

Resource boom, productivity growth and real exchange rate dynamics — A dynamic general equilibrium analysis of South Africa

Hildegunn E. Stokke*

Department of Economics, Norwegian University of Science and Technology, 7491 Trondheim, Norway

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Abstract

This paper studies the impact of a natural resource boom on structural change and real exchange rate dynamics, taking into account the indirect effect that operates through relative sectoral productivity changes. The paper's contribution to the Dutch disease literature is threefold. First, I extend the simple learning by doing productivity specification to include trade barriers and technology gap dynamics, consistent with the modern treatment of productivity growth. Second, I present a dynamic general equilibrium analysis that incorporates imperfect substitution between domestic and foreign goods. Third, I apply the model to South Africa and analyze the macroeconomic impact of increases in gold prices during the 1970s. Political pressure for rapid domestic spending following a surge in resource rents tends to generate myopic government behavior with immediate expansion of government consumption. The model specification captures this fiscal response to higher resource income. Numerical simulations show how the resource boom can help explain the paths of structural change and real exchange rates observed in South Africa. Because of productivity effects, gradual real depreciation follows an initial appreciation of the real exchange rate.

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1. Introduction

Existing Dutch disease analyses typically relate productivity improvements to learning by doing. [Van Wijnbergen \(1984\)](#) investigates the impact of a resource boom in a two-period model, and shows that productivity effects generate real depreciation following an initial appreciation of the real exchange rate. [Torvik \(2001\)](#) finds similar results in a more general setting. In this paper, I present a dynamic general equilibrium analysis of an increase in resource income. The paper's contribution to the literature is threefold. First, the productivity specification is consistent with modern

* Tel.: +47 73591665; fax: +47 73596954.
E-mail address: hildegunnes@svt.ntnu.no.

treatments in which productivity growth is related to trade barriers and technology gap dynamics. Incorporating technology transfer as a source of productivity growth strengthens the productivity effect of a resource boom, and generates additional implications for real exchange rate dynamics and structural change. Second, imperfect substitution between domestic and foreign goods endogenizes the tradable price and affects the real exchange rate path. Third, I apply the model to South Africa and analyze the macroeconomic impact of the increases in gold prices during the 1970s.

Numerical simulations show how the resource boom in the 1970s contributes to the structural change and the real exchange rate path observed in South Africa in subsequent decades. Higher public consumption following the boom leads to real exchange rate appreciation and expansion of nontradables at the cost of the industrial sector. Relative industrial productivity growth declines and the change in relative productivity has feedback effects on the economic structure and real exchange rate dynamics. A gradual real depreciation follows the initial appreciation of the real exchange rate, which is broadly consistent with the South African experience following the gold price boom. The productivity effect also tends to hold back the deindustrialization process.

The rest of the paper is organized as follows: Section 2 reviews the literature; Section 3 describes the South African experience from 1963 to 2003; Section 4 presents a dynamic general equilibrium model that incorporates endogenous productivity dynamics; Section 5 investigates the impact of the 1970s resource boom on the real exchange rate and structural change in South Africa; Section 6 presents a sensitivity analysis with respect to the elasticity of substitution between domestic and foreign goods; and Section 7 concludes the paper.

2. The literature on resource booms, productivity and the real exchange rate

The impact of a resource boom on structural change and the real exchange rate depends on how the additional income is allocated over time. Matsen and Torvik (2005) discuss the optimal spending path and highlight the importance of adopting a fiscal rule to manage resource wealth. Røed Larsen (2005) shows that Norway has avoided the resource curse for 25 years because of effective institutions and the well-designed public management of resource wealth. However, Gelb (1988) explains that higher resource income generates political pressure to increase government spending, and may generate Dutch disease effects. Because this mechanism is relevant to South Africa (documented in Section 3), the dynamic general equilibrium model is specified to incorporate an expansion of government consumption financed by the resource income.

Froot and Rogoff (1995) and Rogoff (1996) survey the long-run determinants of the real exchange rate. Commodity prices, sectoral productivity differentials, government spending, interest rate differentials, and net foreign assets are typically found to affect the path of the real exchange rate. Chen and Rogoff (2003) and Cashin et al. (2004) identify a significant long-run relationship between commodity prices and the real exchange rate. MacDonald and Ricci (2002) find that relative sectoral productivity affects the real exchange rate both directly through tradable prices and indirectly through wages. According to MacDonald and Ricci (2003), the South African real exchange rate path is primarily driven by developments in commodity prices,¹ but is also affected by relative productivity, government spending, relative real interest rates and the degree of openness. Aron et al. (2000) obtain similar findings.

Economy-wide modeling of productivity growth in developing countries often starts with the catching-up advantage of backwardness known as the Veblen–Gerschenkron effect. Nelson and Phelps (1966) first formalized the mechanism, and Parente and Prescott (1994, 2005) offer a modern restatement by introducing the concept of barriers to technology adoption. Nelson and Phelps (1966) concentrate on human capital as a barrier, while Parente and Prescott (1994) incorporate investment barriers. Here, I focus on the broader role of international barriers, as investigated in the literature on productivity spillovers (e.g., Klenow and Rodriguez-Clare, 2005).

A broad empirical literature addresses the sources of productivity growth and documents the importance of international spillovers through trade. Coe et al. (1997) conclude that a developing country can boost its productivity by importing a larger variety of intermediate products and capital equipment that embody foreign knowledge. Several studies indicate the importance for productivity growth in South Africa of both openness and domestic factors. Jonsson and Subramanian (2001) advocate the productivity-enhancing effect of an open economy; Harding and Rattsø (2005) address the endogeneity problem of openness and document the importance of trade barriers to South African

¹ Gold accounts for more than 60% of the South African commodity price.



Fig. 1. Gold price index, 1963–2003. Source: IMF (2004).

productivity growth. Fedderke (2002a) emphasizes domestic factors and identifies important productivity effects of R&D and the ratio of skilled to unskilled labor.

3. The South African experience²

Because South Africa is a resource-rich economy in which mining exports (mainly gold) account for about half of total export earnings, shocks to the world market price of gold are likely to affect the economy³. The gold price remained constant during the 1960s, but increased rapidly in the next decade to peak in 1980, and eventually stabilized at a new level almost ten times higher than the 1960 level (see Fig. 1). The gold price boom generated a rapid, but temporary, increase in resource rents in South Africa, as illustrated in Fig. 2.

Although the mining sector is mainly private, access to rents through taxation combined with political pressure for higher public spending following the resource boom generated higher public consumption as share of GDP from the mid-1970s to the mid-1990s (see Fig. 3). Even though the resource boom is temporary, it is hard to reverse increased public expenditure, and government consumption stabilizes at a new higher level⁴.

Fig. 4 illustrates the development of the South African real exchange rate during 1970–2002. The real exchange rate was stable in the early years; a sharp appreciation followed in the late 1970s, with the exchange rate peaking in 1984. Ignoring short-run fluctuations, the post-1984 trend exhibits a gradual depreciation of the real exchange rate.

Fig. 5 shows that South Africa experienced rapid structural change after 1980 with the service sector increasing from 45% to 65% of GDP during two decades. The expansion of services commonly occurs as countries develop, but South Africa experienced greater deindustrialization compared with the group of upper middle-income countries.

4. The dynamic general equilibrium model with endogenous productivity dynamics

Most applied general equilibrium models from the Dutch disease literature are static and do not consider real exchange rate dynamics or the transitional productivity effects of a boom (Benjamin et al., 1989; Vos, 1998). This paper offers a dynamic general equilibrium analysis to capture endogenous interactions between sectoral productivity, structural change, and the real exchange rate. Important features of the model are endogenous productivity, a myopic fiscal response to higher resource income, and imperfect substitution in tradables. Savings and investments are

² Lewis (2001), Jones (2002a), and Gelb (2004) provide recent surveys of the economic history of South Africa.

³ South Africa is the world's leading producer of gold and accounted for 55% of global production in 1980 (Jones, 2002b). More than half of South Africa's total export earnings in the 1970s and 1980s came from mining, and the share remained at 40% in the 1990s (Fedderke, 2002b).

⁴ In the same period, there was a surge in total public expenditure, mainly driven by public consumption, which accounted for about 50% of total expenditures in the 1960s and early 1970s. Since the mid-1980s, its share has been over 70%.

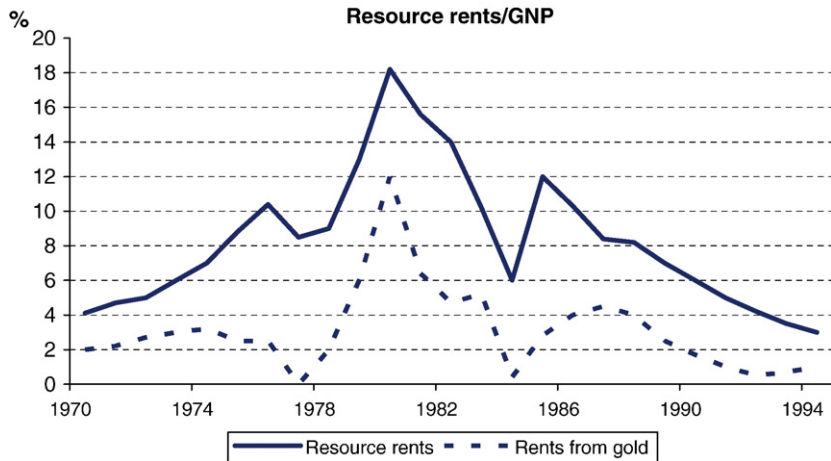


Fig. 2. South African resource rents as share of GNP, 1970–1994. Source: Jenkins (2001).

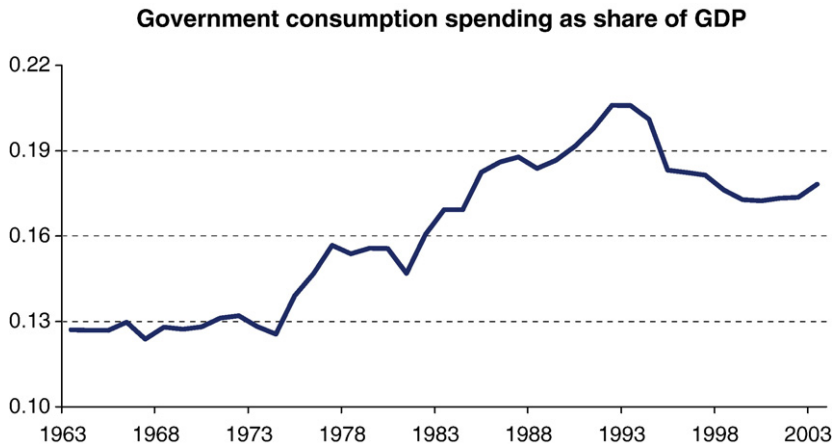


Fig. 3. Government consumption spending as share of GDP in South Africa, 1963–2003. Source: World Bank (2004).

allocated based on intertemporal optimization⁵. I model a small open economy that faces a perfect capital market with the interest rate exogenously given by the world market. Adjustment costs in investment, endogenous productivity, and the Armington specification contribute to prolonged transition dynamics. The rest of this section describes the main equations of the dynamic general equilibrium model; full documentation of the model is contained in a separate appendix, which is available from the author.

4.1. The supply side

The model includes three sectors: a nontradable service sector, a tradable industrial sector and a resource (mining) sector⁶. In the industrial sector, there is imperfect substitution between producing for the domestic market and for the world market, and exports are endogenously determined through constant elasticity of transformation (CET) functions.

⁵ Other Ramsey models with endogenous productivity dynamics include those of Diao et al. (2005, 2006) and Stokke (2004). While these analyses focus on growth issues, the present paper studies the impact of a resource boom on real exchange rate dynamics and structural change.

⁶ Agriculture is included in the tradable sector and accounted for about 4% of GDP in 1998.



Fig. 4. Real effective exchange rate, South Africa, 1970–2002. Source: MacDonald and Ricci (2003).

The mining sector exports all of its output at the exogenous world market price, which is calibrated to replicate the gold price boom of the 1970s.

I model sectoral value added ($X_{i,t}$) as a Cobb–Douglas function of capital ($K_{i,t}$) and labor ($L_{i,t}$):

$$X_{i,t} = A_{i,t}^{\alpha_i} L_{i,t}^{\alpha_i} K_{i,t}^{1-\alpha_i} \quad i = M, R, S \tag{1}$$

where the subscripts M , R , and S represent industry, mining, and services, respectively, and t denotes the time period. Labor and capital are mobile between industry and services and are allocated based on marginal productivities. I model the mining sector as an enclave that has no direct links with the rest of the economy. This sector employs sector-specific factors of production, the supply of which grows exogenously at a constant long-run rate. The specification ignores the resource movement effect of a resource boom and concentrates on the spending effect. This follows the analysis of Benjamin et al. (1989). It seems reasonable for South Africa because mining production depends partly on foreign labor (Jones, 2002a). In addition, an input–output analysis of the South African economy by Stilwell et al. (2000) identified few linkages between mining and the rest of the economy.

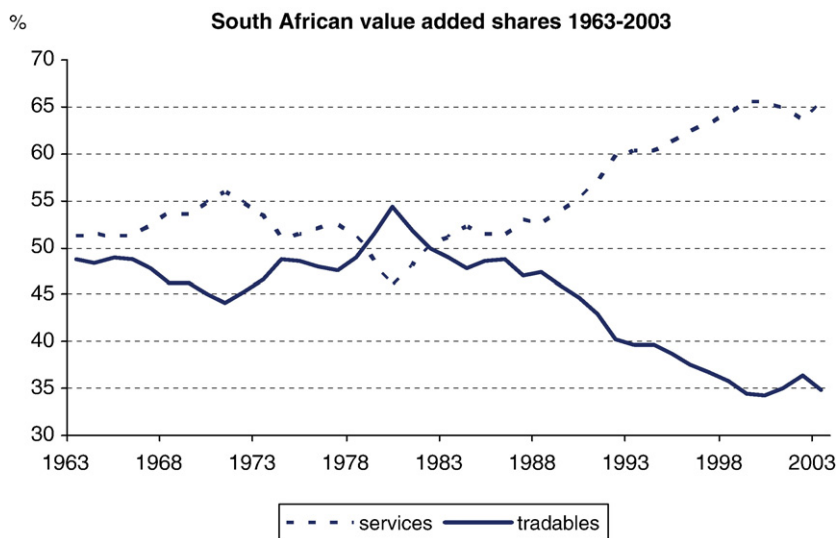


Fig. 5. South African value added shares for tradables and services, 1963–2003. Source: World Bank (2004).

Productivity growth is endogenously determined by sectoral learning by doing and technology adoption. I treat learning by doing as external and model it through the sectoral labor shares, which is consistent with existing specifications in the Dutch disease literature. Following Torvik (2001), I model learning by doing in both tradables and nontradables, but do not consider potential spillovers between domestic sectors. Technology adoption combines two elements: the distance to the world technology frontier defining the learning potential and the role of trade barriers. I apply the modified Nelson–Phelps technology gap specification (Benhabib and Spiegel, 2005). The productivity dynamics are consistent with the catching-up hypothesis, under which the growth rate increases with the distance to the technological frontier. However, unlike in the original Nelson–Phelps formulation, the relationship between growth and the technology gap is linear rather than exponential. This limits the advantage of backwardness and generates technological divergence when the barriers to technology adoption are high.

I specify sectoral productivity growth ($\hat{A}_{i,t}$) in period t as follows⁷:

$$\hat{A}_{i,t} = \lambda_{1,i} \left(\frac{L_{i,t}}{L_t} \right)^{\theta_{1,i}} + \lambda_{2,i} \left(\frac{\text{TRADE}_t}{\text{GDP}_t} \right)^{\theta_{2,i}} \left(1 - \frac{A_{i,t}}{A_{i,t}^*} \right) \quad i = M, S \quad (2)$$

The first term on the right-hand side represents the contribution from learning by doing, while the second term represents the technology adoption function. The terms $A_{i,t}$ and $A_{i,t}^*$ are the domestic and frontier levels of productivity, respectively, and $A_{i,t}/A_{i,t}^*$ represents the technology gap. $L_{i,t}/L_t$ is the sectoral labor share and $\text{TRADE}_t/\text{GDP}_t$ denotes aggregate trade as a share of GDP (not including mining exports)⁸. The parameters $\lambda_{1,i}$, $\lambda_{2,i}$, $\theta_{1,i}$, and $\theta_{2,i}$ are constants.⁹

4.2. The demand side

Perfect capital markets and intertemporal optimization imply that the impact of a resource boom is smoothed over time, because the associated new income can be invested in foreign assets. However, in South Africa, a rapid increase in public spending followed the increase in resource income. To capture this fiscal response to the resource boom, I treat the mining income as public and applied by a myopic government to finance public consumption¹⁰. Government spending does not affect the consumer's savings decision, which means that the model specification does not consider Ricardian equivalence. Public resource income (Y_g) is produced by the factors of production in the mining sector, and is spent on industrial goods (both foreign and domestic) and services according to constant shares (αg_i):

$$Y_{g,t} = w_{2,t} L_{R,t} + Rk_{2,t} K_{R,t} \quad (3)$$

$$P_{i,t} \cdot G_{i,t} = \alpha g_i \cdot Y_{g,t} \quad i = M, S \text{ and } \sum_i \alpha g_i = 1 \quad (4)$$

where $L_{R,t}$ and $K_{R,t}$ are the sector-specific supplies of labor and capital used in the mining sector, and $w_{2,t}$ and $Rk_{2,t}$ are the endogenous factor returns. Eq. (4) represents the balanced-budget constraint, in which $G_{M,t}$ and $G_{S,t}$ denote government consumption of industrial goods and services, respectively. $P_{M,t}$ and $P_{S,t}$ are the corresponding prices.

⁷ Productivity in the mining sector grows exogenously at the long-run rate.

⁸ Harding and Rattsø (2005) argue that aggregate (rather than sectoral) openness is a potential determinant of sectoral productivity growth in South Africa.

⁹ For the calibration, I assume that $\theta_{1,i}$ and $\theta_{2,i}$ are less than unity, which implies decreasing returns with respect to the two corresponding determinants of productivity growth. While the impact of learning by doing is set to be equal between sectors ($\theta_{1,M} = \theta_{1,S}$), the industrial sector benefits more from technology transfer through trade ($\theta_{2,M} > \theta_{2,S}$).

¹⁰ Rodriguez and Sachs (1999) assume a closed capital market, so resource income cannot be invested in international capital markets and must be spent immediately. Their analysis shows that resource-abundant economies may experience below steady-state growth because they are living beyond their means and are overshooting their steady-state level. Although a closed capital market may be relevant to South Africa because of the international sanctions against the Apartheid regime, I focus on the fiscal channel for resource boom effects.

The representative household receives income from employing its primary factors in industry and services, after subtraction of interest payments on its foreign debt. Revenues from sales taxes and import tariffs are transferred to the household in the form of a lump sum. As I explain later in this section, the household is forward looking and maximizes its intertemporal utility. I model within-period consumption by using a Stone–Geary demand system that incorporates minimum consumption levels for each good¹¹. Hence, the household has nonhomothetic preferences, and the income elasticities with respect to industrial goods and services may differ. I define aggregate consumption (Q_t) as:

$$Q_t = cs \cdot \prod_i (C_{i,t} - \bar{C}_i)^{\alpha_{ci}} \quad (5)$$

where $C_{i,t}$ is the consumption of each good and \bar{C}_i is the minimum consumption level, which is constant over time. The parameters α_{ci} and cs are constants. It follows that household demand for each commodity is given by:

$$P_{i,t} \cdot (C_{i,t} - \bar{C}_i) = \alpha_{ci} \cdot PQ_t \cdot Q_t \quad (6)$$

In calibrating the model, I assume that the minimum consumption level is higher for industrial goods. This implies that industrial goods have lower income elasticity. When income increases, demand gradually shifts towards services and away from industrial goods.¹²

I model imports of industrial goods by using an Armington composite system because imperfect substitution between domestic and foreign goods is common in most developing countries. As Benjamin et al. (1989) explain, imperfect substitution in tradables affects Dutch disease dynamics because the price of tradables is endogenously determined, rather than set on the world market. I define the real exchange rate (RER_{*t*}) as the relative price of nontradables and tradables.

$$\text{RER}_t = \frac{P_{S,t}}{P_{M,t}} \quad (7)$$

The tradable price ($P_{M,t}$) is a composite of the exogenous world market price and the endogenous domestic price. Services are not traded internationally and the price level ($P_{S,t}$) is determined endogenously in the domestic market. The assumption of perfect capital markets implies that the impact of interest rate differences on the real exchange rate is not considered. The analysis focuses instead on the gold price, public spending, and relative productivity as potential determinants of the real exchange rate path.

4.3. Intertemporal dynamics

While a myopic government spends the natural resource income, the household allocates its income to consumption and savings to maximize its intertemporal utility subject to a budget constraint. Assuming an intertemporal elasticity of substitution of unity yields the following Euler equation for the optimal allocation of total private consumption expenditure over time:

$$\frac{Q_{t+1}}{Q_t} \frac{PQ_{t+1}}{PQ_t} = \frac{1+r}{1+\rho} \quad (8)$$

where Q_t is aggregate household consumption, PQ_t is the aggregate price, r is the world market interest rate, and ρ is the positive rate of time preference.

¹¹ Geary (1950–51) originally developed the Stone–Geary utility preferences, while Stone (1954) applied them in empirical work.

¹² Rowthorn and Ramaswamy (1999) show that deindustrialization occurred in advanced countries mainly because of higher productivity growth in industry together with a changing composition of demand. I control for these effects in the model specification (through endogenous sectoral productivity and the Stone–Geary demand system) to capture the structural adjustment observed in South Africa.

Capital employed outside the mining sector is managed by an independent investor who chooses an investment path to maximize the present value of future profits over an infinite horizon, subject to a capital accumulation constraint. I model investment adjustment costs (ADJ) as a function of the investment–capital ratio:

$$ADJ_t = a \cdot P_{S,t} \cdot \frac{I_t^2}{K_t} \quad (9)$$

where $K_t = K_{M,t} + K_{S,t}$ is the aggregate capital stock outside mining, I_t is real investment, $P_{S,t}$ is the price of nontradables, and a is a constant parameter. Differentiating the intertemporal profit function with respect to capital yields the following no-arbitrage condition.

$$rq_{t-1} = Rk_{1,t} + P_{S,t} \cdot a \cdot \left(\frac{I_t}{K_t}\right)^2 - \delta \cdot q_t + \dot{q}_t \quad (10)$$

The condition in Eq. (10) states that the marginal return to capital must equal the interest payments on a perfectly substitutable asset with a value of q_{t-1} , where q is the shadow price of capital. The first term on the right-hand side, $Rk_{1,t}$, is the capital rental rate, while the second term is the partial derivative of the adjustment cost function with respect to capital. The marginal return to capital must be adjusted by the depreciation rate, δ , and by the capital gain or loss, \dot{q}_t .

Because investments can be financed through foreign borrowing, decisions about savings and investment can be separated. Domestic savings and investments need not be equal in each period, but there is a long-run restriction on foreign debt.

4.4. Long-run equilibrium

In the long run, the productivity growth rate equals the exogenous frontier growth rate g , and the technology gap is constant. The degree of catch-up depends on the extent to which there are trade barriers and on the learning capacity of the economy. The long-run equilibrium consequently implies a proportional relationship between A_i and A_i^* , as follows:

$$A_{i,T} = \frac{\lambda_{1,i} \left(\frac{L_{i,T}}{L_T}\right)^{\theta_{1,i}} + \lambda_{2,i} \left(\frac{TRADE_T}{GDP_T}\right)^{\theta_{2,i}} - g}{\lambda_{2,i} \left(\frac{TRADE_T}{GDP_T}\right)^{\theta_{2,i}}} \cdot A_{i,T}^* \quad (11)$$

where T represents the steady state periods. The equilibrium values of $L_{i,T}/L_T$ and $TRADE_T/GDP_T$ are constant and, together with the frontier growth rate and the parameters, determine relative productivity. Changes in the sources of learning by doing and technology adoption generate transitional growth, which establishes a new technology gap.

Driven by technological and neoclassical convergence, the long-run growth rate is exogenously given as the sum of the rate of technical progress and the labor growth rate. The capital stock and foreign debt both grow at the constant rate in the long run. The dynamics are consistent with the commonly held view that differences in income and productivity levels are permanent, while differences in growth rates are transitory (Acemoglu and Ventura, 2002).

5. Resource boom, real exchange rate dynamics, and structural change in South Africa

I apply the dynamic general equilibrium model to South Africa with numerical simulations to highlight the adjustment mechanisms related to the gold price boom. The model replicates gold prices during 1963–2003, as Fig. 6 shows. Calibration of the model is based on the 1998 Social Accounting Matrix for South Africa.¹³ I assume a long-run growth rate of 3% (comprising a 1% rate of technical progress and 2% labor growth), while transitional growth is endogenous. To get outside the long-run growth path, I scale down the initial capital stock and productivity levels. Foreign debt and labor supply are adjusted down accordingly. To capture the impact of higher resource income on

¹³ The Social Accounting Matrix is documented in a separate appendix available from the author.

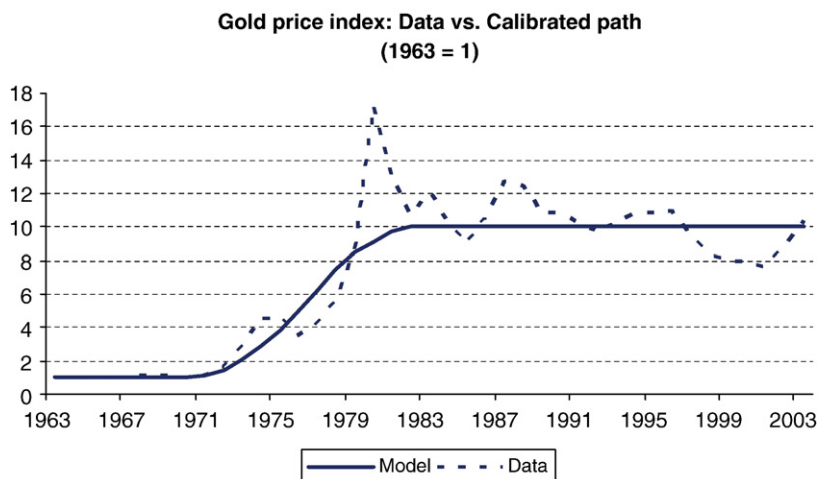


Fig. 6. Calibrated gold price index vs. observed index, 1963–2003.

structural change and real exchange rate dynamics, the baseline transition path based on the calibrated development of gold prices is compared with a counterfactual scenario in which the gold price remains at the initial level over time.

The model generates a public consumption path that is broadly consistent with the actual South African path. Initially, the resource boom leads to a demand-driven real exchange rate appreciation. Higher income increases the demand for both industrial goods and services, but because some of the industrial demand is directed towards foreign goods (because of imperfect substitution) the nontradable price rises by more than the composite industrial price. This causes a real appreciation during the boom period (Fig. 7), which is consistent with the observed development of the rand in the late 1970s (see Fig. 4, Section 3).

The resource boom generates structural change that affects relative productivity between domestic sectors. Over time, relative industrial productivity decreases, and this has a feedback effect on the dynamics of the real exchange rate. When the productivity effect is taken into account, gradual real depreciation follows the initial appreciation of the real exchange rate (Fig. 7). This pattern is consistent with the Balassa–Samuelson hypothesis (Balassa, 1964; Samuelson, 1964). Imperfect substitution between domestic and foreign industrial goods implies that the real depreciation is driven by both a lower nontradable price and a higher tradable price. The model generates real exchange rate dynamics that are broadly consistent with the South African experience and that cannot be captured without taking into account the endogenous productivity effect.

Following the initial real appreciation, capital and labor are allocated towards the service sector at the cost of industry, which leads to deindustrialization. This is the spending effect of a resource boom. Fig. 8 illustrates how the industrial value added share develops.¹⁴ There is a downward trend in the value added share along the counterfactual path on which the gold price is constant. This follows from nonhomothetic preferences and the relatively high income elasticity for services. However, the resource boom exacerbates deindustrialization¹⁵, which is consistent with the empirical analysis of Palma (2005) and Bell and Madula (2002).¹⁶ The structural shift away from industry is observed particularly after 1980 (see Fig. 5, Section 3). In the model, the labor market adjustments occur more quickly than actual adjustments, which explain why deindustrialization follows the resource boom immediately, rather than with the delay recorded by the data.

The resource boom changes sectoral productivity growth rates by affecting the degree of learning by doing and the level of barriers to technology adoption. Deindustrialization reduces the industrial labor share. Learning by doing has a

¹⁴ Because the mining sector is not included in this calculation, services' share of value added is the mirror image of industry's share.

¹⁵ Industry's share of value added declined by about 24 percentage points between 1963 and 2003; along the counterfactual path there is a corresponding decline of 15 percentage points.

¹⁶ Bell and Madula examine the decline of the South African manufacturing sector and highlight the role of the gold price boom, which generated real exchange rate appreciation and a loss of competitiveness.

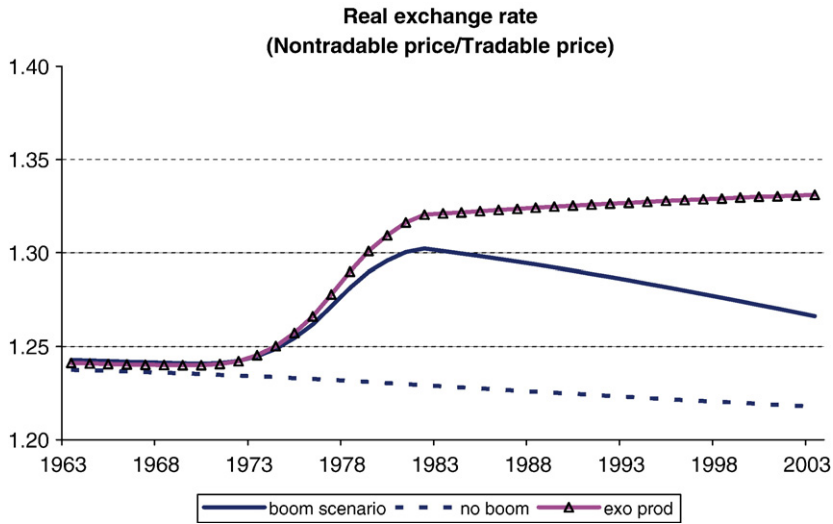


Fig. 7. Effect of the resource boom on the development of the real exchange rate, with and without endogenous productivity effect.

weaker effect on productivity in industry, but a stronger effect in services. There are two opposing effects on the degree of openness in the economy. The structural change away from industry lowers the trade share, but at the same time more of the industrial demand shifts to foreign goods because of the increase in the domestic tradable price. The latter effect depends on the substitution possibilities between domestic and foreign goods. In the simulations (based on a value of 3 for the elasticity of substitution), the first effect dominates. Hence, the trade share falls following the resource boom and this limits the transfer of foreign technology. Increased trade barriers negatively affect productivity growth rates in services and industry. However, because of higher dependence on foreign technology, the decline in industrial productivity is larger. The effects of learning and technology transfer combine to cause productivity growth to fall in industry but rise in services following the gold price boom (Fig. 9).

The change in relative productivity has two opposing effects on the allocation of productive factors between sectors. First, given its relatively low productivity, the industrial sector needs more labor and capital to maintain a given level of production, which slows the deindustrialization process. Second, the productivity change generates relative price effects (illustrated in Fig. 7) that intensify the structural change away from industry. An increase in the tradable price lowers

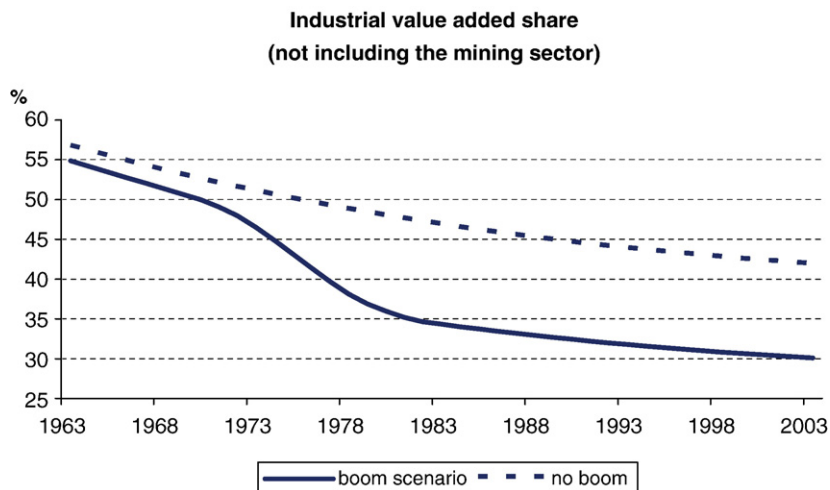


Fig. 8. Effect of the resource boom on industry's share of value added.

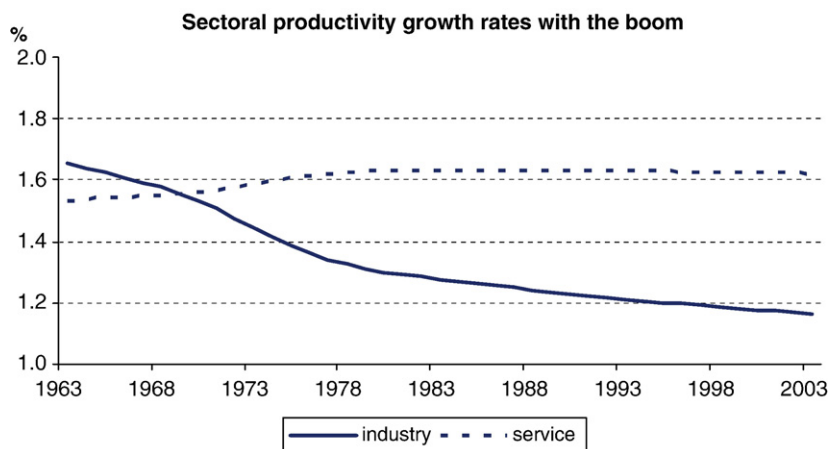


Fig. 9. Productivity growth paths in industry and services under the resource-boom scenario.

industrial demand and production, and shifts labor and capital into services. In the numerical simulations, the first effect dominates, and the feedback effect from a relatively low level of industrial productivity limits deindustrialization. In a counterfactual scenario, in which relative productivity is constant, the industrial value added share falls by 1.6 percentage points more than it does along the South African path. The long-run effect on structural change is even larger (by 3.4 percentage points). The introduction of trade barriers to technology adoption contributes to this outcome. An increase in resource income generates structural change that limits the transfer of foreign technology and strengthens the productivity effect.

6. Sensitivity analysis: the elasticity of substitution between domestic and foreign goods

To determine the impact of the degree of substitution in tradables on the real exchange rate path, I compare scenarios based on low elasticity values ($\sigma_m = 1.5$) and high elasticity values ($\sigma_m = 4$). A higher elasticity of substitution implies that the demand boom from higher resource income leads to a smaller increase in the composite industrial price, which tends to strengthen the initial real appreciation. However, even if the increase in the industrial price is smaller, relatively more demand shifts towards imported goods because of greater substitution possibilities. The decline in the demand for the domestic industrial good restricts production and decreases labor demand and, consequently, lowers wages relative to the low elasticity scenario. Lower household income reduces demand for industrial goods and services, and limits the increase in the nontradable price as well. This effect dominates, and the initial real appreciation is weaker the greater the substitution between domestic and foreign goods.

As explained above, higher resource income lowers relative industrial productivity. The elasticity of substitution in tradables affects the magnitude of this productivity shock. High substitution possibilities exacerbate deindustrialization (because there is lower demand for domestic industrial goods) and, hence, there is less learning by doing in industry. However, at the same time, imports remain high, and this stimulates productivity growth through technology transfer. In the simulations, the trade effect dominates the learning effect, and industrial productivity growth increases as the elasticity of substitution between domestic and foreign goods increases. Productivity growth in services is stimulated by both learning by doing and by technology transfer, but relative industrial productivity declines by less when the elasticity is higher. Industrial productivity growth benefits relatively more from greater substitution possibilities, and the magnitude of the productivity shock is smaller when the elasticity is higher.

The productivity effect generates a gradual real depreciation following the initial appreciation of the real exchange rate. The elasticity of substitution between domestic and foreign goods affects the strength of this feedback effect. As explained above, the magnitude of the productivity shock is smaller when there are greater substitution possibilities, which limits the extent of the real depreciation following the boom. In addition, the flatter demand curve implied by a higher elasticity makes the price effect of a productivity shock smaller. Both effects work in the same direction, and the gradual real depreciation is lessened by a higher elasticity of substitution between domestic and foreign goods.

7. Concluding remarks

This paper examined the macroeconomic impact of the gold price boom of the 1970s on the South African economy. I applied a dynamic general equilibrium analysis to clarify the adjustment mechanisms related to higher resource income. The model specification captured the endogenous interaction between sectoral productivity, structural change, and real exchange rate dynamics. Important features of the model were endogenous productivity, a myopic fiscal response to higher resource income, and imperfect substitution in tradables.

Numerical simulations showed how the resource boom explained the observed paths of structural change and the real exchange rate in South Africa. Increased public consumption following the boom caused a real exchange rate appreciation and led to an expansion of services at the cost of the industrial tradable sector. Structural change affected sectoral learning by doing and the extent of trade barriers (through lower trade share as the nontradable sector expanded). Relative industrial productivity decreased, and led to gradual real depreciation following the initial appreciation of the real exchange rate.

During the period under study, South Africa faced changing trade conditions because of international sanctions against the Apartheid regime. While they may have affected the real exchange rate path and structural adjustments, they were not incorporated in this analysis. Instead, I focused on the effect of the gold price boom, both directly and indirectly via the relative productivity between domestic sectors. Future research should investigate the importance of sanctions in this setting.

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