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A Bayesian Vector Autoregressive Analysis of Price and Industrial Shocks on the Malaysian Economy

(Analisa Kesan Renjatan Harga dan Pengeluaran Industri kepada Ekonomi Malaysia dengan Kaedah Vektor Autoregresif (VAR) Bayesian)

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ABSTRACT

Aside from identifying the determinants of economic growth, ensuring a stable evolution of output is crucial. This paper therefore, intends to shed light on the effects of consumer prices (CPI) and producer prices (PPI) as well as industrial output (IPI) shocks on real aggregate output. Preliminary examination of data suggests a critical analysis on the nexus between aforementioned variables is warranted. Conforming to precedence in the literature, Bayesian Vector Autoregressive analysis was performed on the detrended series. As expected, a shock in consumer prices induces a negative response in real GDP while a positive response was observed from a shock in producer prices. However, we note that the positive response from PPI is subdued which may be accounted for by the consideration of negative consumer sentiment in producers' decision. Additionally, we find positive CPI response on shocks emanating from real GDP and IPI. We note that the weak CPI response from innovation in IPI may be due to the percentage of exported goods in the Malaysian manufacturing sector. Also noteworthy, is that innovations in CPI and real GDP induce positive response in IPI, but followed by mild negative response. We ascribe this observation to inventory overshooting.

Keywords: economic growth; Bayesian; VAR analysis; price indices; industrial production

ABSTRAK

Selain dari mengenalpasti faktor-faktor pertumbuhan ekonomi, memastikan kestabilan evolusi pengeluaran negara adalah penting. Kajian ini bertujuan mengenengahkan kesan perubahan Indeks Harga Pengguna (IHP), Indeks Harga Pengeluar (IHPR) dan Indeks Pengeluaran Perindustrian (IPP) ke atas keluaran agregat sebenar. Pemerhatian data secara kasar menunjukkan analisa mendalam ke atas pembolehubah-pembolehubah tersebut adalah diperlukan. Berdasarkan kajian terdahulu, analisa vektor autoregresif (VAR) Bayesian dilakukan ke atas data yang telah dikawal aliran pertumbuhan. Didapati renjatan harga pengguna membangkitkan respon negatif dari Keluaran Dalam Negara Kasar (KDNK), manakala renjatan harga pengeluar membangkitkan respon positif dari KDNK. Walaubagaimanapun, respon positif dari IHPR adalah lemah yang berkemungkinan besar disebabkan pengeluar mengambil kira sentimen negatif pengguna. Tambahan lagi, renjatan dari KDNK dan IPP membangkitkan respon positif dari IHP. Respon yang lemah dari IHP terhadap renjatan IPP adalah disebabkan peratusan eksport pengeluaran sektor pembuatan Malaysia. Selain itu, renjatan IHP dan KDNK membangkitkan respon positif dari IPP, namun diikuti respon negatif yang lemah. Ini adalah disebabkan keter-lambakan inventori.

Kata Kunci: pertumbuhan ekonomi; Bayesian; analisa VAR; indeks harga; pengeluaran perindustrian.

INTRODUCTION

Economic studies have long reaped the benefits of advances in quantitative methods, underpinned by progress in computing technology. Topics where discussions were previously left to abstract construct, may now be scrutinized through a myriad of quantitative procedures. Statistical analysis has become an integral component of economic scholarly work, so much so, that it has led to the conception of a field entirely dedicated to quantitative economic study that is, econometrics. Such macroeconomic issues as output growth, inflation and capital flows may be methodically assessed by appropriate measures available at a researcher's disposal. Guloglu and Tekin (2012) for instance, utilized Vector Autoregressive (VAR) model in examining the effects of research and innovation on growth performance of Organization for Economic Co-operation and Development (OECD) economies. In a variation of similar model, Abrego and Österholm (2010) examined the effects of external shocks on Colombian economy in a Bayesian Vector Autoregressive (BVAR) model.

Issues concerning the real sector of an economy are numerous. Identifying factors that could bolster output growth performance or assessing social effects of economic growth on a society are just some examples of macroeconomic concerns. As an emerging economy in the dynamic region of Southeast Asia, Malaysian policy

makers and academic economists alike pay particular attention on its output performance. The focus on growth is further heightened by the self-imposed due of 2020 by which time Malaysia aims to be an advanced economy. Despite relatively robust performance amidst rounds of external shocks emanating from western economies in recent years, achieving a developed nation status with only one or two years remaining towards the due date remains a challenging feat. The per capita income threshold to qualify as a high income country specified by the World Bank is US$12,746 while Malaysia's per capita income as of 2014 is US$10,426. As such, public policies of late are geared towards stimulating growth, marking the final thrust towards the finishing line.

The New Economic Model (NEM), the government's long term development blueprint, focuses on driving Malaysia to become a high income country with its own delineated objectives. Specifically, it aims to (i) increase per capita income up to US$15,000 by the year 2020; (ii) ensure a sustainable economic development; and (iii) enable all communities benefit from national development. Complementing NEM are five-year development plans released by Economic Planning Unit, an agency directly within the purview of the Prime Minister's Department. The latest of such policies is the 11th Malaysia Plan, of which implementation period spans from 2016 to 2020. Being the final medium-term development plan before 2020, it is touted to be the most important one yet. The policy hinges on several core thrusts namely, (i) re-engineering economic growth; (ii) strengthening growth enablers; (iii) harnessing talent; (iv) mainstreaming environment and resource management; (v) enhancing inclusivity; and (vi) improving well-being.

On the surface, Putrajaya seems to have a grasp on what is needed to realize its aspiration of placing Malaysia on par with other economic power houses in the region. Emphasis on more private sector participation, inter alia is rightly espoused both in NEM and the 11th Malaysia plan. Such subsidy rationalization initiatives as removal of petrol and food subsidies were pushed through albeit knowing that it will draw unpopular attention on the current government's administration, all in favor of a balanced fiscal budget goal. Delving deeper however, inclusiveness of economic growth remains an issue. Gini index of income inequality as of 2009 stands at 46.2. Efforts in improving income inequality should perhaps be re-examined and incorporate structural changes. Moreover, efficiency in management of public funds could be further improved. Given that policy makers are able to muster the political will needed to push for more drastic changes in areas where it is direly needed, Vision 2020 may well be just a matter of time. If this drive is successful, Malaysia would join the ranks of Singapore, currently the only high income country in Southeast Asian region.

While the importance of stimulating economic growth is well justified, ensuring a robust growth is just as crucial. Knowing how national output responds to exogenous shocks which may stem from either internal or external sources is therefore of equal importance. Supply shocks for instance, may result in price variability which in turn may disrupt output growth. In particular, a Bayesian estimate of VAR examining the effects of oil supply disruption on US's output reports a notable, though modest outcome (Baumeister & Peersman 2013). With regard to Asian economies, external shocks particularly that of external equity market, have had more pronounced effects in the post Asian Financial Crisis period (Yang 2013). Disruptions emanating from external output sources on the other hand, remained as the dominant disruptive factor in both pre-crisis and post-crisis period in emerging Asian economies.

Aforementioned cases highlight some of the external concerns surrounding the issue of resilience in national output. Having attached a dateline to its aim, Malaysia needs not only to stimulate output; it needs to secure a robust growth. While it is noted that Malaysia is a relatively small economy and that it has a high degree of trade openness, economic shocks emanating domestically often has prominent implications. Additionally, unlike foreign shocks, domestic innovations like price indices and industrial output are more malleable to the decisions of policy makers. As such, this paper intends to scrutinize the effects of prices and industrial production shocks on real Gross Domestic Product (GDP). This will serve as an invaluable insight on the impact of unintended disruptions on Malaysian economy. Additionally, we have identified a gap in the literature. While disparate studies have indeed examined the relationship between national output and prices (Lean & Smyth 2010) or between input prices and industrial production (Ali Ahmed & Wadud 2011) for the Malaysian economy, there is no Bayesian VAR model that studies the dynamics between national output, consumer prices, producer prices and industrial evolutions. The Bayesian VAR model adopted in this paper allows for a study between aforementioned variables while overcoming such restrictions as omitted variable bias (Miranda-Agrippino & Ricco 2018).

OBSERVATIONS

For the purpose of framing a basis for investigation, a closer data examination of relevant variables is warranted. Additionally, studies that are germane to our discussions are discussed.

OBSERVATION ON OUTPUT

The convention for gauging economic growth is of course, real GDP. Figure 1 shows the quarterly real GDP for Malaysia from the first quarter of 1991 up to the last quarter of 2014 with a base year of 2010. Generally,

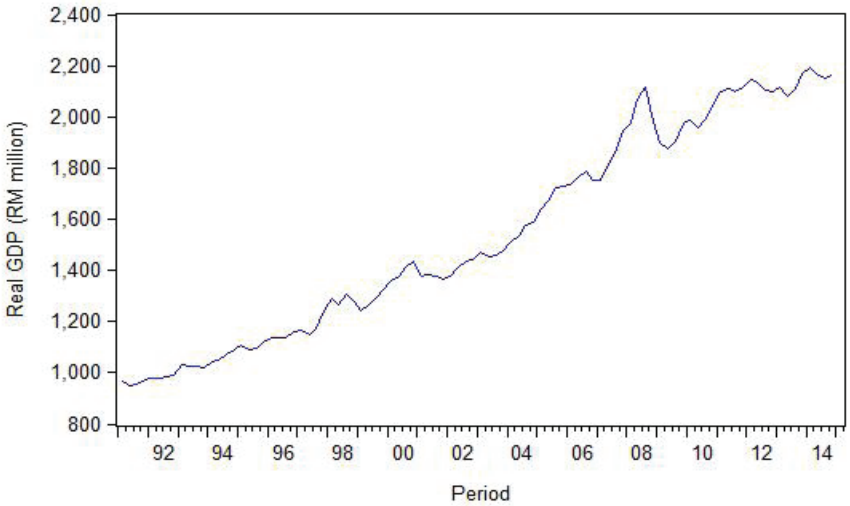

FIGURE 1. Real Gross Domestic Product

this Association of Southeast Asian Nations (ASEAN) member country displays an upward trend with regard to its aggregate output in real terms. For a more concrete measure of its performance, Figure 2 depicts a year-on-year percentage change in real GDP where it averaged at 3.69 percent for the entire data set. In 1999, Malaysia's real GDP is markedly the worst in 1990s of which its early years were characterized by strong growth performance, driven by rapid industrialization. The Asian financial crisis however, brought the emerging economy to its knees, only to bounce back swiftly as compared to many other countries hit by the crisis. In the fourth quarter of 2001, real GDP contracted by 5.1 percent, an even greater magnitude in comparison to a decline of 3.6 percent in 1999, which is mainly due to a sharp fall in demand for exports, a resultant of weak global economic conditions. While exposure to US's financial market is minimal, the financial crisis of 2007/2008 too had its share in weakening Malaysia's economy, mainly through demand for exports. Real GDP in the third quarter of 2009 fell by a staggering 10 percent. This highlights the economy's real sector's exposure to global environment. Sluggish US's recovery coupled with uncertainties in Europe, decline in Petroleum revenue inter alia, has dragged Malaysia's growth engine in recent years.

OBSERVATION ON CONSUMER PRICES

The average prices of consumer goods may be employed to assess the effects of price changes on the economy. Inflationary pressure may dampen domestic demand and thus exert unpropitious outcome on real output. Figure 3 shows Consumer Price Index (CPI) for Malaysia with 2010 as base year. A general upward trend is clearly observable with a salient spike in the third quarter of 2008. Figure 4 depicts the year-on-year change in CPI from 1991 to 2014. Average inflation for the entire period

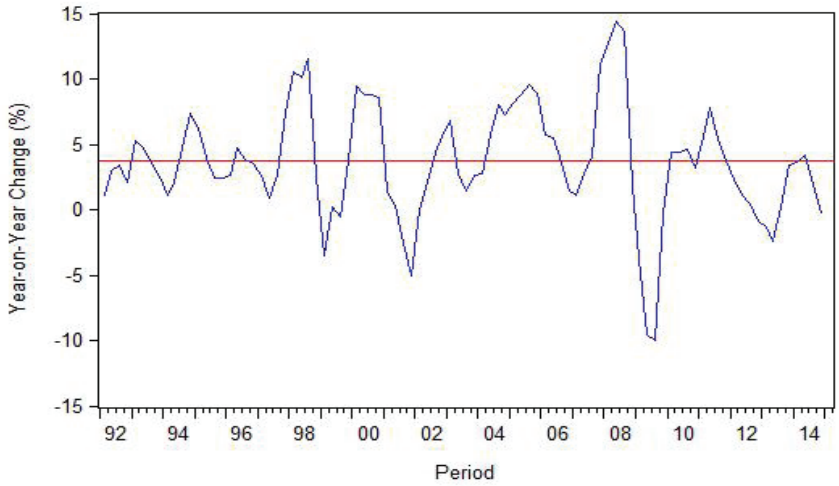

FIGURE 2. Year-on-Year Change in Real Gross Domestic Product.

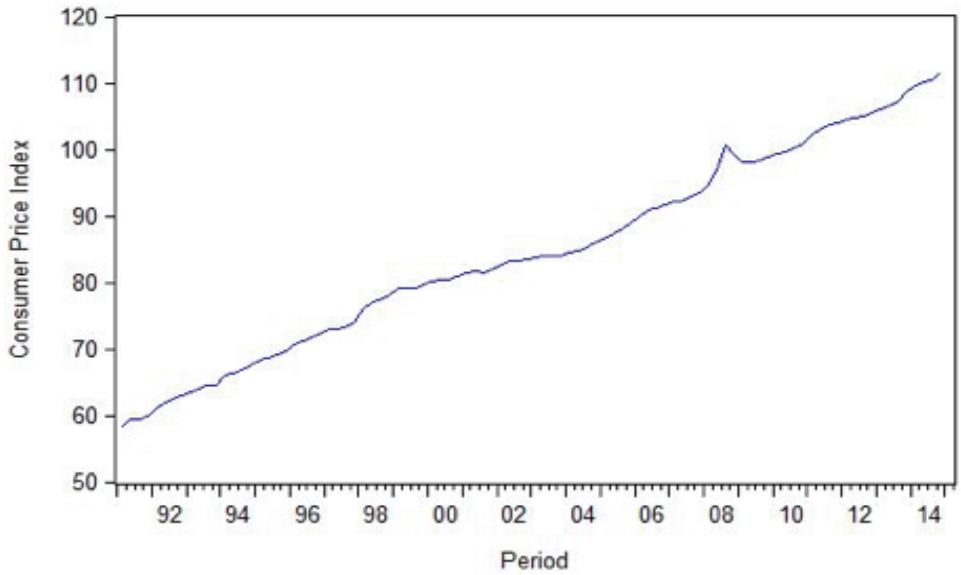

FIGURE 3. Consumer Price Index

is 2.82%. In the post- Asian financial crisis of 1997, inflation declined from its peak of 5.4 percent in the second quarter of 1998 to 2.7 percent in second quarter the following year. Despite a strong rebound of real output, inflation continued to fall amidst weak consumer sentiment and a limping labor market. The contraction in 2001 exacerbated decline in consumer prices. Average inflation for quarter one 2000 up to quarter one 2002 is 1.5 percent. Global financial crisis of 2007/2008 left a greater mark on inflation rate. From a peak of 8.4 percent in the third quarter of 2008, inflation rate declined to -2.4 percent in the same quarter of 2009.

Changes in the general price level may be explained by a theoretical rendition by Sidrauski (1967). The paper posits that monetary expansion in the long run, leads to increase in inflation rate, resulting in a decline in real money stock, though leaving steady-state consumption unchanged. Increasing money supply does however, affect steady-state consumption in the short run, leaving a mark on real output. The relationship reflected in Sidrauski's paper is in line with the Quantity Theory of Money, where a surge in money supply would induce inflationary pressure. An empirical evidence of this is offered in a paper by Jiang, Chang, and Li (2015). Growth

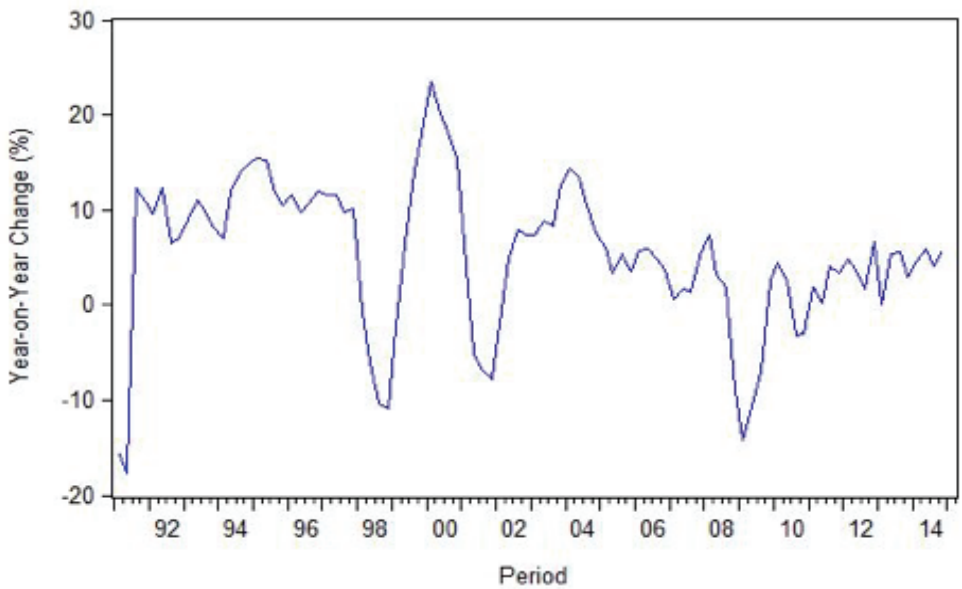

FIGURE 4. Year-on-Year Change in Consumer Price Index.

in money supply was found to be a positive determinant of China's inflation rate.

Though the variability of consumer prices in its self is a fascinating phenomenon, the interplay between prices and output is even more so and merit greater attention. Escalating consumer prices may dampen domestic spending and to a certain extent, persuade the masses to turn on imported goods instead. These possibly compounding scenarios does not bode well for productivity. Empirical evidences on the effects of inflation on growth are abundant. Thanh (2015) for instance, analyzed inflation-growth nexus on the ASEAN-5 economies. Employing a Panel Smooth Transition Regression (PSTR) Model, it was found that a robust negative relationship prevailed between the two variables, which is in agreement with aforementioned argument. This is particularly true for an inflation threshold of above 7.84 percent. The author even went as far as suggesting the ASEAN-5 economies sustain an inflation level below the said threshold for a favorable growth prospect.

On the nature of relationship between inflation and growth, there is compelling evidence which suggest non-linearity (Baglan & Yoldas 2014; Eggoh & Khan 2014; Vinayagathasan 2013). Under a flexible semiparametric panel data model, the authors found that for a significant negative relationship to hold, inflation rate will need to amount up to 12%. This is higher compared to the value found by (Thanh 2015). A sample of 32 Asian countries surveyed by Vinayagathasan (2013) on the other hand, finds a threshold inflation rate of around 5.43%. Another empirical exercise on Pakistan reveals a unidirectional causality from inflation to economic growth though only significant in the short run (Attari & Javed 2013). A possible explanation for such variation could be accounted for by such country-specific factors as financial development, government expenditure, trade openness and capital accumulation (Eggoh & Khan 2014). A robust financial sector for instance, could tolerate higher inflation rate as it channels money more efficiently. Moreover, Bick (2010) notes that omitted variable bias may account for some of these discrepancies. This particular notion of inflation-output nexus is a source of a rich discussion in economic literature for a number of reasons. First, it is a fascinating theoretical construct in its self, that it has spurred numerous empirical studies in order to lend support to the theory. Secondly, the threshold of inflation where it begins to be detrimental to economic growth often varies across economies. This inevitably incites greater empirical inquiry.

Inflation shocks in middle income countries exert short-lived albeit a negative response in output as reported by Caporale and Skare (2014). Output shocks on the other hand, induce positive and long-lasting response in prices. This seems to resonate well with a study by Muzaffar and Junankar (2014), which infers that developing economies need not be alarmed by an over-the-threshold inflation rate as moderate level of price increments may in fact be of advantage. Caporale and Skare (2014) attribute this observation to a positive Tobin's effect. Due to heterogeneity of sample included in a panel VAR as in Caporale and Skare (2014) however, it would be beneficial to alienate a sample of interest and assess whether the conclusion derived from a panel VAR holds in a country-specific study.

Theoretically, the negative relationship between inflation and output could not be explained within the standard Keynesian model with the absence of wage rigidities. Recent developments in economic research however is able to incorporate market imperfections into theoretical constructs in order to better match real world observations. Eksi (2015) for instance shows that trade-off between inflation stabilization and output gap stabilization can be formalized by introducing an interaction between aggregate shocks and firms' mark up. The model was built upon that of Blanchard and Gali (2007) who introduced real wage rigidities for a more realistic Keynesian representation of the economy.

OBSERVATION ON PRODUCER PRICES

Price changes affect producers' behavior as much as they do consumers'. Instead price of final goods however, price changes at the producers' level are of greater relevance to account for this. This paper then, appropriately considers the Producer Price Index (PPI) which gauges price of output produced by producers. An important difference to CPI is that this particular index only includes revenue received by domestic producers. Hence unlike CPI, price of imported goods, sales and excise taxes are excluded. The two indices also differ in terms of the type of goods and services considered. While CPI takes into account general items purchased by urban metropolitan consumers, PPI considers among other things, raw material purchased by rural producers and thus agriculturally biased items. Thus in essence, PPI serves as a supply-side factor whereas CPI is a demand-side consideration. These distinctions provide a justification for the inclusion of PPI alongside CPI in a BVAR study. While it is true that behavior of CPI mirrors that of PPI, this study intends to investigate the efficiency of economic agents within the Malaysian economy in factoring price changes in making economic decisions.

Figure 5 shows Malaysia's PPI from the first quarter of 1991 up to the last quarter of 2014 measured in 2010 prices. The year-on-year change of the index is depicted in Figure 6. A general observation reveals that salient spikes in PPI are mainly centered on the same period in which CPI is affected. The highs of 13.9 percent in second quarter of 1998, 14.9 percent in the second quarter of 2008 and the lows of -5 percent in second quarter of 1999 as well as -11.1 percent in the second quarter of 2009 correspond to parallel peak and nadir of CPI, though fluctuations of PPI are notably more immoderate. Indeed, an analysis

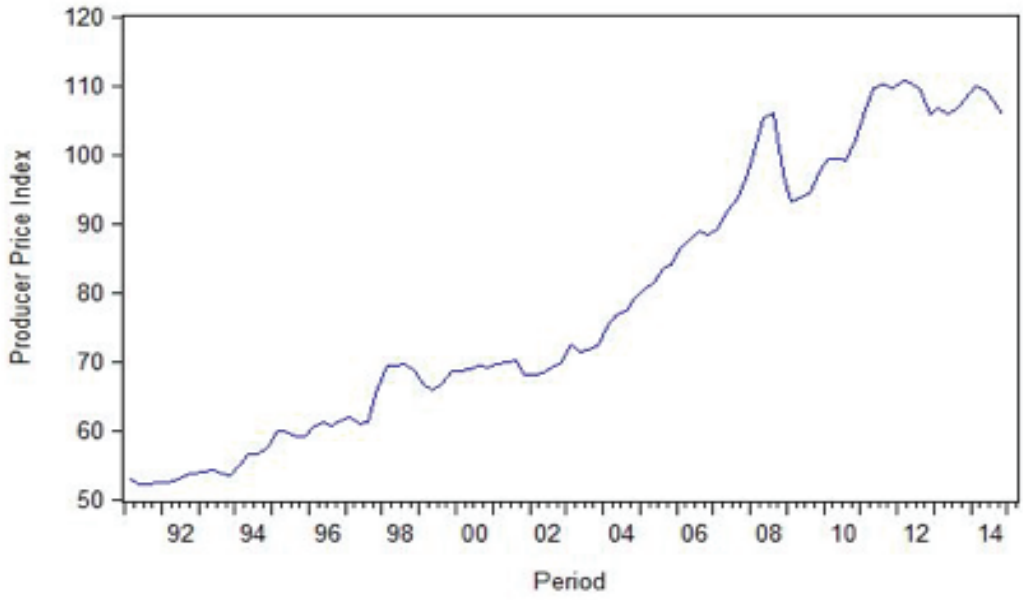

FIGURE 5. Producer Price Index

done on Mexican data reveals a bidirectional causality between the two indices (Tiwari et al. 2014).

Theoretically, an increase in input prices should induce a negative response in output. The literature often adopts energy prices as a representative indicator of input price. Berk and Yetkiner (2014) for instance, developed a two-sector endogenous growth model, factoring in energy consumption as input along other components. The growth model suggests that a spike in energy prices will result in a negative output adjustment. This is supported by numerous empirical studies such as one by Arshad et al. (2016), where a negative relationship is evident between economic growth and energy prices. The authors propose in their econometric model that high energy prices place great strain on public finances and unemployment. This is of course true for net energy importing economies. While the use of energy prices is indeed common in growth literature, this paper argues that IPI should serve as another appropriate gauge, in evaluating the impact of input prices on economic growth. Indeed, we accentuate a gap in the literature in this regard.

Pragmatism of PPI in economic research is in capturing the mechanics of price structuring, specifically how the industries respond to price changes in inputs

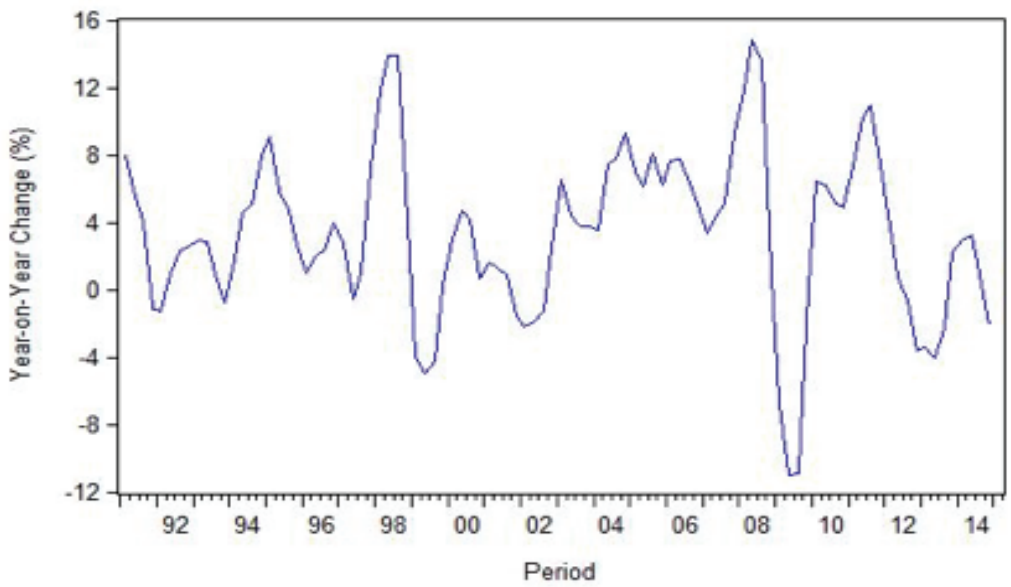

FIGURE 6. Year-on-Year Change in Producer Price Index

(Norman 2008). Upon this premise, understanding how industrial prices affect national output too, has immense benefits. A surge in PPI would translate into higher production costs. This cost increment would induce a negative response in industrial production and thus, pose undesirable effects on real GDP. A scientific scrutiny of such hypothesis is precisely what this paper aims to deliver. Other uses of PPI as found in the literature are numerous and may even be extended to assess implications on a foreign country. This of course depends on the level of exposure economies have with each other. China's PPI data for instance, has been found to have significant ramification on the economies of Gulf Cooperation Council (GCC) (Kim & Hammoudeh 2013).

OBSERVATION ON INDUSTRIAL PRODUCTION

Malaysia's spectacular growth particularly in its Tiger Cubs Economies era has been largely driven by industrial progress. Being a resource abundant country, its tin mining facilities and rubber estates fueled western industries. In post-colonial-rule era, it began to gradually transform from an agrarian economy to a more industrialized one. This transformation is made swift with a clear structure in which Malaysia underwent an industrial revolution of its own. The first Industrial Masterplan (IMP I), which took effect in 1986 spearheaded Malaysia's industrial development in the 1990s during which period, it experienced strong economic growth. This suggests that industrial output acted as a backbone of growth in that particular period, and an indication that it has gained prominence in the Malaysian economy. It would therefore be of relevance to accommodate for the effects of industrial shocks in our model.

A critical examination of industrial sector warrants the use of Industrial Production Index (IPI). The index among others, measures output in the mining, manufacturing, electric and gas industries, all of which are key secondary sector contributors to the economy. Figure 7 represents IPI data for Malaysia with a base year of 2010. Commensurable to its economic development, IPI indicates that Malaysia's industrial sector has been on a steady upward path with several noticeable spikes. Figure 8 summarizes its year-on-year progression. Simple observation exposes that IPI growth is mirrored in real GDP growth. The high points in third quarter of 2005, second quarter of 2008 and second quarter of 2014 with growths of 8 percent, 14.9 percent and 3.2 percent respectively are all consistent with real GDP movements. Similarly, nadirs in second quarter of 1999 and 2009 with IPI contraction of 5 percent and 11.1 percent respectively correspond to negative real economic growth rates.

Despite growing importance of services sector, for a middle-income developing economy like Malaysia, industrial production remains a significant proportion of the economy. Over a third of national output is attributed to industrial output. Factories and mining facilities which make up the bulk of industrial sector occupational area account for more that 35 percent of total employment. It is an intuitive conjecture therefore to say that unfavorable developments in industrial production may adversely affect growth. It is also worth to note while it's true that accommodative government policies play a crucial role in stimulating industrial development, entrepreneurial enthusiasm too is an important factor as evident in an empirical study by Sun and Anwar (2015). The authors found a cointegrating relationship between entrepreneurship, electricity consumption and industrial production in Singapore. Furthermore, evidence of

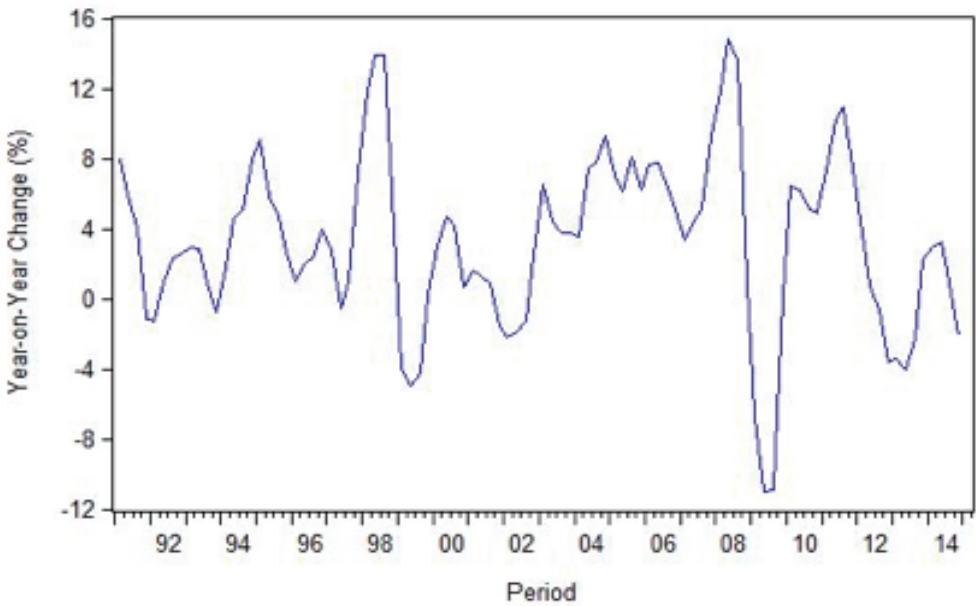

FIGURE 7. Industrial Production Index

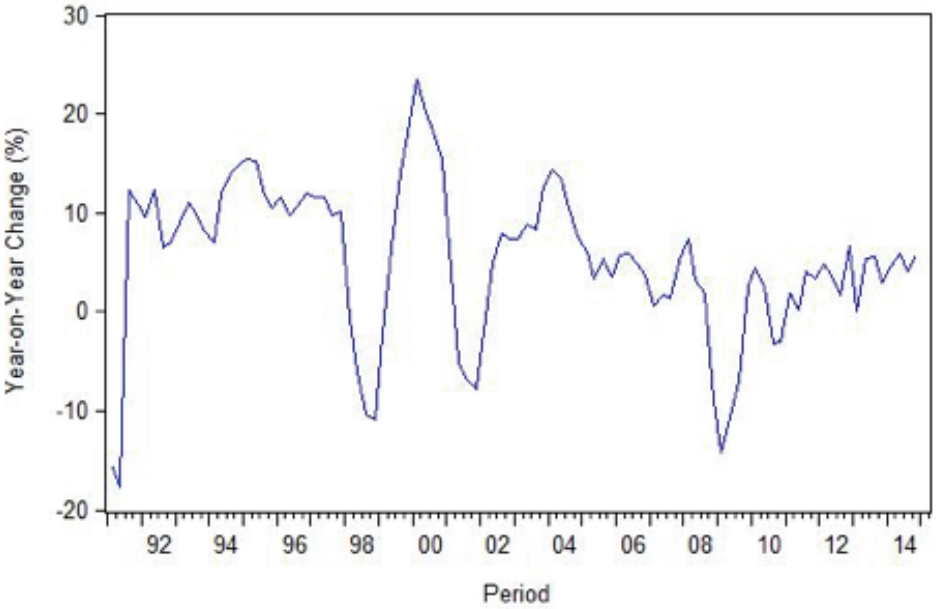

FIGURE 8. Year-on-Year Change in Industrial Production Index

causality running from entrepreneurship to electricity consumption was found, which in turn Granger causes industrial production.

Empirical evidence in the literature suggests that aggregate output and industrial production co-vary in the long-run (Sahoo et al. 2014). This is particularly true for countries which are still largely dependent on secondary sector for its economic development. Connection between the two indicators may not however be as robust for economies which are heavily dependent on agriculture and those that have moved on to services. For scientists, this proposition is an enticing one. This paper intends to investigate the response of Malaysia's real output to industrial shocks. Useful inferences could then be made upon discovery of any empirical evidence.

DISCUSSIONS

This section presents relevant discussions in the literature with regard to price and industrial influence on aggregate output, with particular emphasis on theoretical grounds.

DISCUSSIONS ON PRICE EFFECTS

Prices are important considerations for consumption. An unfavorably steep increase in general price level will reel aggregate consumption which in turn renders output vulnerable to slumps. A significant determinant of aggregate price level is energy prices. As price of energy spikes, cost of energy consumption increases, which in turn exerts downward pressure on consumption. This is modeled within a two-sector framework, where Berk and Yetkiner (2014) theorized that increase in energy prices, $\hat{q}$ will negatively impact energy consumption growth.

$$\hat{E} = \frac{1}{\theta}\left(\mathrm{A} - \delta - \rho - \frac{1-\alpha+\alpha\theta}{\alpha}\right)\hat{q} \qquad (1)$$

Where $1/\theta$ is the intertemporal elasticity of substitution, A is the overall factor of productivity, δ is the capital depreciation rate, ρ is the subjective rate of discount, and α is the parameter of the production technology, $Y = f(K, E)$ where K is physical capital. Given that energy consumption is treated as input in consumption goods,

$$Y_C(\equiv C)K_C^{\alpha} \times E^{1=\alpha} \qquad (2)$$

where K_C and E are flow variables of capital and energy respectively, it follows that evolution of $\hat{q}$ will negatively affect aggregate output under a constant returns to scale Cobb-Douglas production technology. Empirical scrutiny of this theoretical supposition using Autoregressive Distributed Lag (ARDL) approach confirms that increment in energy prices negatively affects GDP per capita and energy consumption. Moreover, this observation provides incentive for investment in renewable energy as a solution to escalating energy prices (Berk & Yetkiner 2014).

In another empirical study, Arshad et al. (2016) finds an overall negative relationship between energy prices and growth in a Generalize method of moments (GMM) estimation. Notably, the authors point out different channels in which energy prices may affect growth. High energy prices depress real interest rate and exert strains on government spending, which in turn are positively associated with economic growth. In addition, increase in energy price will reduce investments, stock prices, exchange rate and increase unemployment, which are in turn negatively associated with economic growth. The

overall effect therefore, would be dependent on dominant channels of energy price and growth relationship.

Instead of treating energy price increase as a proxy for inflationary effects on growth, another strand of literature investigates the direct impact of changes in general price level on the economy. Within a Schumpeterian model, Chu et al. (2015) studies the impact of inflation on growth in the presence of constraints on Research and Development (R&D) investments. Technology growth in the model is given by

$$\frac{\dot{z}^h_{r,t}}{z^h_t} = \lambda^h_t \ln z^h = \frac{(L^h_{r,t})^{1-\delta}}{z^h_t}\ \phi \ln z^h \tag{3}$$

where z is parameter for step size of innovation, h represents a hypothetical country, t is time, which is continuous, λ is arrival rate of next innovation, L is production labor and ϕ is R&D productivity. To assess inflationary effects on growth, Chu et al. (2015) defined a transformed variable, $\zeta^h_t = Z^h_t/(N^h_t)^{1-\delta}$ of which growth rate is

$$\frac{\dot{\zeta}^h_t}{\zeta^h_t} \equiv \frac{\dot{z}^h_t}{z^h_t} - (1-\delta)\frac{\dot{N}^h_t}{N^h_t} = \frac{\dot{z}^h_t}{z^h_t} - (1-\delta)n \tag{4}$$

where parameter δ represents the degree of R&D duplication externality. Assuming steady-state equilibrium condition, $\dot{Z}^h_t/Z^h_t = (1-\delta)n$, Eq (3) may be rewritten as

$$\zeta^h = \frac{\phi \ln z^h}{(1-\delta)n} - (l^h_r)^{1-\delta} \tag{5}$$

The authors argue that $\frac{\dot{\zeta}^h_t}{\zeta^h_t} < 0$ must hold in the short run so that ζ^h may decrease to a lower steady-state value in the long run. In effect therefore, it must be the case that $\frac{\dot{z}^h_t}{z^h_t} < (1-\lambda)n$. Hence, inflation would lead to a temporary decline in growth rate of technology. Since the open economy Schumpeterian model specified by Chu et al. (2015) implies a direct relationship between technology advancement and economic growth, it follows that inflation would exert a temporary negative impact on economic growth.

Excessive inflation thwarts economic growth by dampening purchasing power and consumer sentiment. Empirical evidence for such theoretical conclusion is abundant in the literature (Muzaffar & Junankar 2014). Lean and Smyth (2010) moreover confirm a causal relationship between prices and output using Malaysian data. Some studies however, offer caution to this apparently stylized observation. While negative relationship may prevail between inflation and economic growth, causal analysis in a sample of Organisation for Economic Co-operation and Development (OECD) economies find that inflation does not cause economic growth. The reverse on the other hand, is true (Pradhan et al. 2015). Moreover, negative relationship between output growth and inflation is often found to only materialize after a threshold level of inflation rate (Thanh 2015). These studies therefore suggest that some caveat is in order when discussing the inflation-growth nexus. It is also noteworthy that, as empirically demonstrated by Anthonisen (2013), there is a long-run relationship between output and inflation. This implies that the variables possess the same stationarity process.

DISCUSSIONS ON INDUSTRIAL PRODUCTION EFFECTS

The basis for examining the potential impact of industrial production shocks on aggregate output in this paper lies in the relationship between industrial dynamics and output proposed by Ju et al. (2015). In the model, economic agent faces the following problem:

$$\max_{C(t)} \int_0^\infty \frac{C(t)^{1-\sigma} - 1}{1-\sigma}\ e^{-\rho t} dt \tag{6}$$

subject to

$$\dot{K}(t) = \xi K(t) - E(C(t)),\ K(0) = K_0 \tag{7}$$

where σ is a constant and ρ is time discount rate. (6) and (7) imply that determination of endowment structure and capital allocation for consumption goods, $E(t)$ is dependent on agent's decision on intertemporal consumption flow, $C(t)$. Derivation of industrial dynamics in Ju et al. (2015) reveals that (7) becomes:

$$K(t) = \alpha_n + \beta_n e^{((\xi-\rho)/\sigma)t} + \gamma n e^{\xi t},\ t \in [t_n, t_{n+1}] \tag{8}$$

where

$$\alpha_n = -\left(\frac{a^{n+1} - a^n}{\lambda^{n+1} - \lambda^n}\right)\frac{\lambda^n (a-\lambda)L}{\xi(a-1)}, \tag{9}$$

$$\beta_n = -\left(\frac{a^{n+1} - a^n}{\lambda^{n+1} - \lambda^n}\right)\frac{C(0)}{\frac{\xi-\rho}{\sigma}\xi}, \tag{10}$$

$$\gamma_n = \left[\frac{\lambda^n L}{C(0)}\right]^{-\frac{\xi\sigma}{\xi-\rho}} \left\{\vartheta_n + \frac{(a^{n+1} - a^n)}{\lambda - 1}\left[\frac{1}{\left(\frac{\xi-\rho}{\sigma} - \xi\right)} + \frac{(a-\lambda)}{\xi(a-1)}\right]\right\} \tag{11}$$

where a^n is capital intensity of good n, λ^n is marginal productivity of good n and $\xi = A - \delta$ with capturing learning effect and δ represents depreciation of capital goods.

The change in functional form of capital accumulation path represents structural change in an economy. Intuitively, this begs the question of how the Malaysian economy which had undergone considerable industrial

adjustments respond in terms of output evolution. The use of IPI in examining relationship between economic growth and industrial dynamics is substantiated by the literature where Sahoo et al. (2014) confirmed long run and short run relationships exist between GDP and IPI in India. Intuition behind the connection between the two indicators is that, as an agrarian economy like Malaysia transforms into an industrialized economy, IPI captures the transformation. Part of the transformation is also reflected by GDP. The motive behind examining relationship between IPI and GDP in this paper however is to investigate to what extent does industrial evolution affects output evolution. This is an important consideration as Malaysia continues to ascend on the spectrum of economic development.

METHODOLOGY

The use of VAR analysis is prevalent in economic studies (Abrego & Österholm 2010; Dungey & Vehbi 2015; Mumtaz & Surico 2009; Yang 2013). This paper adopts Bayesian method of VAR analysis which requires knowledge on prior, likelihood and posterior distributions. For instance, the parameters of a model utilizing data, y is denoted by $\theta = (\beta, \sigma)$. Assuming prior distribution is $\pi(\theta)$ and the likelihood is $l(y|\theta)$, the distribution of θ given y is

$$\pi(\theta|y) = \frac{\pi(\theta)l(y|\theta)}{\int \pi(\theta)l(y|\theta)d\theta} \tag{12}$$

Bayesian estimation aims to posterior moments of parameters in question. Location or coefficient estimates as in standard analysis could be derived from posterior since all information on the parameter is contained in posterior distribution. For instance, consider a vector $y_t = (GDP_t, CPI_t, PPI_t, IPI_t)$ for $t = 1, ..., T$. A VAR(p) setup for the vector would be

$$y_t = a_0 + \sum_{j=1}^{p} A_j y_{t-j} + \epsilon_t \tag{13}$$

Note that y_t contains $m = 4$ series in this study and ϵ_t is a $m \times 1$ vector of errors which is assumed to be independent and identically distributed, $N(0, \Sigma_\epsilon)$. Furthermore, (13) could be compressed as

$$y = (I_m \otimes X)\theta + e \tag{14}$$

where $X = (x_1, ..., x_t)'$ is a $T \times (mp + 1)$ matrix for $x_t = (1, y'_{t-1}), ..., y'_{t-q}))$, I_m is a m-dimension identity matrix, $\theta = vec(A)$ and $e \sim N(0, \Sigma_\epsilon \otimes I_T)$. Based on (14), the likelihood function is

$$l(\theta, \Sigma_\epsilon) \propto |\Sigma_\epsilon \otimes I_T|^{-1/2}$$
$$\exp\left\{-\frac{1}{2}(y - (I_m \otimes X)\theta)'(\Sigma_\epsilon \otimes I_T)^{-1}(y - (I_m \otimes X)\theta)\right\} \tag{15}$$

Assuming Σ_ϵ is known and a multivariate normal prior for θ:

$$\Pi(\theta) \propto |V_0^{-1/2}| \exp\left\{-\frac{1}{2}(\theta - \theta_0)'V_0^{-1}(\theta - \theta_0)\right\} \tag{16}$$

where V_0 is the prior covariance and θ_0 is the prior mean. This fact coupled with (15) leads to the posterior density:

$$\Pi(\theta|y) = \exp\left\{-\frac{1}{2}.((V_0^{-1/2}(\theta - \theta_0))'(V_0^{-1/2}(\theta - \theta_0)) + \{(\Sigma_\epsilon^{-1/2} \otimes I_T)y - (\Sigma_\epsilon^{-1/2} \otimes X)\theta\}' + \{(\Sigma_\epsilon^{-1/2} \otimes I_T)y - (\Sigma_\epsilon^{-1/2} \otimes X)\theta\})\right\} \tag{17}$$

Defining w and W as

$$w = \begin{bmatrix} V_0^{-1/2}\theta_0 \\ (\Sigma_\epsilon^{-1/2} \otimes I_T)y \end{bmatrix} \tag{18}$$

$$W = \begin{bmatrix} V_0^{-1/2} \\ (\Sigma_\epsilon^{-1/2} \otimes I_T)y \end{bmatrix} \tag{19}$$

(17) can be rewritten as

$$\Pi(\theta|y) \propto \exp\left\{-\frac{1}{2}(w - W\theta)'(w - W\theta)\right\}$$
$$\propto \exp\left\{-\frac{1}{2}(\theta - \bar{\theta})'W'W(\theta - \bar{\theta}) + (w - W\theta)'(w - W\bar{\theta})\right\} \tag{20}$$

where the posterior mean is

$$\bar{\theta} = (W'W)^{-1}W'w$$
$$= [V_0^{-1} + (\Sigma_\epsilon^{-1} \otimes X'X)]^{-1}[V_0^{-1}\theta_0 + (\Sigma_\epsilon^{-1} \otimes X)'y] \tag{21}$$

Hence, the posterior is

$$\pi = (\theta|y) \propto \exp\left\{-\frac{1}{2}\theta - \bar{\theta})'W'W(\theta - \bar{\theta})\right\}$$
$$= \exp\left\{-\frac{1}{2}(\theta - \bar{\theta})'\bar{V}^{-1}(\theta - \bar{\theta})\right\} \tag{22}$$

and the posterior covariance is

$$\bar{V} = [V_0^{-1} + (\Sigma_\epsilon^{-1} \otimes X'X)]^{-1}. \tag{23}$$

RESULTS AND DISCUSSIONS

Following (Migliardo 2010), we perform the BVAR analysis on detrended series. Figure 9 depicts the impulse response functions from BVAR specification of model (13) where $y_t = (GDP_t, CPI_t, PPI_t, IPI_t)$ for $t = 1, ..., T$. The response of RGDP to innovations in CPI, IPI and PPI are relatively benign. Increase in consumer prices stimulates a negative response from RGDP, which diminishes by five quarters after the shock. The negative response nevertheless corroborate empirical evidences in other model specifications such as that of Muzaffar and Junankar (2014) and Thanh (2015). This observation suggests that consumption expenditure in Malaysia is relatively sensitive to price increments to the extent of prompting a negative pressure on output. On the contrary, increase in producer prices stimulates a positive response, which recedes after three quarters. This

observation indicates that price increments for businesses act as a stimulant to real output as manufacturers drive up production in response to favorable prospect for revenue. We note that the extent of response from PPI is somewhat muted compared to CPI as producers take into account the impact of negative consumer sentiment on revenue. Meanwhile the IPI activates a positive response from RGDP, of which magnitude is relatively higher compared to price innovations. Variance decomposition in Table 1 confirms this observation where variance in RGDP excluding variance due to its own innovations, is explained the most by IPI followed by CPI and PPI. This particular observation is instrumental as it answers a key research question that this paper intends to answer. Industrial production evidently still wields considerable influence over Malaysia's RGDP, despite structural shifts towards a services-centric economy and relocation of industrial foreign investments to other economies in the region. The effect of IPI shock however dwindles by the fourth quarter.

The effects of innovations to consumer prices are more disparate depending on source of exogenous shocks. Most notably, innovation in RGDP exerts the biggest influence over CPI as opposed to PPI and IPI, although all innovations stimulate a positive response. The response to shocks from RGDP and PPI dies out by the fourth quarter. The response to IPI on the other hand, exhibits a certain lag where the effect materializes by the third and diminishes by the fifth quarter after the shock. The relatively large influence that RGDP plays over the CPI is not surprising as output increment underpinned by strong aggregate demand inevitably applies upward pressure on consumer prices as the economy recalibrates. Nor is the positive response from PPI bewildering as increments in producer prices are expected to be passed on to consumers. The relatively weak response from innovation in IPI is however intriguing. Despite exerting a notably significant shock on RGDP, CPI is somewhat unresponsive. This may be explained by the nature of Malaysian manufacturing sector, which includes a myriad of such exported goods as electrical and electronics (E&E) components. Table 1 shows that variance in CPI excluding variance due to its own innovations, is mostly explained by RGDP followed by PPI and IPI, confirming inferences made from IRF.

Innovation in RGDP induces a significant positive response in PPI, which quickly dampens and turns mildly negative by the third quarter. This negative response lasts up to the sixth quarter. PPI's response to CPI innovation is similar albeit within a shorter time frame. The IRF shows that it turns negative by the second quarter and recedes by the fifth quarter. A shock in IPI induces a positive response from PPI which ends by the fifth quarter. Similar to CPI, the positive response to RGPD shock is expected. Producer prices increase as domestic and external demand shores up producers' production capacity which translates into higher prices accrued to domestic producers. This distinction is necessary due to the nature of PPI briefed in earlier section. The mild negative effect that follows the steep positive response could be explained by inventory overshooting. As domestic producers drive up production in response to demand pressure, some form of production overflow is bound to materialize, which will ultimately exert downward force on PPI. We note however, the positive response could far outweigh fall in PPI. Similar argument may explain the initial positive response to CPI shock which is followed by a negative response as strong consumer demand underpins both output and

TABLE 1. Variance Decomposition

	Endogenous Variable			
	RGDP			
	Exogenous Variable			
Period	RGDP	CPI	PPI	IPI
1	100.00	0.00	0.00	0.00
2	96.73	0.89	0.19	2.19
3	96.06	1.49	0.19	2.26
4	95.94	1.59	0.22	2.25
5	95.91	1.59	0.25	2.26
	Endogenous Variable			
	CPI			
	Exogenous Variable			
Period	RGDP	CPI	PPI	IPI
1	21.19	78.81	0.00	0.00
2	26.18	72.34	1.47	0.01
3	26.26	72.04	1.53	0.17
4	26.23	72.04	1.53	0.20
5	26.25	72.02	1.53	0.20
	Endogenous Variable			
	PPI			
	Exogenous Variable			
Period	RGDP	CPI	PPI	IPI
1	54.77	0.58	44.65	0.00
2	55.61	1.78	42.37	0.24
3	54.92	2.62	41.83	0.63
4	54.99	2.72	41.65	0.64
5	55.07	2.72	41.54	0.67
	Endogenous Variable			
	IPI			
	Exogenous Variable			
Period	RGDP	CPI	PPI	IPI
1	5.07	1.79	8.48	84.66
2	5.04	2.17	8.60	84.19
3	5.96	2.32	8.50	83.22
4	6.20	2.31	8.52	82.97
5	6.21	2.32	8.54	82.92

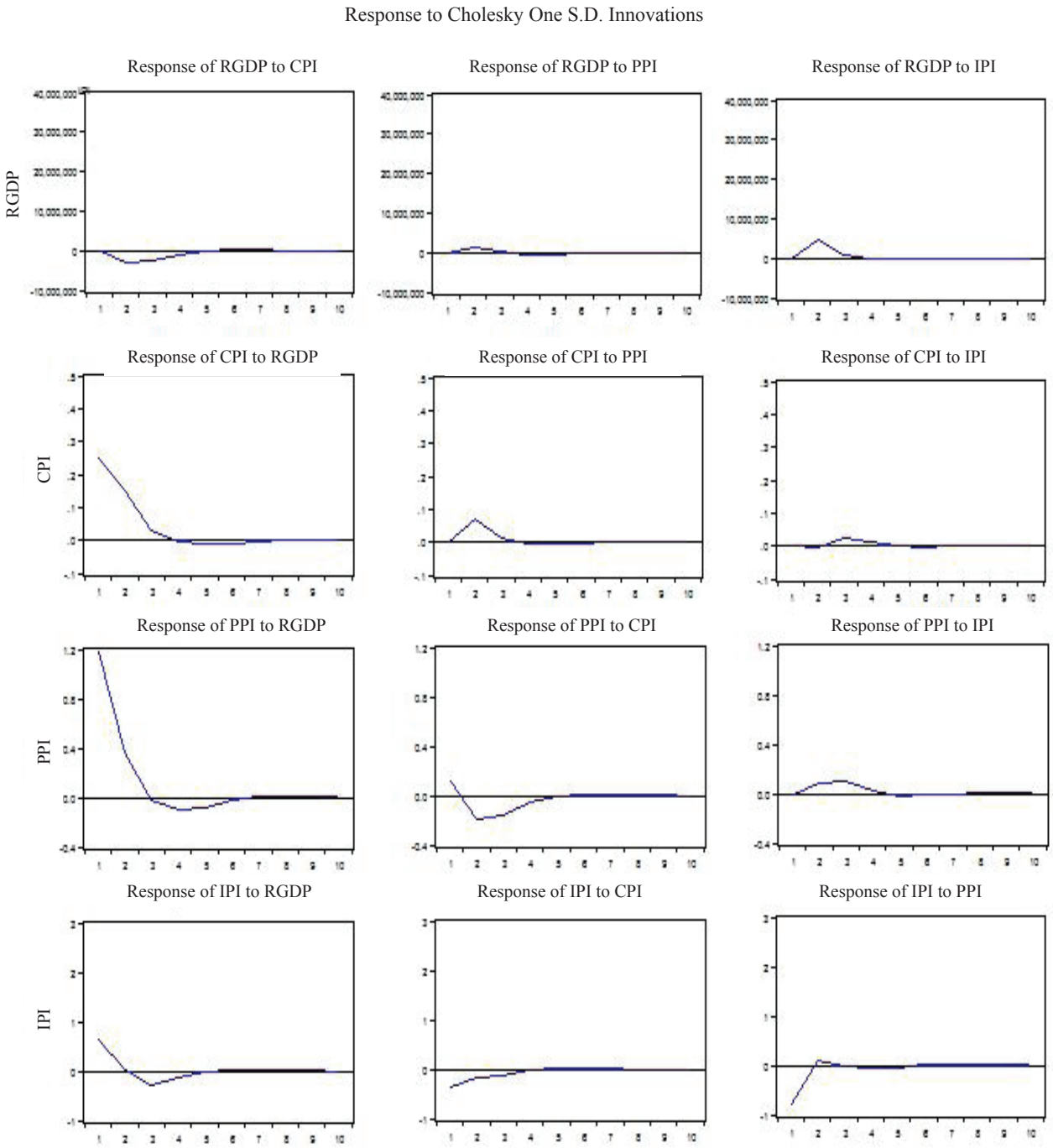

FIGURE 9. Impulse Response Functions

CPI innovations. The positive response in PPI due to IPI innovation stems from the fact that PPI captures prices of output produced by domestic industries. Hence, it is expected that increase in industrial production bolstered by strong demand growth would induce increment in producers' prices. From Table 1, it is evident that variations in PPI excluding variance due to its own innovations, is mostly explained by RGDP followed by CPI and IPI. This confirms IRF results in Figure 9.

A shock in RGDP induces a positive response in IPI in the first and second quarter from time of shock and slides into negative territory in the third quarter. The response diminishes by the fifth quarter. Innovations in CPI and PPI both induce negative response in IPI. Response from CPI shock dies out by the fourth quarter while response from PPI innovation wanes by the third quarter before slightly sliding into positive territory in the second quarter. The positive response from a shock in RGDP is natural as industrial output is ramped up in tandem with aggregate demand. Specifically, RGDP growth underscores strong demand in major sectors of the economy, which invites industrial inventory accumulation to cater to prospecting

demand. The negative response that follows is the industrial adjustment from overproduction. Innovations in consumer and producer prices induce negative response in IPI due to the fact that higher prices could signal excess supply in the market. Hence, industrial production begins to respond by lowering output, in light of price shocks for a smoother adjustment to a decline in aggregate demand. This is supported in the literature where Ali Ahmed and Wadud (2011) found that input prices are the second most important explanatory variable in explaining variations in Malaysian industrial output after its own innovations. As can be seen in Table 1, variance in IPI excluding variance due to its own innovations, can be mostly explained by PPI followed by RGDP and CPI.

We acknowledge that the VAR model set up in this paper excludes many variables which have been established in the literature to have significant influence over GDP, particularly foreign variables. However, our model is appropriate in serving this paper's aim of analyzing the impact of domestic price and industrial output shocks on Malaysia's GDP. Moreover, as noted by Miranda-Agrippino and Ricco (2018), Bayesian VAR may be used to address the problem of omitted variable bias. As such, our model is statistically sound. Additionally, this paper fills a gap in the literature where there is no Bayesian VAR model that examines the dynamics between national output, consumer prices, producer prices and industrial evolutions for the Malaysian economy.

The dynamics of exogenous shocks in CPI, PPI, IPI and RGDP provide several policy implications. First, the negative response in real output to shocks in consumer prices suggest inflation targeting model is apt for Malaysia's economy. Second, although positive responses in CPI and IPI due to RGDP innovations are expected, the responses are significantly larger than responses to innovations in PPI. This suggests consumer and producer expenditures drive output demand which in turn results in inflationary pressure. Policy initiatives that are targeted to moderate the demand side of the economy, particularly consumer and producer expenditures would be favorable to ease inflation. In the interest of academic investigation, it would be useful to examine our model with the presence of foreign sector shocks, contrasting the dynamics between the variables in different model specifications.

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