Foreign direct investment developments and the minerals industry

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Abstract

This paper analyses the reaction of the minerals industry to foreign direct investment *developments* in South Africa. This is achieved by augmenting a Taylor (1993) rule type central bank monetary policy reaction function with foreign direct investment inflows. The empirical results provide evidence of a statistically significant effect of an increase in foreign direct investment on output of the minerals industry, which briefly decreases followed by an increase and a peak out after 8 months, the effect of which is statistically significant between 6 and 14 months. The results further show a statistically significant effect of an increase in output of the minerals industry on foreign direct investment, which decreases and bottoms out after 6 months, the effect of which is statistically significant up to 8 months, which implies a feedback effect between foreign capital flows and output of the minerals industry. Foreign direct investment is, thus, important for economic activity, hence policymakers should monitor the developments in cross border capital flows to support economic activity and the minerals industry.

JEL Classification:C10, E50, G10, L72
Keywords: Foreign direct investment, Minerals industry, Economic cycles

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Introduction

Foreign direct investment flows have increased remarkably in recent decades as a result of the opportunities that exist across international borders, especially in emerging and developing economies. According to the International Monetary Fund (IMF) (1994), the surge in cross border investment flows benefit of both the host countries, though access to funding for economic growth prospects, and the Transnational Corporations (TNCs), or Multinational Enterprises (MNEs), through diversification of lending and investment as well as higher potential returns in host countries. The inward foreign direct investment flows by partner country, according to the Organization for Economic Cooperation and Development (OECD) (2025), are the value of cross border direct investment transactions received by the reporting economy during a year. In essence, foreign direct investment refers to the ownership stake in a foreign company or project made by an investor, company, or government from another country. According to Feldstein (2000), Loungani and Razin (2001) as well as Hayes (2024), foreign direct investment lies at the heart of globalisation and serves as an important source for the transfer of goods and services, fixed capital formation, technology as well as information across economies.

Foreign direct investment can be made in a variety of ways, including horizontal, referred to as opening or acquiring a subsidiary, or associate company, in a foreign country, vertical, opening or acquiring a controlling interest, or stake, in an complementary foreign company, as well as conglomerate, by means of an acquisition, merger or joint venture, with a non core foreign company, according to Hayes (2024). Foreign Portfolio Investment (FPI) is related to foreign direct investment but instead involves owning, or purchasing, the securities, such as stock or bonds, issued by foreign companies, rather than direct capital investments. According to Loungani and Razin (2001) and Lipsey (2001), whereas foreign direct investment has proved to be resilient during periods economic uncertainty and crises, Portfolio equity and debt flows, and particularly the short term Foreign Portfolio Investment

(FPI) flows, are subject to large reversals during the same period, in contrast. Claessens et al. (1995), Calvo and Reinhart (1999), Calvo and Mendoza (2000) as well as Lipsey (2001) contend that Foreign Portfolio Investment (FPI) flows are speculative in nature and hence are prone to sudden stops and reversals, which can lead to currency depreciations, asset prices bubbles and a banking sector crises.

Macroeconomists advocate for free flow of capital across national borders because it allows it to seek out the highest rate of return, given that it offers several advantages, including its contribution to investment and growth in host countries, as discussed. However, according to Bosworth et al. (1999), Feldstein (2000) and Loungani and Razin (2001), the resilience of foreign direct investment during financial crises has lead many emerging and developing countries to consider it as the private capital inflow of preference. As notes Mallampally and Sauvant (1999), countries have in recent decades liberalised their national policies to establish a hospitable regulatory framework for foreign direct investment by relaxing the regulations on market entry and foreign ownership, harmonising governance structures and promotion of well functioning of markets. Arvanitis (2006) laments the low foreign direct investment in South Africa, while a detailed discussion on cross border capital flows can be found in Bacchetta (2000), Calvo and Mendoza (2000), Claessens (2000), Adalet and Eichengreen (2007) and Cavallo (2019). Bosworth et al. (1999) and Edwards (2000) provide an extensive survey on the consequences of capital flows on investment and growth in emerging and developing countries.

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 foreign direct investment *developments* in South Africa. This is achieved by augmenting a Taylor (1993) rule type central bank monetary policy reaction function with foreign direct investment inflows. Understanding the reaction of the minerals industry to foreign direct investment *developments* over the economic cycle is important to mining authorities and policymakers alike. This is particularly the case given the trend break, as well as the protracted underperformance of South Africa's minerals industry, relative to the total economy, since the 1970s. According to Walsh and Yu (2010), factors influencing foreign direct investment may vary by sector, while Diebold and Rudebusch (1970), Kydland and Prescott (1990), Romer (1993) and Kose and Terrones (2015), argue that the different economic sectors respond differently to endogenous and exogenous shocks as well as the long run and short run disturbances. According to the International Monetary Fund (IMF) (1994) and European Central Bank (ECB) (2016), quantifying foreign direct investment and its impact on economic activity is crucial because free flow of capital across borders allows it to seek the highest returns, while it contributes to fixed investment and economic growth.

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 foreign direct investment *developments*. The variables comprise output of mining and quarrying, inflation rate, monetary policy interest rate and foreign direct investment. 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. Foreign direct investment is the value of cross border direct investment transactions received by the reporting economy during a given period of time. The data on mining and quarrying output and inflation rate was sourced from Statistics South Africa, while data on monetary policy interest rate, and foreign direct investment was sourced from South African Reserve Bank. The descriptions the variables are presented in Table 1. Mining output is denoted $GVAMng$, inflation rate is denoted $CPIRate$, monetary policy, or central bank, interest rate, is denoted $CBRate$, while $FDInv$ denotes foreign direct investment.

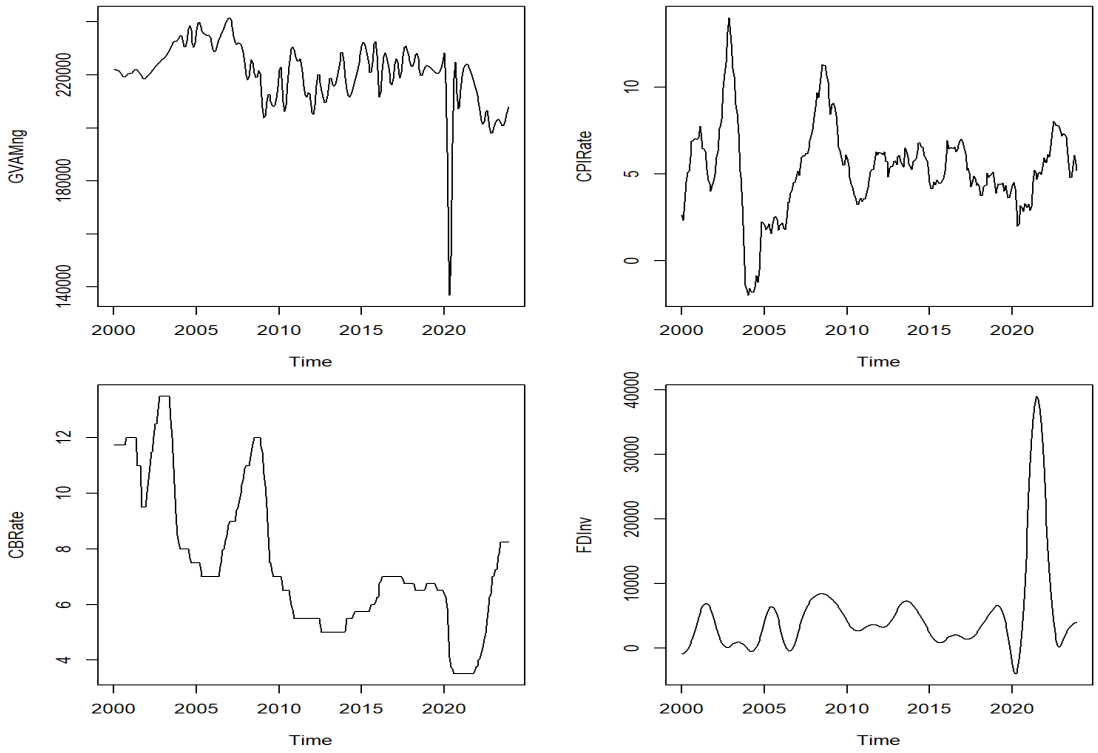
Variable	Denotation	Description
Mining output	GVAMng	Gross Value Added (GVA) of the mining and quarrying, or minerals, industry
Inflation rate	CPIRate	Inflation rate, or annual Consumer Price Index (CPI), is the annual headline consumer price inflation
Interest rate	CBRate	Central bank policy rate and is the rate at which private sector banks borrow from the central bank
Direct investment	FDInv	Value of cross border direct investment transactions received by the reporting country

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 $FDInv$ denotes foreign direct investment.

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.

Foreign direct investment inflows averaged just above 5.00 billion U.S. dollars between 2000 and 2023, or during the sample period. the value of foreign direct investment inflows increased from 2000 and peaked in 2001, following which the indicator decreased and bottomed out under 1.00 billion U.S. dollars in 2004. Foreign direct investment inflows increased again from 2005 and reached a peak at just under 10.00 billion U.S. dollars in 2008. This was followed by a decrease between 2009 and 2012, 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, central bank monetary policy interest rate, is denoted $CBRate$ and $FDInv$ denotes foreign direct investment.

Figure 1: Plots of the variables

another peak in foreign direct investment inflows was realised in 2013 at about 8.00 billion U.S. dollars. Foreign direct investment inflows were low between 2014 and 2020, the indicator bottomed out at around 1.50 billion U.S. dollars in 2015 before recovering slowly between 2016 and 2020. Foreign direct investment inflows increased substatially in 2021 and peaked just above 40.00 billion U.S. dollars before falling back to the long term avarage of about 5.00 billion U.S. dollars in 2022 and 2023. According to Arvanitis (2006), direct investment inflows remained at relatively low compared with emerging market countries despite the improvement in overall macroeconomic conditions and the advantages of natural resources abundance and market size. Annual foreign direct investment inflows averaged less than 1.50 percent of GDP during the sample period, compared with 2–5 percent in the comparable countries.

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 foreign direct investment *developments* over the economic cycle.

Methodology

A Vector Autoregression (VAR) model is estimated to capture the relationship between the minerals industry and foreign direct investment *developments*. The specified Vector Autoregression (VAR) model follows Stock and Watson (2001) and Kadiyala and Karlsson (1997). Vector Autoregression (VAR) models were introduced in applied macroeconomic research by Sims (1980), while the early contributions to their Bayesian 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 foreign direct investment *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, or 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.

As discussed, conventional macroeconomic models distinguish between alternative "anchors" to stabilise the cyclical behavior of economic activity. 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 foreign direct investment as follows

$$i_t = \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_Y(Y_t - \bar{Y_t}) + \theta_F(F_t - \bar{F_t}) + \epsilon_t \tag{5}$$

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, F_t denotes foreign direct investment, while $\bar{F_t}$ denotes its natural rate. θ_π, θ_Y and θ_F 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 from its natural rate, respectively. ϵ_t is the error term and the subscript t denotes the time period. The central bank monetary policy reaction function captures the process through which the monetary policy decisions affect the 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 level, consumer price inflation is equivalent to its target rate and foreign direct investment equals its steady state level, hence the nominal central bank interest rate is also equal to its natural rate.

The variables in the specified central bank monetary policy reaction function comprise output of mining and quarrying, denoted $GVAMng_t$, inflation, denoted CPI_t, interest rate, denoted $CBRate_t$ and foreign direct investment, denoted $FDInv_t$. Y_t in Equation 1 can, thus, be rewritten as

$$Y_t = (GVAMng_t, CPI_t, CBRate_t, FDInv_t) \tag{6}$$

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 residuals of the Vector Autoregression (VAR).

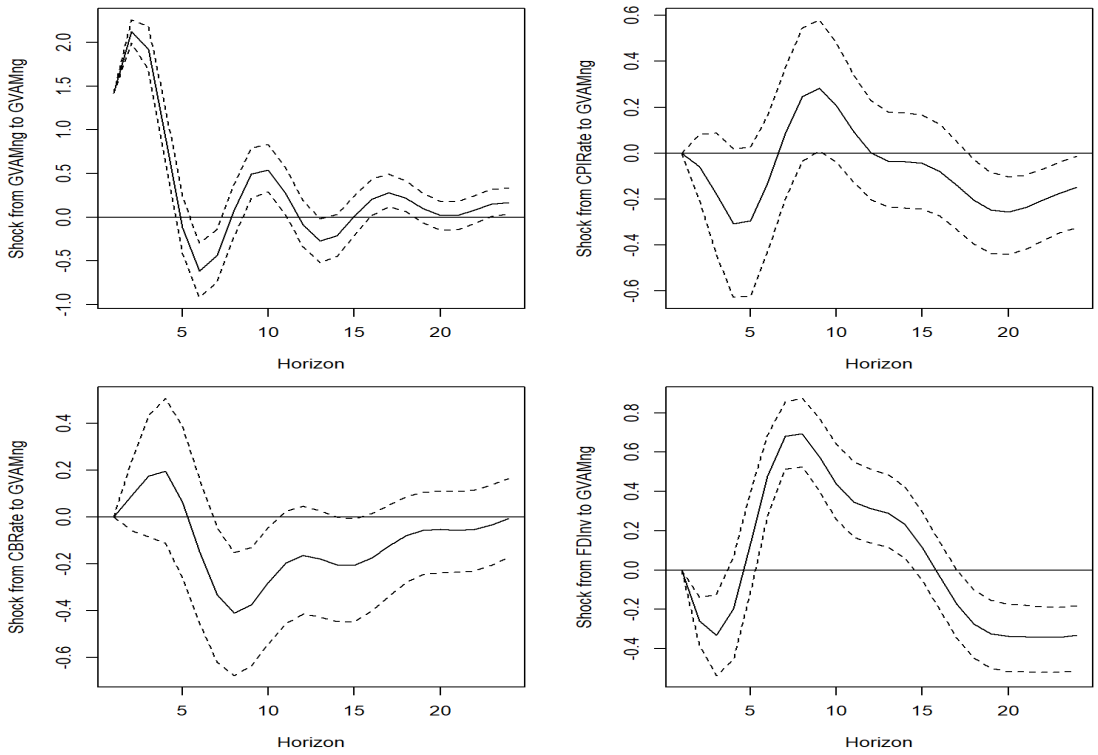
According to Stock and Watson (2001), the standard practice in Vector Autoregression (VAR) model analysis is to report the results from Impulse Response Functions (IRFs) and Forecast Error Variance Decompositions (FEVDs). The reason is that these statistics are more informative than the estimated Vector 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 developments in foreign direct investment.

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 2.13 percentage points after 2 months. The initial increase is followed by a rapid decrease where the minerals industry output bottoms out at -0.62 percentage points after 6 months. The initial increase in in output of the minerals industry remains statistically significant for about 11 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 20 months. Following an unexpected 1 percentage point increase in consumer price inflation, output of the minerals industry decreases and bottoms out at -0.30 percentage points after 4 months. Output of the minerals industry then increases and peaks at 0.28 percentage points after 9 months. Minerals industry output then fluctuates, and progressively tends, towards its natural rate. The effect of the increase in consumer price inflation is somewhat statistically significant between 18 and 24 months.

Following an unexpected 1 percentage point increase in monetary policy interest rate, output of the minerals industry increases slightly and peaks at 0.20 percentage points after 4 months. The initial increase in output of the minerals industry is followed by a decrease where the minerals industry output bottoms out at -0.38 percentage points after 9 months. The effect of the surprise increase in monetary policy interest rate is, however, statistically significant between 6 and 18 periods, following which it begins to progressively discipate and hence the minerals industry output gradually tends towards its steady state level. Following a surprise 1 percentage point increase in foreign direct investment, output of the minerals industry decreases and bottoms out at -0.33 percentage points after 3 months. The decrease is followed by an increase where output of the minerals industry peaks out at 0.70 percentage points after 8 months. The increase is followed by another decrease in output of the minerals industry which bottoms out at -0.34 percentage points after 23 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 foreign direct investment on minerals industry output is statistically significant between 2 and 3 months, 6 and 14 months and from 18 months and the end of the sample period.

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 increases and peaks at 2.13 percentage points after 2 months. The initial increase is followed by a rapid decrease where minerals industry output



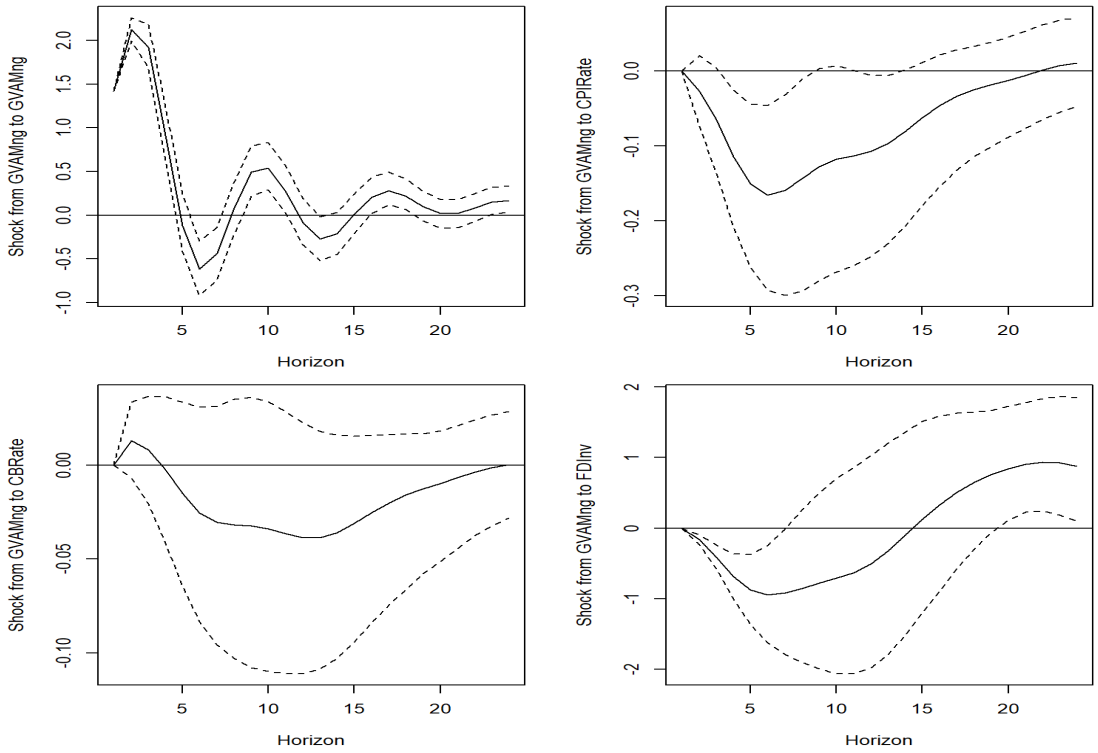
Notes: Data sourced from Statistics South Africa and South African Reserve Bank. Output of mining and quarrying is denoted $GVAMng$, consumer price inflation rate, is denoted CPI, monetary policy interest rate, is denoted $CBRate$ and $FDInv$ denotes foreign direct investment. The x axis depicts the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

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

fluctuates and moves towards its equilibrium, or steady state level, in about 20 months. output of the minerals industry remains statistically significant for about 11 months. Following an unexpected 1 percentage point increase in output of the minerals industry, consumer price inflation decreases and bottoms out at -0.16 percentage points after 6 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 after about 21 months. The effect of a surprise increase in output of minerals industry on consumer price inflation is statistically significant between 4 and 8 months.

Following an unexpected, or surprise, 1 percentage point increase in output of the minerals industry, the central bank monetary policy interest rate initially increases and peaks at 0.01 percentage points after 2 months. The initial increase is followed by a decrease where monetary policy interest rate bottoms out at -0.04 percentage points after 12 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 insignificant in all time periods. Following an unexpected, or surprise, 1 percentage point increase in output of the minerals industry, foreign direct investment decreases and bottoms out at -0.94 percentage points after 6 months. This is followed by a sustained increase where foreign direct investment peaks at 0.93 percentage points after 22 months. Foreign direct investment then fluctuates and progressively tends towards, its equilibrium, or steady state, level. The effect an unexpected increase in output of the minerals industry on foreign direct investment is statistically significant up to 8 months and from 20 months to the end of the sample.

Foreign direct investment inflows, which are the value of cross border direct investment transactions received by the reporting economy during given period, according to the Organization for Economic Cooperation and Development (OECD) (2025), hence the International Monetary Fund (IMF) (1994) and European Central Bank (ECB) (2016) advocate the free flow of capital across borders given that allows such investment flows to seek the highest returns, while they contribute to fixed capital formation and economic growth. The empirical results provide evidence of a statistically significant effect of an unexpected, or surprise, increase in foreign direct investment on output of the minerals industry, which



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 $FDInv$ denotes foreign direct investment. 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

briefly decreases followed by an increase and a peaks out at 0.70 percentage points after 8 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 results further show that the effect of an unexpected, or surprise, increase in foreign direct investment on output of minerals industry is statistically significant between 6 and 14 months. The results are consistent with the view that cross border capital flows support fixed investment and economic growth of the host countries.

Conclusion

This paper analysed the reaction of the minerals industry to foreign direct investment *developments* in South Africa. This was achieved by augmenting a Taylor (1993) rule type central bank monetary policy reaction function with foreign direct investment inflows. The empirical results have provided evidence of a statistically significant effect of an increase in foreign direct investment on output of the minerals industry, which briefly decreases followed by an increase and a peaks out after 8 months, the effect of which is statistically significant between 6 and 14 months. The results further shown a statistically significant effect of an increase in output of minerals industry on foreign direct investment, which decreases and bottoms out after 6 months, the effect of which is statistically significant up to 8 months. Foreign direct investment is, thus, important for economic activity, hence policymakers should continue to monitor the developments in foreign capital flows to support economic growth and the minerals industry. Several indicators, such as inflation, monetary policy interest rates, Government expenditure and taxation, exchange rates and prices of commodities, 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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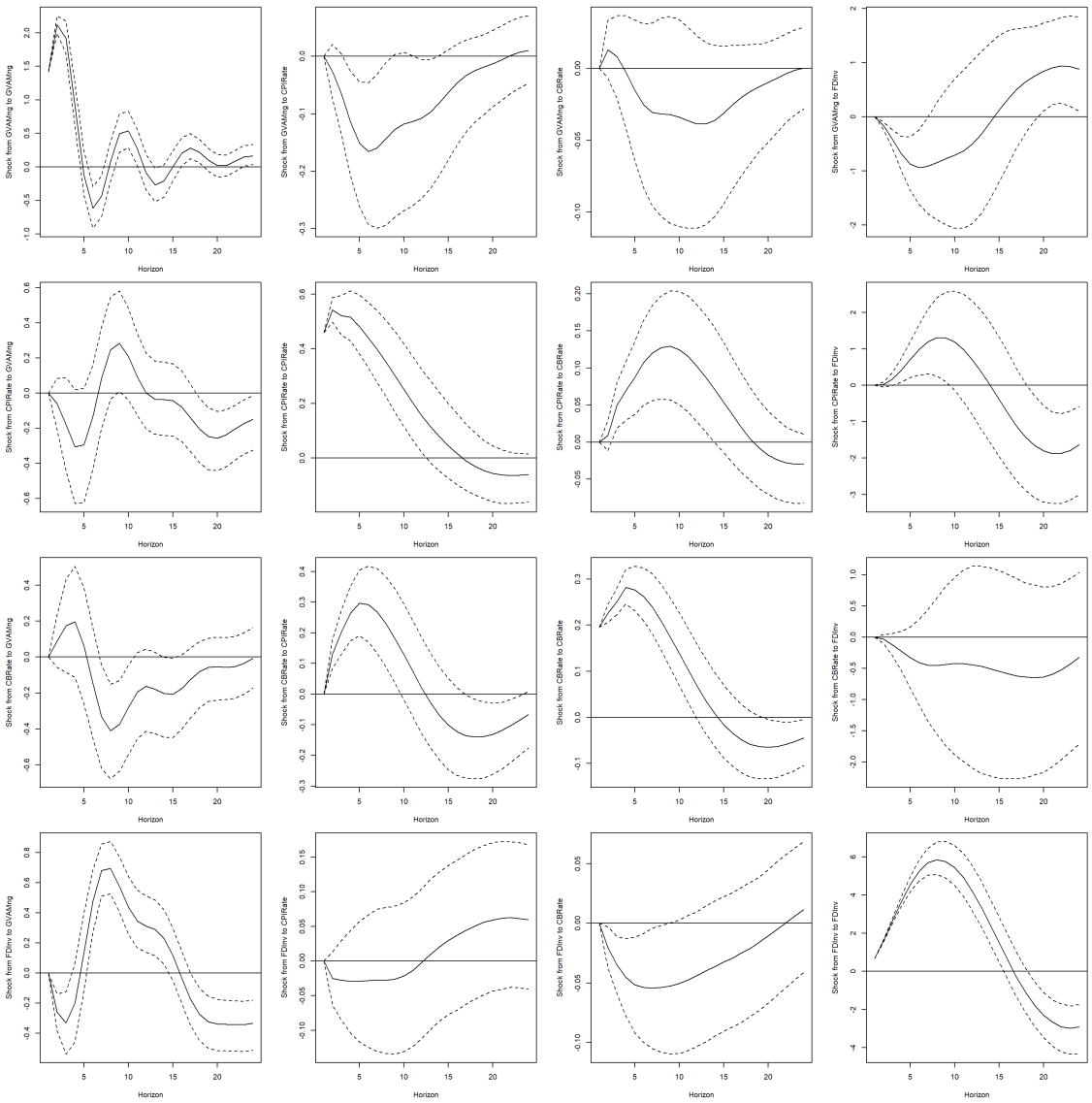
Appendix

Appendix 1. Complete Impulse Response Functions (IRFs)

The complete Impulse Response Functions (IRFs) of a Vector Autoregression (VAR) model with foreign direct investment 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 $FDInv$ denotes foreign direct investment. The x axis depicts the horizon of the Impulse Response Functions (IRFs).

Figure 4: Complete Impulse Response Functions (IRFs) with foreign direct investment