Resources Policy 45 (2015) 193–201

Contents lists available at ScienceDirect

Resources Policy

journal homepage: www.elsevier.com/locate/resourpol

Input cost and international demand effects on the production of platinum group metals in South Africa

Corris Krogscheepers, Sean Joss Gossel *

University of Cape Town Graduate School of Business, South Africa

ARTICLE INFO

Article history:
Received 7 October 2014
Received in revised form
30 April 2015
Accepted 30 April 2015
Available online 25 May 2015

Keywords:
Demand
Input costs
Platinum group metals
Production
South Africa

ABSTRACT

This study uses a VECM with impulse response, variance decomposition and block Granger causality analysis to investigate the effects of international and domestic factors on the production of platinum group metals (PGM) in South Africa from 1980 to 2011. The results of the impulse responses show that shocks to the international factors negatively affect production while domestic shocks positively affect production. The variance decompositions find that in the long-run, production is most significantly impacted by international demand, domestic electricity tariffs, and salary shocks. The block Granger causality analysis further finds that the international factors causally affect the domestic factors, but production is driven by PGM price fluctuations, electricity tariffs, and output per employee.

Introduction

Mining plays a pivotal economic role in natural resource rich South Africa. In 2011, the mining sector, accounted for 8.8% (USD35.9 billion) of national GDP, 20% of private sector investment, 12.3% of total investment and 29% (USD192.8 billion) of the All Share Index (ALSI) of the Johannesburg Stock Exchange (JSE) (Chamber of Mines, 2012). The rising prices of platinum group metals (PGM)[1] since 2000 has led to PGMs replacing gold as the key mineral export of South Africa (Walker and Minnitt, 2006). The total PGM export sales value for 2011 was USD10.1 billion, whilst gold accounted for USD9.0 billion (DMR, 2012). There are more than 30 mines operating in the Bushveld Igneous Complex (Klopper, 2011), employing 194,000 people directly (DMR, 2012).

Currently the three largest PGM mining companies in South Africa, in terms of production, are Anglo American Platinum, Impala Platinum and Lonmin. These three mining companies have operations which span the three types of PGM ore. However, South Africa has experienced various challenges in the mining sector in recent years, which have been amplified due to cost and social circumstances (Kane-Berman, 2011). Consequently, some operations have either been discontinued or 'moth-balled', whilst capital expenditure has been deferred or restricted until market conditions improve[2] (Anglo American Platinum, 2012a; Impala Platinum, 2012a; Klopper, 2011; Lonmin, 2012).

Hence, this study investigates the effect of international (demand and price) and domestic (salaries, electricity tariffs, and output per employee) factors on the production of a PGM unit mined in South Africa from 1980 to 2011. The remainder of this study is organised as follows. Section 2 reviews the literature associated with PGM sector costs. In Section 3, the empirical model and methodology are discussed. Section 4 sets out the data utilised to conduct the empirical investigation. The empirical results are then presented in Section 5, and the study concludes with a discussion of the key findings and PGM sector policy implications in Section 6.

Literature review

Operating costs in the PGM sector consist primarily of day-to-day costs associated with the production and processing of the commodity. These costs include wages, consumable material such as chemicals and explosives, transportation, electricity and fuel

* Corresponding author. Tel.: +27 21 406 1027/27 72 521 2872.
E-mail address: gosselse@gsb.uct.ac.za (S.J. Gossel).

[1] Platinum Group Metals/Minerals (PGM) refer to the accessory bearing mineral in which Platinum Group Elements (PGE) are found. PGEs consist of the following elements, ruthenium (Ru), rhodium (Rh), palladium (Pd), osmium (Os), iridium (Ir) and platinum (Pt) in varying ratios (Xiao and Laplante, 2004).

[2] Examples include: Anglo American Platinum capital expenditure rationed from USD1.1 billion to USD877 million (Anglo American Platinum, 2012b); Impala Platinum approved USD170.5 million for expenditure for 2013 for the Leeuwkop Project but then restricted this amount to USD31.8 million (Impala Platinum, 2012b); and Lonmin deferred spending on Hossy, K4 and Saffy shafts (Lonmin, 2012: 11).

http://dx.doi.org/10.1016/j.resourpol.2015.04.009
0301-4207/

(Anglo American Platinum, 2012a; Impala Platinum, 2012a; Lonmin, 2012; Rudenno, 2012).

However, Crowson (1984, 1998: 139–141) notes that the causal relationship between costs and a commodity price is bi–directional rather than unidirectional. Gentry (1988) argues that a unique characteristic of mining is that the commodities are fungible in that there is little or no difference in product quality among producers. Since mineral products are traded on international markets, the markets determine the price and hence input costs adjust accordingly, thus commodity producers are 'price takers'. Furthermore, Tilton and Coulter (2002) concluded that there are various uncertainties underlying the future supply and demand of minerals and thus inter alia real PGM prices will continue to be significantly impacted by unpredictable underlying factors. Furthermore, Baffes and Haniotis (2010) argue that the high degree of price variability tends to overwhelm long-run price trends and thus mining companies need to manage both the input costs and the selling price they receive for the commodity. Hence, Tilton and Coulter (2002) and Baffes and Haniotis (2010) argue that in order to maximise value, the main factors a mining company has influence over are input costs.

However, the impact of input costs is significantly affected by the supply-demand effects of the business cycle phases.The most extreme effects are associated with 'Dutch disease' (Economist, 1977) whereby labour prices increase significantly during a business cycle upswing and then in a downswing the heightened salaries have an adverse effect on the profitability of an industry. According to Tilton (2001), a possible means of counteracting this detrimental cycle is if mines increase their productivity (and inter alia their production) during the downswing despite maintaining the 'sticky' salaries. Hence, productivity can be considered to be a long-run factor while salaries can be considered to be a short-run factor.

In addition to salary costs, the PGM sector also uses a significant amount of electricity for the transport of personnel, material and ore; powering production machines and mineral processing, as well as for vital health and safety related applications such as the pumping of water, ventilation and refrigeration (Chamber of Mines, 2000). However, Smyth (1993) reports that the impact of relative energy price movements on productivity are not symmetrical and thus it is not possible to increase production by reducing energy costs. Furthermore, Bils and Chang (2000) find that prices respond considerably more to cost increases arising from energy prices than to increases in wages or decreased productivity.

With regards to productivity itself, Asafu-Adjaye and Mahadevan (2003) report that mining productivity growth in five sectors (coal, iron ore, copper, gold, oil and gas) in Australia during 1968–1995 was largely input driven (total cost and input prices of capital, energy, and labour) rather than productivity driven. This suggests that there was a direct relationship between capital spent and production, as opposed to an increasing variable in production due to an accompanying improvement in productivity. Nattrass (1995) and Topp et al. (2008) argued that as the underlying quality and accessibility of the natural resource being mined systematically changes over time as it becomes depleted, the amount of capital and labour needed for extraction increases. Although depletion might only become a factor in South Africa's PGM mines in future decades (Cawthorn, 1999), the greater depths at which extraction takes place increases both dilution due to waste rock and costs due to mining requirements. This implies that over time, increased input costs are required to uphold the same production curve (Nattrass, 1995, Topp et al., 2008, Asafu-Adjaye and Mahadevan, 2003). Hence, productivity reflects not only changes in production efficiency, but also changes in the underlying quality and accessibility of the natural resources being mined.

Methodology

This study uses a vector error correction model (VECM) (Johansen, 1988) with impulse response, variance decomposition, and block Granger causality analysis to examine the effects that international and domestic factors have on PGM production in South Africa. Prior to conducting the empirical analysis, the data must first be tested to determine whether the series are level stationary (I(0)) or contain a unit root (I(d)) so as to avoid spurious regression (Engle and Granger, 1987; Granger and Newbold, 1974). Hence this study makes use of the ubiquitous augmented Dickey-Fuller Test (ADF) (Dickey and Fuller, 1979, 1981), Phillips-Perron (PP) (Phillips and Perron, 1988), and ADF with structural break unit root tests.

After examining the stationarity conditions of the data, the next step of the analysis is to test for cointegration among the difference-stationary variables. Cointegration is defined as the existence of a long run relationship between non-stationary time series. If there are two or more series which are individually non-stationary (and integrated of the same order), but there exists a linear combination which is stationary, then the series are deemed to be cointegrated (Hendry and Juselius, 2000; Wójcik, 2011). The two common methods for identifying cointegration are the Engle and Granger (1987) two-step procedure and the Johansen (1995) maximum likelihood approach. This study makes use of the Johansen (1995) cointegration procedure as it allows for the identification of more than one cointegrating relationship and is better suited to small samples (Sjö, 2008; Steward, 2005). The Johansen cointegration test makes use of two test statistics: the trace test statistic, which tests the null hypothesis that the rank of the matrix (Π) is less than or equal to the number of cointegrating vectors (r); and maximal eigenvalue test statistic, which tests the null hypothesis that there are exactly r cointegrating vectors.

Thereafter, if no cointegration is found then the empirical analysis can be conducted using an unrestricted vector autoregression (VAR) model with the following form (Sims, 1980):

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + \mu_t \quad (1)$$

where y_t is a vector of k potentially endogenous variables, p is the number of lags, A_i is a $(k \times k)$ matrix of parameters, and μ_t is an unobservable error term. However, if cointegration is found then the long-run and short-run dynamics can be estimated using a vector error correction model (VECM) (Johansen, 1988) with the following form:

$$\Delta y_t = \prod y_{t-1} + \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{p-1} \Delta y_{t-p+1} + u_t \quad (2)$$

where $\prod = -(I_k - A_1 - \ldots - A_p)$ and $\Gamma_i = -(A_{i+1} + \ldots + A_p)$ for $i = 1, \ldots, p-1$.

Thus the VECM in Eq. (2) is obtained from the VAR in Eq. (1) by subtracting y_{t-1} from both sides and rearranging terms. Since the variables are at most I(1), only Πy_{t-1} contains the I(1) variables, which in turn implies that Πy_{t-1} contains the cointegrating relationships because it is I(0) (Lütkepohl and Krätzig, 2004). Hence, Πy_{t-1} is typically referred to as the long-run relationship and Γ is referred to as the short-run relationship (Harris, 1995).

In this study, the effects of the international and domestic factors on PGM production are examined using the following model:

$$Y_t = f(\text{Ln\_Demand}_t, \text{Ln\_Price}_t, \text{Salary\_Empl}_t, \text{Elect}_t, \text{Kg\_Empl}_t, \text{Ln\_Prod}_t) \quad (3)$$

where *Ln_Demand* is the natural logarithm of net international demand, *Ln_Price* is the natural logarithm of the dollar sales price of per kilogram unit of PGM, *Salary_Empl* is the dollar salary per employee, *Elect* is the annual change in electricity tariffs, *Kg_Empl* is the output (kilogram) per employee, and *Ln_Prod* is the natural