External demand developments and the minerals industry

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Abstract

This paper analyses the reaction of the minerals industry to external demand *developments* in South Africa. This is achieved by augmenting a Taylor (1993) rule type central bank monetary policy reaction function with an indicator of external demand. The empirical results provide evidence of a statistically significant effect of an increase in external demand on output of the minerals industry, which increases slightly and peaks out after 2 months follwing which it decreases and bottoms out after 5 months. The effect of the surprise increase in external demand on mining and quarrying output is statistically significant between 7 and 10 months. Output of the minerals industry, thus, does not conform to the classical theories of international trade, at least at business cycle frequencies, such as the Heckscher-Ohlin, or factor endowment, theory which emphasises specialisation in production of the most abundant factors. External demand is important for economic activity, hence policymakers should monitor the developments in external demand conditions to support economic growth and the minerals industry.

JEL Classification:C10, E10, F10, L70
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Introduction

External demand conditions, which refer to the overall state of willingness and ability of consumers, businesses and governments to purchase goods and services across the world, play a crucial role in shaping the countries' balance of trade and hence their level of economic growth. According to United Nations Industrial Development Organisation (UNIDO) (2023) and Gill and Kose (2024), external demand encompass factors such as consumer tastes and preferences, economic conditions and global events, directly impact on cross border demand for goods and services. Consumer tastes and preferences include demographics and cultural norms and values, economic conditions include income and purchasing power, while global events include climate, pandemics and geopolitical tensions. Countries with strong external demand for their goods and services across the world often experience higher levels of economic growth, hence external demand conditions are crucial to understand the production, trade patterns and overall economic growth of countries around the world, as contend Palley (2012) and Kilian and Zhou (2018). Consequently, increased external demand often lead countries towards export orientation, whereas low external demand may encourage reliance on import substitution strategies.

External demand conditions are crucial within the context of open economy macroeconomics given that they influence a country's exports and imports, impacting its trade balance and overall economic output, as discussed. Open economy macroeconomics, which focuses on international flow of goods and services, or the current account, as well as financial assets, or the capital account, and their affects on economic growth, price level and exchange rates, can be described within the realm of the classical theories of international trade as relates to the external demand conditions. According to Dornbusch (1987), Obstfeld and Rogoff (1996) and Uribe and Schmitt-Grohe (2017), the classical theories of international trade include mercantilism which dominanted the 16th to 19th centuries, absolute advantage developed by Adam Smith, comparative advantage advanced by David Ricardo as well as the Heckscher-Ohlin theory which was developed by Eli Heckscher and Bertil Ohlin. The classical theories of international trade focus on how countries can gain wealth and benefit from trade by specialising in production and exporting goods and services they can produce more than other countries using similar resources, have a lower opportunity cost or the more abundant factors of production.

According to Diebold and Rudebusch (1970) and Romer (1993), different economic sectors and industries respond differently to endogenous and exogenous economic shocks. A case in point is the widely accepted phenomenon that the trend break, as well as the protracted underperformance, of the minerals industry relative to the total economy since the 1970s was a problem of structural misalignments. South Africa's mining sector was the second most important industry in the 1970s and 1980s, with more than 20 percent contribution to the Gross Domestic Product (GDP). Meanwhile, the sector currently accounts for single digit figure to the economy. The minerals industry output stagnated in real terms, while it has declined progressively as a percentage of Gross Domestic product (GDP), in recent decades. Paradoxically, the aggregate economy has been growing at rates of about 4 percent between 2000 and 2010 as well as at rates of below 2 percent, on average, since then. According to Government Communication and Information System (GCIS), South Africa is known for its abundance of mineral resources and is estimated to have the world's fifth largest mining sector, while its mining companies are key players in the global industry. The industry is, thus, perceived not to be affected by the fluctuations in economic stabilisation policies, such as financial, monetary and fiscal policies.

Macroeconomics literature highlights the importance of t different shocks, that include demand and supply side shocks, while it also emphasises the effects of these shocks during the different phases and components of the economic cycle. A case in point is the widely accepted phenomenon that the trend break, as well as the protracted underperformance of South Africa's minerals industry, relative to the total economy, since the 1970s was a problem of structural misalignments, hence the sector cannot be affected by changes in economic stabilisation policies, such as financial, monetary and fiscal policies. According to Blanchard et al. (1986), Shapiro (1987), Blanchard and Quah (1988), Shapiro and Watson (1988), Quah (1988), Kydland and Prescott (1990), Gali (1992) as well as Romer (1993), the short term, or transitory, economic fluctuations are determined by demand shocks, while the long term, or permanent, economic fluctuations are determined by supply shocks. Futhermore, the European Central Bank (ECB) (2012) and Morgan Stanley Capital International (MSCI) (2014) contend that the investment literature distinguishes between the types of industries, such as defensive, cyclical and sensitive industries, based on how they respond to economic fluctuations over the economic cycle.

Conventional macroeconomic models, further, distinguish between alternative "anchors" to stabilise the cyclical behavior of economic activity. The short term, or transitory, economic fluctuations emanate from changes in monetary, financial and fiscal policies as well as consumer and business sentiments. The long term, or permanent, economic fluctuations emanate from the nominal rigidities that include changes in technological advancement, privatisation, deregulation as well as multilateral agreements. The short term economic fluctuations are, therefore, determined by demand side shocks, while long term economic fluctuations are determined by the supply side shocks. The demand and supply side economic management paradigm, therefore, suggest the decomposition of macroeconomic indicators into their transitory and permanent components. A discussion on the isolation of economic variables into the short and long run components can be found in Kydland and Prescott (1990), King and Rebelo (1993), Romer (1993) and Stock and Watson (1999). Hodrick and Prescott (1997), Baxter and King (1999) as well as Christiano and Fitzgerald (2003), provide methodological details. Since Burns and Mitchell (1946), extraction of the business cycle component is a long tradition in macroeconomics.

This paper analyses the reaction of the minerals industry to external demand *developments* in South Africa. This is achieved by augmenting a Taylor (1993) rule type central bank monetary policy reaction function with an indicator of external demand. Understanding the reaction of the minerals industry to external demand *developments* over the economic cycle is important to mining authorities and policymakers alike. The comovement, or divergence, of the fluctuations of different economic sectors and industries, as with the minerals industry, could be because they behave differently to the common endogenous and exogenous shocks. As opposed to the macroeconomics literature, according to the European Central Bank (ECB) (2012) and Morgan Stanley Capital International (MSCI) (2014), the investment literature distinguishes between types of industries, categorised into defensive, cyclical and sensitive industries, based on how they respond to economic fluctuations over the economic cycle. The classical theories of international trade, as discussed in Dornbusch (1987), Obstfeld and Rogoff (1996) and Uribe and Schmitt-Grohe (2017), in particular Heckscher-Ohlin theory, also known as factor endowment theory, posits that countries should specialise in production and export goods and services that use their most abundant factors of production, such as labor, capital and natural resources.

The paper is organised as follows. The next section discusses data and this is followed by the specification of the model and the estimation technique. The subsequent section presents the empirical results and last is the conclusion, together with recommendations and areas of further research.

Data

Monthly data spanning the period January 2000 to December 2023 is used to analyse the reaction of the minerals industry to external demand *developments*. The variables comprise output of mining and quarrying, inflation rate, monetary policy interest rate and external demand. Mining output is Gross Value Added (GVA) of mining and quarrying, or the minerals industry. Inflation rate, or the change in annual Consumer Price Index (CPI), is the headline consumer price inflation. Monetary policy interest rate, or central bank interest rate, is the short term policy rate, also called repurchase rate, and is the rate at which private sector banks borrow from the central bank. External demand is OECD industrial production, or the overall state of willingness and ability to purchase goods and services across the world. The data on mining and quarrying output and inflation rate was sourced from Statistics South Africa, the data on monetary policy interest rate was sourced from South African Reserve Bank, while data on external demand was sourced from OECD Data Explorer. The descriptions the variables are presented in Table 1. Mining output is denoted $GVAMng$, inflation rate is denoted $CPIRate$, central bank monetary policy interest rate, is denoted $CBRate$, while $PNDWld$ denotes external demand.

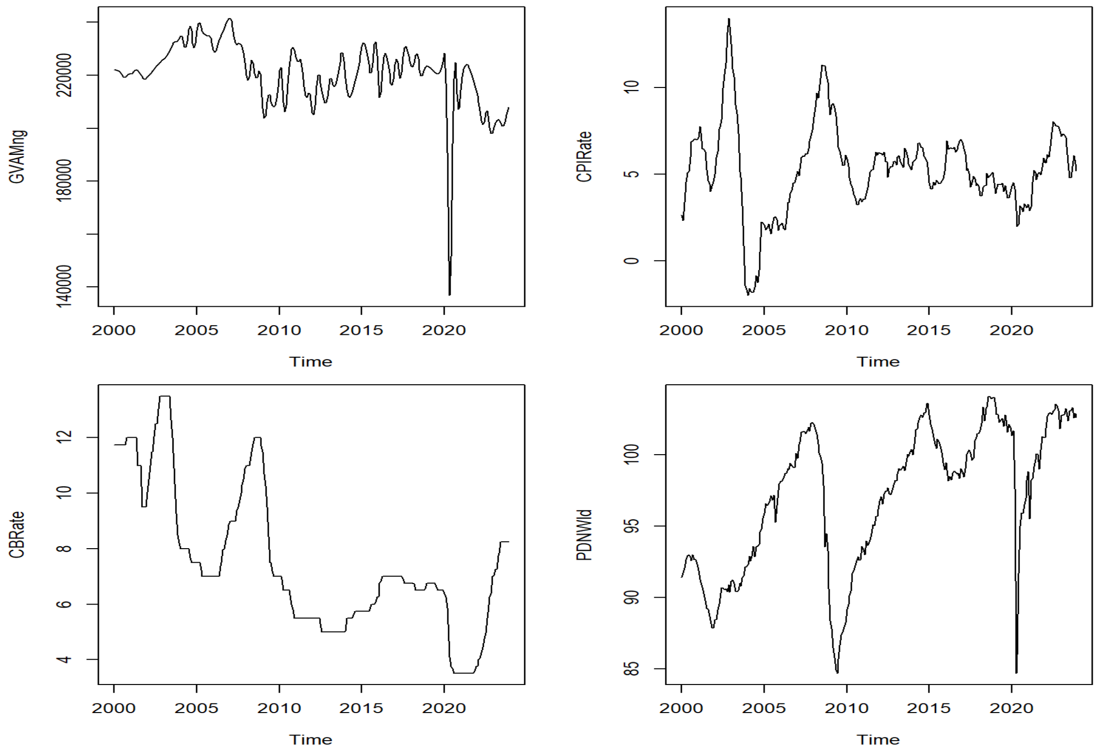
Variable	Denotation	Description
Mining output	GVAMng	Gross Value Added (GVA) of the mining and quarrying, or minerals, industry
Inflation rate	CPIRate	Inflation rate, or annual Consumer Price Index (CPI), is the annual headline consumer price inflation
Interest rate	CBRate	Central bank policy rate and is the rate at which private sector banks borrow from the central bank
External demand	PDNWld	OECD industrial production, or the willingness and ability to purchase goods and services across the world.

Notes: Data sourced from Statistics South Africa and South African Reserve Bank. Output of mining and quarrying is denoted $GVAMng$, consumer price inflation rate, is denoted CPI, central bank monetary policy interest rate, is denoted $CBRate$ and $PNDWld$ denotes external demand.

Table 1: Description of the variables

The evolutions of the variables are depicted in Figure 1. Output of the mining and quarrying industry increased between 2003 and 2007, where it reached a peak before decreasing significantly to 2009. The decrease in output of the mining and quarrying was due to the onset of the global financial crisis in late 2008. Output of the mining and quarrying industry then increased, albeit volatile, from 2010 to 2015 where it subsequently decreased from 2016 to 2023, and more so in 2022 and 2023. The significant decrease in output of the mining and quarrying in 2020 was due to the onset of the Covid 19 pandemic. Inflation rate, or the change in annual Consumer Price Index (CPI), increased from 2000 and reached a peak in 2003 where it decreased significantly and bottomed in 2004. Inflation rate increased again between 2005 and 2008 before it decreased between 2009 and 2011. The indicator then remained range bound but volatile between 2012 and 2021 where it then spiked in in 2022 before decreasing in 2023. Movements of the central bank monetary policy interest rate closely mirrored the fluctuations in inflation rate during the sample period between 2000 and 2023. However, the interest rate, which is the rate at which private sector banks borrow from the central bank, was generally in a downward trend between 2000 and 2023 with notable spikes and peaks in 2003, 2008 and 2023, while the opposite is true in 2005, 2013 as well as in 2021. The central bank interest rate increased substantially from early 2022 to counteract the rising consumer price inflation in the same period.

External demand, which is the Organisation for Economic Cooperation and Development (OECD) industrial production, decreased in 2000 and bottomed out in 2001. Industrial production increased again from 2002 and peaked in 2007, following which it decelerated sharply in 2008 and bottomed



Notes: Data sourced from Statistics South Africa and South African Reserve Bank. Output of mining and quarrying is denoted $GVAMng$, consumer price inflation rate, is denoted CPI, central bank monetary policy interest rate, is denoted $CBRate$ and $PNDWld$ denotes external demand.

Figure 1: Plots of the variables

out in 2009. The indicator increased again between 2010 and peaked in 2014, decreased somewhat between 2015 and 2016, following which it increased in 2017 and peaked in 2018. Industrial production decreased significantly from 2019 and bottomed out in 2020. The indicator quickly recovered and increased steeply peaking in 2022, where it remained range bound to the end of the sample period. External demand bottomed out in 2001, 2009 and 2020, which coincide with the bust of the dot-com bubble, onset of the global financial crisis as well as breakout of the Covid 19 pandemic. Conversely, external demand peaked in 2007 as well as in 2014 and 2018 and again in 2022. As discussed in United Nations Industrial Development Organisation (UNIDO) (2023) and Gill and Kose (2024), 2001, 2009 and 2020 mark depressed external demand conditions, which can be explained by muted atmosphere in factors such as consumer tastes and preferences, economic conditions and global events, specifically economic crises, with potentially a negative impact on cross border demand for goods and services.

The variables were transformed to the deviation from their Hodrick and Prescott (1997) trends. 24 months were forecasted at the end of each variable series to correct the Hodrick and Prescott (1997) trend end point problem following Ravn and Uhlig (2002) and Mise et al. (2005). The Hodrick and Prescott (1997) isolates the cyclical component, or the short run fluctuations around the trend often related to business cycles, where the trend represents long term fluctuations. Dating the phases of the economic time series as well as decomposing the economic time series into its short run and long run components are discussed in Burns and Mitchell (1946), Friedman et al. (1963), Romer (1986), Gordon (2007), Kydland and Prescott (1990), Romer (1993) and Stock and Watson (1999), while Hodrick and Prescott (1997), Christiano and Fitzgerald (2003) as well as Baxter and King (1999) provide the methodological aspects of decomposing the economic time series into its components. Decomposing the economic time series into its unobserved short term, also called cyclical, as well as long term, also called permanent or trend, components, will facilitate the analysis of the reaction of the mining and quarrying, or minerals industry, to *developments* in cross border demand over the economic cycle.

Methodology

A Vector Autoregression (VAR) model is estimated to capture the relationship between the minerals industry and external demand *developments*. The specified Vector Autoregression (VAR) model follows Stock and Watson (2001) and Kadiyala and Karlsson (1997). Vector Autoregression (VAR) models were first introduced in applied macroeconomic research by Sims (1980), while the early contributions to their Bayesian analysis equivalents include Litterman (1984).According to Stock and Watson (2001) and Rudebusch (1998), a Vector Autoregression (VAR) is a system of linear equations, one for each variable in the system. In reduced form, each equation in a Vector Autoregression (VAR) model specifies one of the variables as a linear function of its own lagged values as well as the lagged values of other variables in the system and a serially uncorrelated error term. In general, for a VAR(p) model, the first p lags of each variable in the system are used as the regression predictors for each variable.

Vector Autoregression (VAR) models have become standard tools in macroeconomics structural analysis and forecasting, as argue Giannone et al. (2010), Koop and Korobilis (2010) and Koop (2013). According to Del Negro and Schorfheide (2011), these models can capture the important stylised facts about the economic time series despite their simple formulation. These include the decaying pattern in the values of the autocorrelations as the lag order increases and the dynamic linear interdependencies between the model variables. A Vector Autoregression (VAR) model is specified as follows

$$Y_t = \delta + \theta_1 Y_{t-1} + ... + \theta_p Y_{t-p} + \epsilon_t \tag{1}$$

where $Y_t = (Y_{1,t}, ..., Y_{n,t})$ is the $n * 1$ is vector of random variables observed at time t. $\delta = (\delta_1, ..., \delta_n)$ is the $n * 1$ vector of constants or intercept terms, $\theta_1, ..., \theta_p$ are $n * n$ matrices of coefficients, p is the number of lags of each of the n variables and $\epsilon_t = (\epsilon_{1,t}, ..., \epsilon_{n,t})$ is the $n * 1$ dimensional vector of white noise error terms denoted

$$\epsilon_t \sim N(0, \Sigma) \tag{2}$$

where Σ is the $n * n$ variance covariance matrix. Evans and Kuttner (1998), Rudebusch (1998) and Stock and Watson (2001) argue that the error terms are the unanticipated policy shocks, or surprise movements, after taking the Vector Autoregression (VAR) model's past values, or lags, into account.

A general matrix notation of a Vector Autoregression (VAR) model with p number of lags, or VAR(p), and no deterministic regressors, can be written as

$$\begin{bmatrix} Y_{1,t} \\ Y_{2,t} \\ \vdots \\ Y_{n,t} \end{bmatrix} = \begin{bmatrix} \delta_1 \\ \delta_2 \\ \vdots \\ \delta_n \end{bmatrix} + \begin{bmatrix} \theta_{1,1} & \theta_{1,2} & \cdots & \theta_{1,n} \\ \theta_{2,1} & \theta_{2,2} & \cdots & \theta_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ \theta_{n,1} & \theta_{n,2} & \cdots & \theta_{n,n} \end{bmatrix} \begin{bmatrix} Y_{1,t-1} \\ Y_{2,t-1} \\ \vdots \\ Y_{n,t-1} \end{bmatrix} + \begin{bmatrix} \epsilon_{1,t} \\ \epsilon_{2,t} \\ \vdots \\ \epsilon_{n,t} \end{bmatrix} \tag{3}$$

where in this instance, p, or the number of lags, is equal to 1 for each of the n variables. A detailed discussion on Vector Autoregression (VAR) models can be found in Hamilton (1994), while the recent contributions include Lütkepohl (2005), Koop and Korobilis (2010) as well as Giannone et al. (2015).

A Vector Autoregression (VAR) model is estimated using Bayesian methods. A Minnesota prior is specified and a Gibbs style sampler is used in estimation following Kadiyala and Karlsson (1997). At the heart of Bayesian analysis is the Bayes theorem and it is specified as

$$P(\theta_i, \Sigma \mid Y_t, M_i) P(Y_t \mid \Sigma, M_i) = P(Y_t \mid \theta_i, \Sigma, M_i) P(\theta_i, \Sigma \mid M_i) \tag{4}$$

where M_i is an arbitrary model among a general class of models, θ_i is the parameter vector described above, $p(\theta_i \mid Y_t, M_i)$ is the posterior model probability, $p(Y_t \mid \theta_i, M_i)$ is the marginal likelihood of the model, $p(\theta_i \mid M_i)$ is the prior model probability and $p(Y_t \mid M_i)$ is the constant integrated likelihood over all models. The details on a Bayesian Vector Autoregression (BVAR) model estimation with Minnesota prior, first introduced by Litterman (1979), Litterman (1980) and Litterman (1984) and developed by Sims (1989), is used in this paper, while a brief introduction to Bayesian econometrics and Bayesian Vector Autoregression models, can be found in O'Hara (2015). A more general treatment of Vector Autoregression (VAR) models, including Bayesian estimation with the different types of model priors, can be found in Koop and Korobilis (2010), Canova (2011) as well as Giannone et al. (2015).

According to Rudebusch (1998), the appeal of using Vector Autoregression (VAR) models for analysing policy reaction functions is that they have the ability to identify the effects of shocks without a need to specify a complete structural model of the economy. Giannone et al. (2010) contend that Vector Autoregression (VAR) models have become popular among empirical macroeconomists because they facilitate insight into the dynamic relationships between the economic variables in a relatively unconstrained manner. Koop and Korobilis (2010) and Koop (2013) further argue that the Bayesian methods have become an increasingly popular way of dealing with the problem of over parameterisation of economic models given the limited length of standard macroeconomic datasets. Vector Autoregression (VAR) models can be used successfully in macroeconomic forecasting with a large number of variables when coupled with Bayesian estimation, as argue Sims and Uhlig (1991), due to the flexibility provided by the application of the Bayesian parameter shrinkage. Sims and Uhlig (1991) further argue that Bayesian versions of these models can incorporate unit root nonstationary variables with no disadvantageous consequences on the inference of the parameters of the model.

Results

A Bayesian Vector Autoregression (BVAR) model was estimated to capture the relationships between the minerals industry and external demand *developments*. The estimated Bayesian Vector Autoregression (BVAR) specifies a Minnesota prior and uses a Gibbs style sampler following Stock and Watson (2001) and O'Hara (2015). The 0.05 prior was set on all coefficients except the own first lags which were set to 0.95 to account for persistence in the variables. The number of lags to include of each variable was set to 4 following the Schwarz (1978) Bayesian information criterion. The integer value for the horizon of the Impulse Response Functions (IRFs) was set to 24, corresponding to 2 years, given that monthly data is used in estimation. 10000 is the number of Gibbs sampler replications to keep from the sampling run, while 1000 is the sampling burn in length for the Gibbs sampler. Gibbs sampling, also called Gibbs sampler, is a Markov Chain Monte Carlo (MCMC) technique used to sample from probability distributions, where the Gibbs sampler draws iteratively from the posterior conditional probability distributions, in contrast to sampling from the joint posterior probability distribution.

Conventional macroeconomic models distinguish between alternative "anchors" to stabilise the cyclical behavior of economic activity, as discussed. Macroeconomics literature further highlights the importance of demand side and supply side shocks, market rigidities as well as investor and consumer sentiments. A Taylor (1993) rule type central bank monetary policy reaction function with the output of mining and quarrying industry is, thus, augmented with an indicator of external demand as follows

$$i_t = \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_Y(Y_t - \bar{Y}_t) + \theta_E(E_t - \bar{E}_t) + \epsilon_t \tag{5}$$

where i_t is the nominal interest rate, ρ is the natural rate of interest, π_t is the inflation rate, π_t^* is the central bank target for inflation, Y_t is output, $\bar{Y}_t$ is the natural rate of output, E_t denotes external demand, while $\bar{E}_t$ denotes its natural rate. θ_π, θ_Y and θ_E measure the responsiveness of the nominal interest rate to the deviations of inflation from the central bank inflation target, the deviations of output from its natural rate and the deviations of external demand from its natural rate, respectively. ϵ_t is the error term and the subscript t denotes the time period. A typical central bank monetary policy reaction function captures the process through which the monetary policy decisions affect consumer price inflation in particular and the aggregate economy in general. The specified central bank monetary policy reaction function ensures market clearing, or equillibrium, condition, in that whenever output equals its steady state, consumer price inflation is equivalent to its target rate and external demand equals its steady state, hence the nominal central bank interest rate is the same as its natural rate.

The variables in the specified central bank monetary policy reaction function comprise output of mining and quarrying, denoted $GVAMnE_t$, inflation, denoted CPI_t, interest rate, denoted $CBRate_t$ and external demand, denoted $PNDWld_t$. Y_t in Equation 1 can, thus, be rewritten as

$$Y_t = (GVAMnE_t, CPI_t, CBRate_t, PNDWld_t) \tag{6}$$

where Y_t is the vector of random variables observed at time t. Stock and Watson (2001) argue that a reduced form Vector Autoregression (VAR), on the one hand, expresses each variable as a linear function of its own past values, the past values of all other variables being considered and a serially uncorrelated error term. On the other hand, a recursive Vector Autoregression (VAR) constructs the error terms in each regression equation to be uncorrelated with the error in the preceding equations by including contemporaneous values as regressors. Consequently, the results of a recursive Vector Autoregression (VAR) depend on the order of the variables, where changing the order of model variables also changes the equations, coefficients as well as the residuals of the Vector Autoregression (VAR).

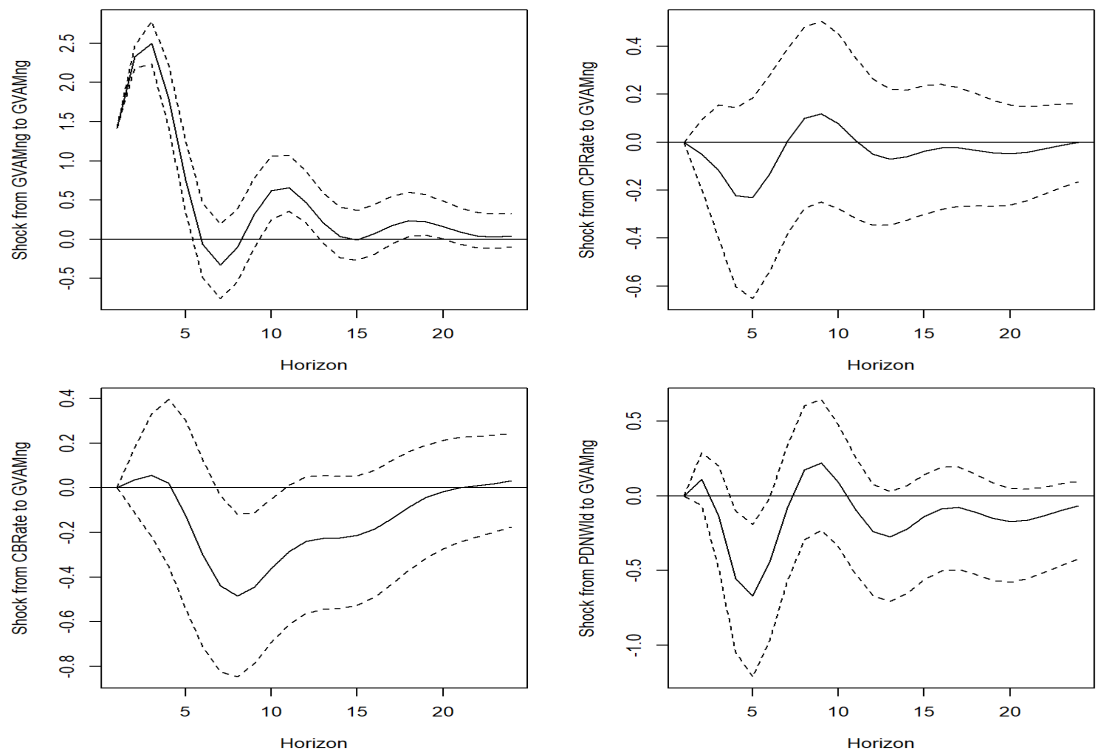
According to Stock and Watson (2001), the standard practice in Vector Autoregression (VAR) model analysis is to report the results from Impulse Response Functions (IRFs) and Forecast Error Variance Decompositions (FEVDs). The reason is that these statistics are more informative than the estimated Vector Autoregression (VAR) regression coefficients. Rudebusch (1998) further argues that most Vector Autoregression (VAR) model equations do not have a clear structural interpretation. Vector Autoregression (VAR) models are also atheoretical, that is, they are not built on some economic theory, hence a theoretical structure is not imposed on the equations. Every variable is assumed to influence every other variable in the system, which makes a direct interpretation of the estimated coefficients difficult, according to Hyndman and Athanasopoulos (2018). Therefore, in this paper, the Impulse Response Functions (IRFs) are the only model statistics that are reported given that the interest is to analyse the reaction of the minerals industry to the developments in external demand.

The variables were transformed to stationarity in that they were decomposed into deviations from their long term trends. The detrending is useful conceptually because it eliminates the common steering force that time may have on each variable series and hence induces stationarity. As such, the variables are mean reverting, thus, the Bayesian Vector Autoregression (BVAR) model is assumed to be covariance stationary. As discussed above, Rudebusch (1998) and Stock and Watson (2001) argue that the residuals of the Vector Autoregression (VAR) model are unanticipated shocks, or surprise movements in the variables. According to Stock and Watson (2001), the Impulse Response Functions (IRFs) trace out the response of current and future values of each of the variables to a unit increase in the current value of one of the Vector Autoregression (VAR) errors. This error is assumed to return to zero in subsequent periods and that all other errors are equal to zero. Consequently, the Impulse Response Functions (IRFs) show the impact, or effect, of a unit, or 1 percentage point, change in the variable under consideration on the rest of the other Vector Autoregression (VAR) model variables.

The Impulse Response Functions (IRFs) of a Vector Autoregression (VAR) model for the reaction of the minerals industry output to innovations, or shocks, in the other variables are depicted in Figure 2, together with their 95 percent confidence intervals, or bands. According to the results, following an unexpected 1 percentage point increase in output of the minerals industry, minerals industry output increases and peaks at 2.50 percentage points after 3 months. The initial increase is followed by a rapid decrease where the minerals industry output bottoms out at -0.32 percentage points after 7 months. The initial increase in in output of the minerals industry remains statistically significant for about 12 months following which its potency begins to progressively wane, or dissipate. Output of the minerals industry, thereafter, fluctuates and rapidly moves towards its steady state level in about 22 months. Following an unexpected 1 percentage point increase in consumer price inflation, output of the minerals industry decreases and bottoms out at -0.23 percentage points after 5 months. Output of the minerals industry then increases and peaks at 0.12 percentage points after 9 months. Output of the minerals industry then fluctuates, and progressively tends, towards its natural rate. The effect of the increase in consumer price inflation is, however, statistically insignificant in all time periods.

Following an unexpected, or surprise, 1 percentage point increase in monetary policy interest rate, output of the minerals industry increases slightly and peaks at 0.06 percentage points after 3 months. The initial increase in output of the minerals industry is followed by a decrease, where the minerals industry output bottoms out at -0.48 percentage points after 8 months. The effect of the surprise increase in monetary policy interest rate is, however, statistically significant between 7 and 10 periods, following which this surprise effect begins to progressively discipate and hence the minerals industry output gradually tends towards its steady state level. Following a surprise, or unexpected, 1 percentage point increase in external demand, output of the minerals industry increases slightly and peaks out at 0.11 percentage points after 2 months. Output of the minerals industry then decreases bottoming out at -0.67 percentage points after 5 months. The decrease is followed by an increase where output of the minerals industry, which peaks out at 0.23 percentage points after 9 months. The increase is followed by another decrease in output of the minerals industry, which subsequently fluctuates and gradually move towards its equilibrium, or steady state, level. The effect of the surprise increase in external demand on mining and quarrying output is only statistically significant between 7 and 10 months.

The Impulse Response Functions (IRFs) of a Vector Autoregression (VAR) model with innovations, or shocks, in the minerals industry output are depicted in Figure 3, together with their 95 percent confidence intervals, or bands. The results of the reaction of the minerals industry output to its own innovations, or to an unexpected 1 percentage point increase in minerals industry output, are reported above, that output of the minerals industry, minerals industry output increases and peaks at 2.13 percentage points after 2 months. The initial increase is followed by a rapid decrease where



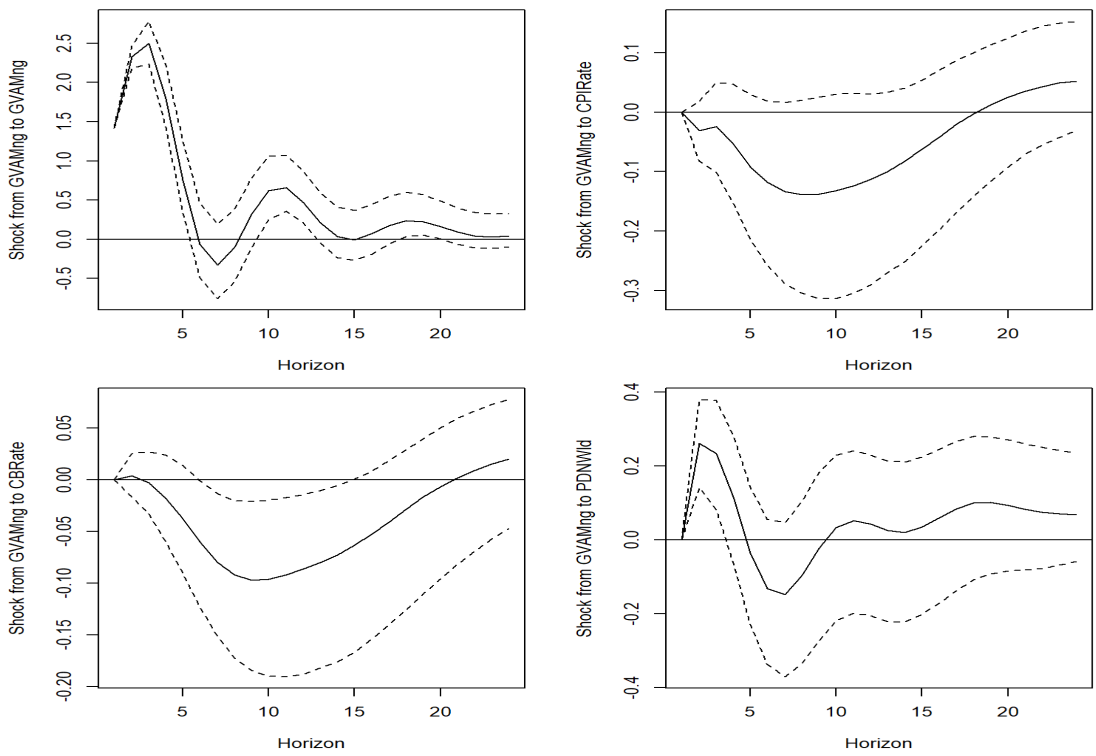
Notes: Data sourced from Statistics South Africa and South African Reserve Bank. Output of mining and quarrying is denoted $GVAMng$, consumer price inflation rate, is denoted CPI, monetary policy interest rate, is denoted $CBRate$ and $PNDWld$ denotes external demand. The x axis depicts the horizon of the Impulse Response Functions (IRFs)

Figure 2: Impulse Response Functions (IRFs) with shocks to output of the minerals industry

output of the minerals industry remains statistically significant for about 11 months following which it fluctuates and moves towards its steady state level in about 20 months. Following an unexpected, or surprise, 1 percentage point increase in output of the minerals industry, consumer price inflation decreases gradually and bottoms out at -0.13 percentage points after 8 months. The initial decrease is followed by a stable and sustained increase where consumer price inflation progressively tends towards and fluctuates around, its equilibrium, or steady state, level. The effect of a surprise increase in output of mining and quarrying on consumer price inflation is statistically insignificant in all time periods.

Following an unexpected, or surprise, 1 percentage point increase in output of the minerals industry, the central bank monetary policy interest rate initially increases slightly and peaks after 2 months. The initial increase is followed by a decrease where the monetary policy interest rate bottoms out at -0.10 percentage points after 9 months. The central bank interest rate subsequently increases and progressively tends towards, and fluctuates around, its equilibrium, or steady state, level. The effect an unexpected, or surprise, increase in output of the minerals industry on the central bank monetary policy interest rate is, however, statistically significant between 6 and 15 months. Following an unexpected, or surprise, 1 percentage point increase in output of the minerals industry, external demand increases and peaks out at 0.26 percentage points after 2 months. The initial increase is followed by a rapid decrease where the minerals industry output bottoms out at -0.15 percentage points after 7 months. The initial increase in in output of the minerals industry remains statistically significant for about 4 months following which its potency begins to progressively wane, or dissipate. Output of the minerals industry, subsequently, fluctuates and gradually moves towards its equillirium, or steady state, level.

Countries with strong external demand for their goods and services across the world, as discussed, often experience higher levels of economic growth, hence external demand conditions are crucial to understand the production, trade patterns and overall economic growth of countries around the world, according to Palley (2012) and Kilian and Zhou (2018). According to Government Communication and Information System (GCIS), South Africa has an abundance of mineral resources and is estimated to have the world's fifth largest mining sector, while its mining companies are key players in the global industry. Classical theories of international trade, also discussed in Dornbusch (1987), Obstfeld and



Notes: Data sourced from Statistics South Africa and South African Reserve Bank. Output of mining and quarrying is denoted $GVAMng$, consumer price inflation rate, is denoted CPI, monetary policy interest rate, is denoted $CBRate$ and $PNDWld$ denotes external demand. The x axis depicts the horizon of the Impulse Response Functions (IRFs).

Figure 3: Impulse Response Functions (IRFs) with shocks from output of the minerals industry

Rogoff (1996) and Uribe and Schmitt-Grohe (2017), in particular the Heckscher-Ohlin theory, or the factor endowment theory, contends that countries should specialise in production and export goods and services that utilize their most abundant factors of production, such as labor, capital, land as well as minerals. As discussed in Wijnbergen (1984), South Africa is, thus, hypothetically in good standing to realise benefits from strong external demand for its goods and services across the world, in particular, given abundance of mineral resources, the opposite of which is the natural resource curse.

The empirical results provide evidence of a statistically significant effect of an unexpected, or surprise, increase in external demand on output of the minerals industry, which only initially increases slightly and peaks out after 2 months. Output of the minerals industry then decreases bottoming out after 5 months. Output of the minerals industry subsequently fluctuates and gradually move towards its equilibrium, or steady state, level. The effect of the surprise increase in external demand on mining and quarrying output is statistically significant between 7 and 10 months. The results essentially show a statistically significant decrease in output of the minerals industry following an improvement in external demand conditions. The results are inconsistent with the view that countries with strong external demand for their most abundant goods and services across the world should specialise in production and export of such goods and services. The empirical results are, however, not surprising given that the minerals industry relies on acquisition of fixed capital investment in property, plant and equipment, which are generally considered fixed and long term in nature. The minerals industry, thus, does not conform to the classical theories of international trade, at least at business cycle frequencies.

Conclusion

This paper analysed the reaction of the minerals industry to external demand *developments* in South Africa. This was achieved by augmenting a Taylor (1993) rule type central bank monetary policy reaction function with the indicator of external demand. The empirical results provide evidence of a statistically significant effect of an increase in external demand on output of the minerals industry, which only initially increases slightly and peaks out after 2 months. Output of the minerals industry then decreases bottoming out after 5 months. Output of the minerals industry subsequently fluctuates and gradually move towards its equilibrium, or steady state, level. The effect of the surprise increase in external demand on mining and quarrying output is statistically significant between 7 and 10 months. External demand conditions are important for economic activity, hence policymakers should continue to monitor the developments in external demand conditions to support economic growth and the minerals industry. Several indicators, such as inflation, monetary policy interest rates, Government expenditure and taxation, foreign exchange rates, commodities prices, affect economic activity, at least theoretically, hence it is important for future research to analyse their impact on the minerals industry.

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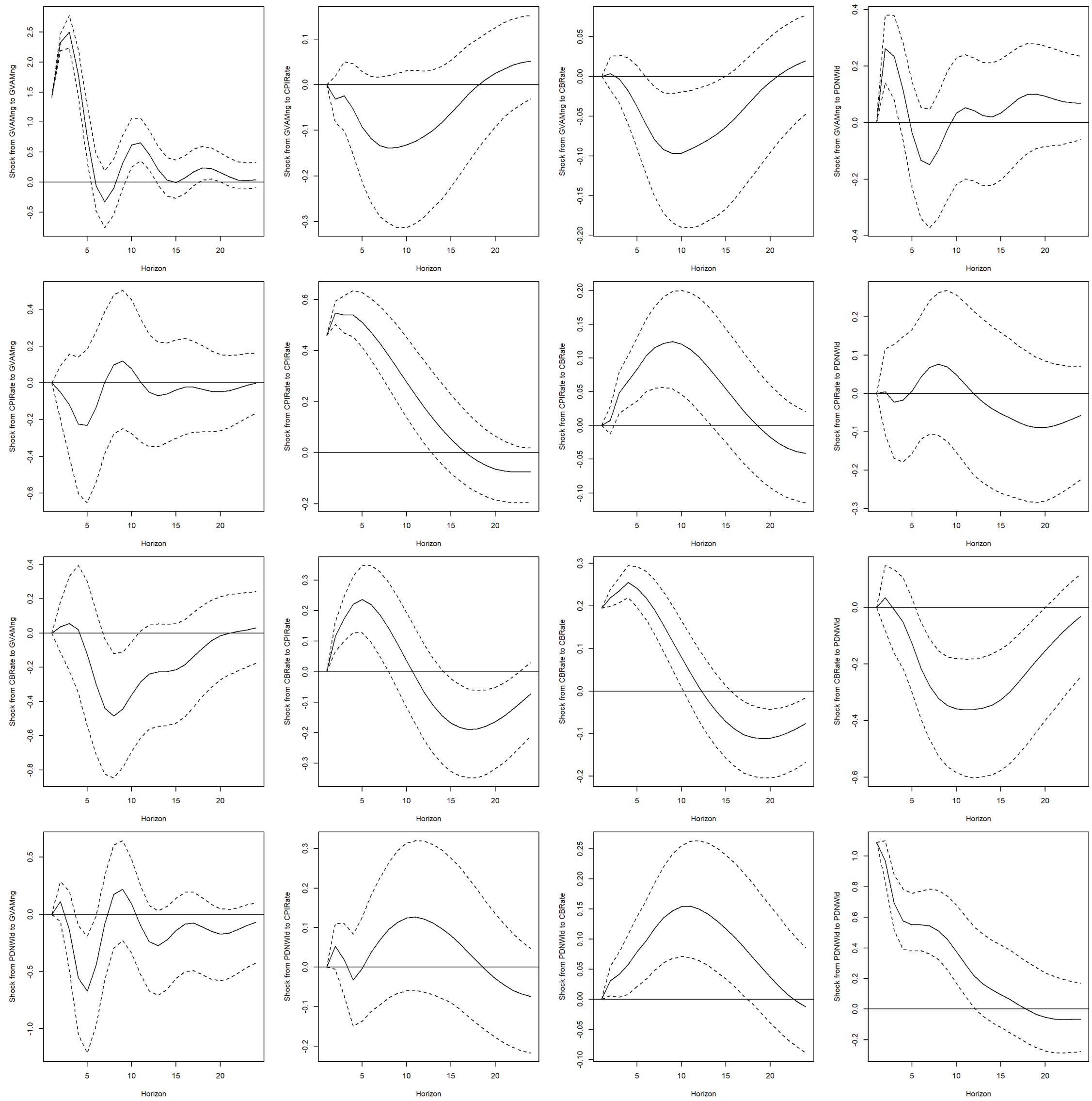
Appendix

Appendix 1. Complete Impulse Response Functions (IRFs)

The complete Impulse Response Functions (IRFs) of a Vector Autoregression (VAR) model with external demand are shown in Figure 4. This Figure is not intended to be a part of the paper, but is included to demonstrate the completeness of the analysis.



Notes: Data sourced from Statistics South Africa and South African Reserve Bank. Output of mining and quarrying is denoted $GVAMng$, consumer price inflation rate, is denoted CPI, monetary policy interest rate, is denoted $CBRate$ and $PNDWld$ denotes external demand. The x axis depicts the horizon of the Impulse Response Functions (IRFs).

Figure 4: Complete Impulse Response Functions (IRFs) with external demand