	0.5381	12.54	20.26	0.4015
At most 2	4.46	9,16	0.3478	4.46	9.16	0.3478
* Denotes rejection of the hypothesis at the 0.05 level; ** MacKinnon-Haug-Michelis *p*-values						

Table 4: Estimated Long-run Coefficients and Error Correction

Estimated Long-run Coefficients (*p*-values in parentheses)				
	IP_t	NF_t	Error Correction Term	Max Lag Length
EM_t	19.0969 (0.0000)	-21.5633 (0.0000)	-0.02552 (0.0000)	3

Table 5: Lagrange-multiplier test

Lag	Chi-Square Value	Degrees of freedom	Prob > Chi-Square
1	8.3693	9	0.49740
2	10.7683	9	0.29192
3	15.7689	9	0.07187
H_0: No autocorrelation at lag order			

Table 6: ARDL Bounds Testing Approach (Dependent Variable is ΔEM)

Variable	Coefficient	Std. Error	*p*-value
EM_{t-1}	-0.043375	0.021404	0.0435
IP_{t-1}	0.626289	0.291095	0.0321
NF_{t-1}	-0.536280	0.120798	0.0000
ΔEM_{t-1}	-0.479718	0.060640	0.0000
ΔEM_{t-2}	-0.055313	0.059817	0.3557
ΔIP_{t-1}	0.744167	0.650074	0.2531
ΔIP_{t-2}	-0.006264	0.702360	0.9929
ΔIP_{t-3}	0.673584	0.568765	0.2371
ΔNF_{t-1}	0.288444	0.143688	0.0455
ΔNF_{t-2}	0.174676	0.123647	0.1586
Constant	26.73129	8.489852	0.0018
R-squared	0.242765	Mean dependent var	2.710000
Adjusted R-squared	0.221672	S.D. dependent var	58.68471
S.E. of regression	51.77336	Akaike info criterion	10.76091
Sum squared resid	962292.5	Schwarz criterion	10.87725
Log likelihood	-1979.768	Hannan-Quinn criter.	10.80712
F-statistic	11.50932	Durbin-Watson stat	1.991452
Prob(*F*-statistic)	0.000000	$n = 370$	

Table 7: Error Correction Representation for the Selected ARDL Model

ARDL(2,3,2) selected based on SBC			
Regressor	Coefficient	Standard Error	*p*-value
dEM1	-0.39	0.05	0.000
dIP	4.48	0.48	0.000
dIP1	3.18	0.58	0.000
dIP2	1.48	0.49	0.003
dNF	0.45	0.10	0.000
dNF1	0.34	0.11	0.002
Comstant	24.2	7.38	0.001
EM(-1)	-0.054	0.02	0.004
Note: dEM is the first difference of EM; dEM1 is the first difference of one period lagged values of EM; dIP2 is the first difference of two period lagged values of IP; EM(-1) is the error correction term. Durbin-Watson = 2.05			

Table 8: Estimated Long Run Coefficients using the ARDL Approach

Dependent variable: EM (371 observations used for estimation from 1983M4 to 2014M2); ARDL(2,3,2); Lag length selected based on Schwarz Bayesian Criterion			
Regressors	Estimated Coefficient	Standard Error	*p*-value
IP	13.08	1.78	0.000
NF	-6.12	2.71	0.024
Constant	450.14	106.87	0.000

Table 9: Granger Causality Tests (3 Lags)

Null Hypothesis	Observations	*F*-Statistic	*p*-value
IP does not Granger Cause EM	371	1.64863	0.1778
EM does not Granger Cause IP	371	3.39887	0.0180
NF does not Granger Cause EM	371	5.32554	0.0013
EM does not Granger Cause NF	371	1.86532	0.1350
NF does not Granger Cause IP	371	2.80183	0.0398
IP does not Granger Cause NF	371	2.73700	0.0434