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A DYNAMIC ANALYSIS OF FINANCIAL INTERRUPTION ON A SMALL OPEN ECONOMY: A CASE STUDY ON SOUTH AFRICA

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ABSTRACT

The paper examines the effectiveness of the financial embargo on South Africa, which was imposed in 1985 and lifted in 1993. The theoretical framework is a simple, small, open economy version of Ramsey's growth model calibrated to South African conditions. The South African embargo limited the country's ability to borrow through imposing a proportional tax on foreign borrowings to capture the disinvestment during the embargo period. By assuming apartheid as a constant tax on foreign borrowings to South Africa, the effect of the embargo on South African apartheid was incorporated. Using quarterly data from 1960 to 2008, our empirical findings, based on the logit and intervention methods, indicate that (i) there is a negative relationship between financial isolation and foreign investment, and (ii) there is a negative link between the embargo and the degree of apartheid. The policy implication of our results is that the financial embargo was effective in dismantling South African apartheid.

Contribution/Originality: This study adds to the literature by providing a dynamic analysis on the impact of the sanction on South Africa's economy.

1. INTRODUCTION

From 1948 to 1994, the Nationalist Party governed South Africa. Upon coming into power, the Nationalist Government enacted legislations that laid the foundation of the apartheid regime, a regime under which citizens from different racial groups had different rights. This system faced growing international criticism and condemnation in the 1960s, and the United Nations and several countries imposed economic sanctions on the country to put an end to the apartheid system. The sanctions imposed by the international private financial sector were probably the most damaging of all the foreign measures initiated against South Africa when the long-run private capital account first moved into deficit (Jones & Muller, 1992). In 1985, the economic sanctions were intensified and led to the debt crisis, which, in turn, gave a boost to the sanctions campaign by exposing an area of vulnerability (Lipton, 1988). However, the economic sanctions continued until the apartheid system was dismantled in 1993. Thus, the period from 1985–1993 is called the embargo period, which are the years when the sanctions were in force.

During the embargo period, average growth rates decreased from 0.2 percent to -2.6 percent for investment, from 3.5 to 1.3 percent for capital per worker, and from 2.2 to 0.8 percent for output per worker. Generally speaking, due to the embargo, net capital inflows reversed to net outflows of approximately 2 percent of GDP per year, the current account reversed from an average of 2 percent of GDP deficit prior to the embargo to a 2.4 percent surplus during the embargo period, and finally, foreign liabilities as a percentage of GDP decreased from 53 percent prior to

1985, to 44 percent during the embargo period. In short, the descriptive statistics of investment, capital, and output suggest that the embargo adversely influenced the economy.[1]

With this brief overview of sanctions against South Africa, it might be tempting to estimate the effectiveness of the embargo on foreign capital inflows to South Africa. Furthermore, we incorporate the effect of the embargo on South African apartheid, as very few studies have examined the role of the financial embargo on South African economic behavior. Lowenberg (1997) argued that South Africa's apartheid regime failed because the inefficiencies generated by apartheid policies escalated as the economy's structure changed. A mercantile development strategy distorted trade patterns, exacerbated dependence on foreign capital inflows, and created chronic difficulties regarding balance payment. In addition, Lowenberg mentioned that the apartheid educational policy led to a skill shortage and the administrative and defense costs of implementing apartheid were onerous. These domestic weaknesses increased South Africa's vulnerability to capital flight, changes in world prices and business cycle conditions, and political changes abroad. He concluded that the internal dynamic of the system dictated the retrenchment of apartheid, which would have taken place even without foreign sanctions. Evenett (2002) analyzed the effect of eight industrialized economies' sanctions on their imports from South Africa by estimating gravity equations. He concluded that sanctions adversely affected South African exports the most. Mohamed (2007) examined the effect of the financial embargo on South Africa on the time path of the economic growth rate of the country. She concluded that the financial embargo that was imposed on South Africa had no permanent effect on the economic growth of the country. Finally, Coulibaly (2009) studied the impact of financial isolation and financial integration on the South African economy during the pre-embargo, embargo, and post-embargo periods. His model was calibrated to the South African economy utilizing specific benchmark parameters. With the benchmark parameters, he used the time-elimination method following Mulligan & Sala-i-Martin (1991) and the numerical estimation method. His results showed that there is a positive (negative) link between financial integration (isolation) and economic growth.

To measure the effect of the financial embargo on South African investment and apartheid, a simple Ramsey's growth model was introduced in the context of a small open economy with perfect capital mobility. The theoretical framework consists of two parts. The first part assumes that the financial embargo is a proportional tax on foreign borrowings to South Africa and shows that the extent of the effect of the embargo depends on the model variables. The second part connects the financial embargo with apartheid, i.e., it assumes that the embargo is a constant tax on foreign borrowings to South Africa. Since the embargo changes according to the degree of apartheid, the extent of its imposition increases as the violations of human rights increase and decreases or halts as the apartheid system is lifted. The resulting dynamic for investment confirms a negative link between the extent of the financial embargo and the interest rate, i.e., the interest rate decreases as the extent of the embargo increases. This can then explain the outflows of capital from South Africa through the period of the international financial embargo. In summary, the theoretical part concludes that the financial embargo could be an effective tool in achieving its goals.

Finally, we test whether the financial embargo performs well in addressing the above-mentioned issues or realizing its goals in South Africa. For this test, a logit analysis and intervention model were used. Here we are juxtaposing the financial embargo as an external variable and use the degree of the observed human rights violation as an internal variable in order to arrive at the politicization of the financial embargo as an economic variable. Our empirical findings based on the logit approach and intervention model indicate that (i) there is a negative relationship between financial isolation and foreign investment, and (ii) there is a negative link between the embargo and the degree of apartheid. However, our empirical results were found to be in line with the results derived from the theoretical framework.

The remainder of the paper is organized as follows: Section 2 introduces the neoclassical growth model calibrated to South African conditions, Section 3 presents the data and empirical methodology, Section 4 provides the empirical findings, and the last section offers conclusions.

2. THEORETICAL FRAMEWORK

We present a simple open economy version of Ramsey's model with perfect capital mobility[2] assuming that firms produce a single commodity Y by means of human capital, skilled labor, whites (N_W), and unskilled or black labor (N_B). The Cobb–Douglas technology with constant return to scale is explained in Equation 1 as:

$$Y = (\mathrm{AK})^{a} (N_B)^{(1-a)} \quad (1)$$

Where AK is white labor or human capital (N_W), N_B is black or unskilled labor, and A is the factor of productivity. The subscript t (time) is eliminated to save notations. We assume that A is constant for two reasons: to simplify the analysis and to maintain the fundamental features of a neoclassical production function.

Whites own the entire capital in South Africa's economy. In this study, a strong assumption is made that each white owns a unit of AK. In an open economy version, domestic output can be devoted to gross private consumption, gross domestic investment, and net exports, as explained in Equation 2:

[1] The data was obtained from the South African Reserve Bank (http://www.resbank.co.za) and the Trade and Industrial Policy Strategies Database (http://www.tips.org.za).

[2] See Barro & Sala-i-Martin (1995) and Barro & Sala-i-Martin (2003).

$$Y = C + I + X, \quad (2)$$

Where C is consumption, I is domestic investment, and X is net exports. For simplicity, there are no depreciation or adjustment costs for investment. Investment I adds to the capital stock K, which is owned by whites N_W only:

$$K = I, \quad (3)$$

Where the dot on the variable denotes the time derivative. A financial embargo is considered in which sanctions M are imposed on foreign borrowing:

$$M = m\,B, 1 > m \geq 0, \quad (4)$$

Where M is the degree of the embargo, B is foreign borrowing, and M equals zero in peace times and 1 in war times, which is not applicable in this case, and it ranges between zero and 1 in hostile times (the value of m then depends on international relation issues). Equation 4 is an external equation imposed by lenders on the target country. Thus, the rest of foreign borrowing $(1-m)\,B$ is added to the foreign debt D and the accumulation of foreign debt will be restricted by $(1-m)$ and it is assumed that:

$$D = B. \quad (5)$$

On the other hand, foreign borrowing B equals interest payments on foreign debt ($r_w D$) minus net exports X., assuming that the country in question is a debtor country, i.e.:

$$B = r_w D - X. \quad (6)$$

As long as $(1-m)$ of foreign borrowings is only available for the target country to borrow, then Equation 6 will be also restricted by $(1-m)$. Furthermore, the apartheid $(Apartheid)$ is added to the sanctions M and more apartheid induces more international interventions to end the apartheid system:

$$M = Apartheid \quad (7)$$

Labor force N includes both black labor and white labor,

$$N = Nw + N_B. \quad (8)$$

Black labor grows at a constant rate n_B,

$$N_B = n_B N_{B..} \quad (9)$$

White labor grows at constant growth rate n_W,

$$N_W = n_W N_{W..} \quad (10)$$

For simplicity, it is assumed that the total population growth rate is zero but the growth rate of each labor group does not equal zero.

Firms maximize profits under perfect competition.[3] The marginal product of capital MPK determines the interest rate r, and the marginal product of labor MPN determines the wage rate w, i.e.,

$$r = MPK = \P Y/\P K = a(AK)^{a-1} AN_B^{(a-1)} = a\,Y/K. \quad (11)$$

And since whites own capital, the return on capital is the same as the return on white labor, so:

$$w_w = r. \quad (12)$$

$$w_B = \P Y/\P N_B = (1-a)\,(N_W/N_B)^{a.} \quad (13)$$

Households maximize utility within an infinite horizon assuming that both blacks and whites have the same consumption preferences, while whites are the decision makers since they have the political power according to the apartheid system. The general optimal problem then takes the following formula: μ

$$Max\ U_o = \int_0^{\mu} e^{-rt}\ ln\,(c^t).dt \quad (14)$$

[3] Firms maximize profits under perfect competition in terms of its economic perspectives. This assumption does not mean that the competition between black labor and white labor is considered here since both types of labor are considered to be heterogeneous.

$$o$$

Subject to:

$$D = C + I + r\,D - f(K), \tag{15}$$

M =mB, $0 \leq m < 1$

K = I,

M = Apartheid,

$$\lim_{t \to \mu} e^{-rt} D_t = 0, \tag{16}$$

$$r = r_w, \tag{17}$$

Where r is the constant rate of time preference. Equation 16 is the non-Ponzi game condition and Equation 17 is the stability condition to guarantee a stable consumption path only if there is no financial embargo imposed in the above model. With a financial embargo, the situation will be different and we have to impose another condition on m in which m could be between zero and 1. Then, we can express the model in per capita terms by dividing each variable by N.

2.1. The Optimal Solutions[4]

This problem can be solved under two main assumptions:

(i) We assume that financial embargo equals mB where m is the degree of the financial embargo. The range of m is from 0 to 1 but it must be less than 1 to obtain a stable solution. Thus, sanctions M are considered to be a proportional tax on the foreign borrowings to South Africa. Consequently, we have $M_t = mB$. This is because the available foreign borrowing to the target country is restricted by $(1-m)$.

$$H_t = [u(c_t) - \lambda_t \{c_t - mc_t + i_t - mi_t + \rho d_t - m\rho d_t - f(k_t) + m\,f(k_t)\} + \lambda_t\, q_t\, i_t]e^{-\rho t} \tag{18}$$[5]

(ii) We assume that the sanction is a constant tax that will be subtracted from foreign borrowings $(B - M)$. In this case, we impose the apartheid variable $(Apartheid)$ in the model internally since we assume that sanctions depend on $Apartheid$, i.e., more apartheid leads to more sanctions. For simplicity, we assume that the relationship between the apartheid and the sanction is linear; $M = a\,Apartheid$.[6] When apartheid reduces, M declines by a, where a is a constant factor. In the second assumption, we make a connection between an external variable (sanction) and an internal political variable (apartheid). Thus, we have:

$$H_t = [u(c_t) - \lambda_t\{c_t + i_t + \rho d_t - f(k_t) - M_t\} + \lambda_t\, q_t\, i_t - \lambda_t\, g_t\, Apartheid]e^{-\rho t}. \tag{19}$$[7]

2.2. The Optimal Solution under the First Assumption

The necessary and sufficient conditions are as follows:

(i) $$\partial H_t / \partial c_t = e^{-pt}\, u'(c_t) - \lambda_t\, e^{-\rho t}(1-m) = 0. \tag{20}$$

Therefore,

$$u'(c_t) = \lambda_t\,(1-m), \tag{21}$$

The shadow value of foreign debt λ_t less the degree of the financial embargo times the shadow value of foreign debt $m\,\lambda_t$ equals the marginal utility of consumption $u'(c_t)$. Thus,

$c_t = 1/[\lambda_t\,(1-m)]$ and (22)

(ii) $$\partial H_t / \partial i_t = -e^{-\rho t}\,\lambda_t\,\{(1-m)\} + e^{-\rho t}\,\lambda_t\, q_t = 0. \tag{23}$$

This equation leads to:

$$q_t = (1-m), \qquad 1 > m \geq 0. \tag{24}$$

The shadow value of the capital stock q_t equals 1 minus the degree of the financial embargo m. If the degree of the financial embargo is zero then the shadow value of the capital stock will equal 1 and the investment will be zero. So,

(iii) $$\partial\,(-\lambda_t\, e^{-\rho t}) / \partial t = -\partial H_t / \partial d_t = \lambda_t\, e^{-\rho t}\,\partial(1-m). \tag{25}$$

This equation leads to:

[4] See Appendix A for more detailed solutions.

[5] This is because both Equation 5 & 6 are restricted by $(1-m)$ in both sides.

[6] For convenience, let $M = a\,A$, and $dM/dt = A$, then $(dM/dt)/M = 1/a$.

[7] This is just the regular Hamiltonian equation when solving the simple open economic version of the Ramsey model but we just added and subtracted the effect of sanctions from the same equation. Although this will not add mathematically more implications but it adds more interpretations to the model and can count for the effect of sanctions and its relationship to the apartheid. This is a standard methodology in theoretical analyses in Economics in general. See for instance the analysis of the effect of the sudden shock in the standard aggregate supply/aggregate demand model with nominal rigidities.

$$\lambda_t / \lambda_t = \rho m. \quad (26)$$

This is a difference equation and its solution combined with Equation 22 leads to:

$$c_t = e^{-(\rho t m)t} c_o. \quad (27)$$

By integrating the dynamic budget constraint, we get the following intertemporal budget constraint:

$$c_o (1-m)/\rho \int = \int_o^{\infty} e^{-(1-m)\rho t} (1-m) [f(k_t) - i_t].dt - d_0, \quad (28)$$

Where $(f(k_t)- i_t)$ is the net output. The growth rate of consumption is illustrated in the following equation:

$$c_t / c_t = \rho m \quad (29)$$

If the degree of the financial embargo $m = 0$, the growth rate of the consumption will equal zero as well and consumption will be constant. According to Equation 29, the degree of the financial embargo times the foreign interest rate affects the growth rate of consumption. Then, by imposing a financial embargo, consumption grows by rate ρm. The plausible interpretation for this result is that consumers get used to living with hostilities as long as the hostility is persistent and their precautions for the future reduce over time. Thus, the optimal saving becomes:

$$S_t / N_t = f(k_t) - \{ e^{-(m\rho)t} \{ [\rho/(1-m)] \int_o^{\infty} e^{-(1-m)\rho t} (1-m) [f(k_t) - i_t].dt \} + (\rho m/(1-m)) d_t. \quad (30)$$

If the degree of the financial embargo is zero, the optimal saving will not depend on the level of foreign debt in this model and q_t will equal 1 and hence i will equal zero (see Appendix A). Also note that with $1 > m > 0$, the change in the optimal saving with respect to the level of debt will equal $\rho m/(1 - m)$. Thus, if d decreases by 1, optimal saving will decrease by $\rho m/(1 - m)$.

(v) $$\partial(\lambda_t q_t e^{-\rho t}) / \partial t = -\partial H_t / \partial K_t = - e^{-\rho t}\lambda_t f'(k_t) + e^{-\rho t}\lambda_t m f'(k_t). \quad (31)$$

Equation 31 leads to Equation 32 (see Appendix A for details):

$$f'(k_t) = \rho - \rho m. \quad (32)$$

If the degree of the financial embargo is zero, the result will be the static equilibrium condition. For optimal capital stock, the marginal product of capital equals the interest rate. If the degree of the financial embargo is 1, then interest rate will be zero. Accordingly, all capital will flow out of the country, which is unreasonable. For that reason, it is necessary to impose the condition of $m < 1$.

According to Equation 32, when the degree of the financial embargo increases, the return on capital decreases and capital flows out of the country. This result confirms huge capital outflows from South Africa during the period of the imposed embargo. Also note that the wage rate of white people will be affected according to the assumptions of the model since they own the capital stock.

2.3. The Optimal Solution under the Second Assumption

Interest groups (whites) will benefit from maximizing the apartheid since it gives them more power in the economy:

(i) $$\partial Ht / \partial (Apartheid) = e^{-\rho t} \lambda_t a - e^{-\rho t} \lambda_t g_t = 0 \quad (33)$$

Equation 33 leads to the following results:

(ii) $$\partial(\lambda_t g_t e^{-\rho t}) / \partial t = \partial H_t / \partial M_t = e^{-\rho t} \lambda_t \quad (34)$$

Where $a = dM / d(Apartheid)$, when the apartheid increases, the sanctions increase by a and the shadow cost of apartheid g_t equals the responsiveness of the sanctions to the apartheid system a. If the responsiveness of the international sanctions to the apartheid is zero, then the shadow cost of the apartheid becomes zero (it is assumed that a is a constant factor for simplicity).

$$g_t = a, \quad (35)$$

By solving Equation 34 with the combination of Equation 35 and Equation 32 with $m=0$, we obtain the following final result[8]:

$$f'(k_t) = 1/a. \quad (36)$$

Equation 36 has important implications. According to the assumptions of the model, the marginal product of capital $f'(k_t)$ equals the wage rate of whites. This implies that if the responsiveness of the financial embargo to the apartheid increases (or when the cost of implementing apartheid increases) the wage rate of whites decreases. On the other hand, the reduction of the capital return inside the country will make the domestic environment less attractive for investment. This implies that capital will flow out of the country. This result proves again that the embargo could

[8] We solve here under the second assumption in which $m = 0$ and sanction is considered as a constant tax from foreign borrowings. The solution will lead to $f'(k) = \rho$ in which the interest rate equals marginal product of capital.

be a very effective weapon since it directly hits whites' power or their wage rates. It also explains the relationship between the responsiveness of sanctions to apartheid and the capital outflows during the time of imposing the sanction.

3. DATA AND EMPIRICAL METHODOLOGY

In this study, two main hypotheses are tested.

1) There is a link between the degree of the observed human rights violations in South Africa and the degree of the embargo. Thus, the first null hypothesis states that sanctions are not a function of the degree of the observed human rights violations. Here, the apartheid is measured by the periods of the observed human rights violations.

2) The official multilateral financial embargo of 1986–1991 is the main explanation for the capital outflows during the same period. Thus, the second null hypothesis is that the financial embargo does not have a significant negative effect on foreign capital flows.

These two hypotheses are tested by utilizing a logit approach and an intervention analysis, respectively. The dataset used in this study is quarterly for the period from 1960-I to 2008-IV and was obtained from the *International Financial Statistics*. The descriptions of all dummy variables used in this study are based on the studies by Evenett (2002), GATT (1993), Hufbauer, Schott, & Elliott (1990), Levy (1999) and Lipton (1988).[9]

In the case of the first hypothesis, the embargo is the dependent variable and it is constructed as a dummy variable. The degree of the apartheid is measured by the degree of human rights violations that drew the attention of the international community, which, in turn, created political instability in the country. The main variable is the embargo (*EMBARGO*), which refers to the imposition of the embargo, 1 if this is the case, 0 otherwise. We consider three different measures of *EMBARGO*: *EMBARGO1*, 1 during the period of the imposed multilateral financial embargo (started in 1986 and officially lifted in 1991)[10], 0 otherwise; *EMBARGO2*, 1 during the periods of imposed financial sanctions on South Africa other than during the period of 1986–1991, 0 otherwise; and *EMBARGO3*, 1 during the periods of any type of imposed sanctions on South Africa other than the financial embargo (such as trade embargo, disinvestment, technological embargo, or mixed embargoes), 0 otherwise. Incorporating these three different measures for *EMBARGO* is to collect data from various sources and to control for other periods of imposed embargoes rather than solely the period in question.

The variable (*APARTHEID*) reflects the degree of the observed human rights violations in South Africa and takes on the values for: (1) for the highest degree of the observed violation of human rights, (2) if there is a stable state of apartheid, i.e., the human rights violations did not draw the attention of the international community, (3) if there is a domestic political reform to reduce human rights violations, and (4) if the apartheid is lifted.

According to the theoretical model,

$$EMBARGO = f(APARTHEID). \quad (37)$$

This is because the main goal of imposing the embargo is to end the apartheid in South Africa. To address the relationship between these two variables (*EMBARGO* and *APARTHEID*), we use a logit approach because the dependent variable, *EMBARGO*, is a binary dummy variable that only takes on two values.[11] Table 1 shows the results of the estimation by using the three different measures of *EMBARGO*.

According to the three estimated models in Table 1, there is a significant negative relationship between *APARTHEID* and *EMBARGO*. The results reveal that a higher degree of human rights violations draws more attention from the international community and increases the embargo and vice versa since higher *APARTHEID* values means fewer human rights violations and more political stability.[12] Thus, we can then reject the first null hypothesis and conclude that imposing an international embargo against South Africa was a credible strategy.

[9] We also used the following website for the construction of our dummies: https://www.thoughtco.com/african-history-4133338, http://www.sahistory.org.za, http://www.ia-forum.org/Files/EFTHKF.pdf.

[10] A few countries lifted their economic sanctions in 1993.

[11] We also used a probit model and extreme value analysis. The results, which are not presented here but are available on request, indicate a significant relationship between EMBARGO and APARTHEID.

[12] In order to control for the stability of the relationship between *APARTHEID* and *EMBARGO1*, we regressed the first model by including three more variables that are supposed to have some impact on the dependent variable. These three variables are the internal economic circumvention to the international actions against the government of South Africa (*REACTION*), the degree of the openness of the country represented by trade share in GDP (*TRADESHARE*), and the imposition of other types of sanctions. This separates the effects of the financial embargo from other types of embargoes (*TARGET*), where *REACTION* takes on the following values: (1) if there is any trial for financial circumventions; (2) if there is any trial for other economic circumventions; (3) if there is no internal economic circumvention. *TARGET* is another dummy variable which takes on the following values: (1) if there are comprehensive international sanctions; (2) if there is only a financial embargo; (3) if there are no sanctions imposed on South Africa. *TRADESHARE* is a quantitative variable that measures the ratio of trade to GDP in South Africa as a measure of the degree of South Africa's openness. However, the impact of *APARTHEID* on *EMBARGO1* is still significant whether we include or exclude those three variables. The results are available on request from the authors.

Table 1. Logit analysis results.

	EMBARGO1	EMBARGO2	EMBARGO3
C_o	-0.136170 (-0.203317) (0.8389)	2.583008 (3.221171) (0.0013)	2.263935 (3.773012) (0.0002)
APARTHEID	-0.793528 (-2.62824) (0.0086)	-1.707464 (-4.33439) (0.00000)	-1.331487 (-4.853818) (0.0000)
McFadden R-squared	0.062008	0.195962	(0.169277)
Log Likelihood	-68.34971	-85.86944	-100.2922
Probability (LR stat)	0.002646	9.82E-11	1.62E-10

Notes: The numbers between the first parentheses are z-statistics, and the numbers between the second parentheses are *P*-values. The dependent variable is EMBARGO. The number of observations is 196 (1960-I, 2008-IV).

In the case of the second hypothesis, an intervention model was employed proposed by Enders, Sandler, & Cauley (1990).[13] This enables us to study the impact of the degree of the observed human rights violations on the time path of the real net foreign financial flows (*REALNFF)* of South Africa (see Figure 1). The model is given by Equation 38 below.

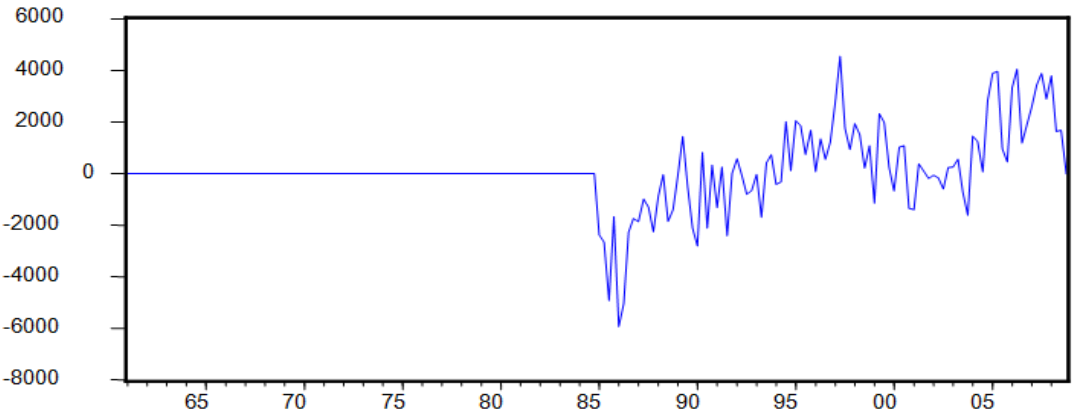

Figure 1. Plot showing the behavior of the *REALNFF* variable over time.
Note: Effectiveness of the embargoes on foreign capital flows (1961-I, 2008-IV)

$$REALNFF_t = a_0 + A(L)REALNFF_{t-1} + c_o\, APARTHEID + B(L)\,\varepsilon_t, \quad (38)$$

Where *APARTHEID* is an intervention variable that again represents the degree of the *observed* human rights violations in South Africa (it takes the same values as represented above and ε_t is a white noise disturbance term). In addition, $A(L) = 1 + a_1L + a_2L^2 + \ldots + a_qL^q$ and $B(L) = 1 + b_1L + b_2L^2 + \ldots + b_qL^q$ are polynomials in lag operator *L*.

Prior to estimating the parameters in Equation 38, we checked the time-series properties of the underlying data in order to avoid spurious and misleading inference. The first step is to test the *REALNFF* series for stationarity by applying the Phillips–Peron test**.** No evidence of unit root in the *REALNFF* series was found. We also tested the series for the presence of autoregressive conditional heteroskedasticity (ARCH) effects using the correlogram test. We found evidence of conditional heteroskedasticity in the *REALNFF* series. Thus, we used the ARCH method suggested by Enders (1995) to run the regression. Equation 39 below shows the results of the best fit intervention model that has the lowest AIC and SC and satisfies all diagnostic checks, with 192 observations (1961-I, 2008-IV):[14]

$$EALNFF_t = -507.0013 + 0.842438\, REALNFF_{t-1} + 252.2818\, APARTHEID,$$
$$(-8.132373) \quad (8.549971) \quad (11.54526)$$
$$(0.0000) \quad (0.0000) \quad (0.0000) \quad (39)$$
$$Adj\ R^2 = 0.369431$$

The numbers between parentheses are z-statistics and *p*-values, respectively. According to the best fit intervention model in Equation 39, there is a significant negative relationship between the degree of the observed human rights violations and the real net foreign financial flows in South Africa. Fewer observed human rights violations lead to capital inflows (see the degrees of *APARTHEID* explained above). The contrary is also true;

[13] Fomby & Hayes (1990) and Lloyd (1993) also used an intervention analysis.

[14] The following criteria were used to identify the best fit intervention model: (i) the lowest Akaike Info Criterion (AIC) and Schwarz criterion (SC), (ii) the highest adj R^2, and (iii) according to Enders (1995), "All coefficients should be statistically significant at conventional levels and the autoregressive coefficients should imply that the $\{y_t\}$ sequence is convergent and the residual should approximate white noise."

more observed human rights violations lead to capital outflows (or a reduction in net real foreign financial flows). This result may explain the capital outflows that happened during the embargo. In addition, we can deduce from Equation 39 that the effect of this instability will not last longer. Figure 2 illustrates the forecast of the model described in Equation 39. We also used the net foreign borrowings *REALNKF* (see Figures 3 and 4) as another proxy for capital inflows. The results (not presented here but available on request) did not show any significant changes. Thus, we can reject the second null hypothesis and conclude that the apartheid led to the capital outflows. This empirical result also confirms the theoretical results in the previous section.

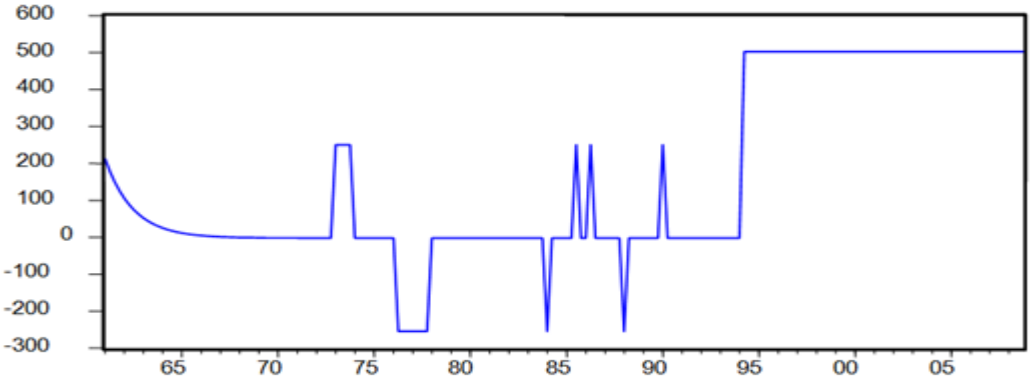

Figure 2. Plot showing the forecast of best fit intervention model for *REALNFF* over time.
Note: Effectiveness of the embargoes on foreign capital flows (1961-I, 2008-IV).

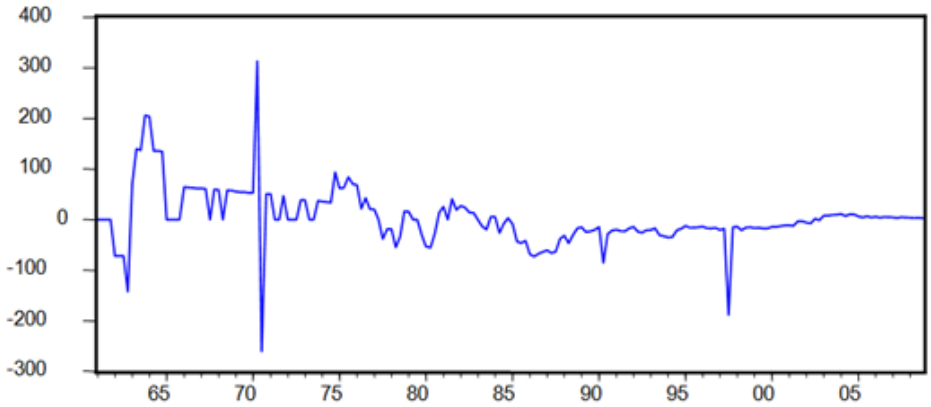

Figure 3. Plot showing the behavior of the *REALNKF* variable over time.
Note: Effectiveness of the embargoes on foreign capital flows (1961-I, 2008-IV).

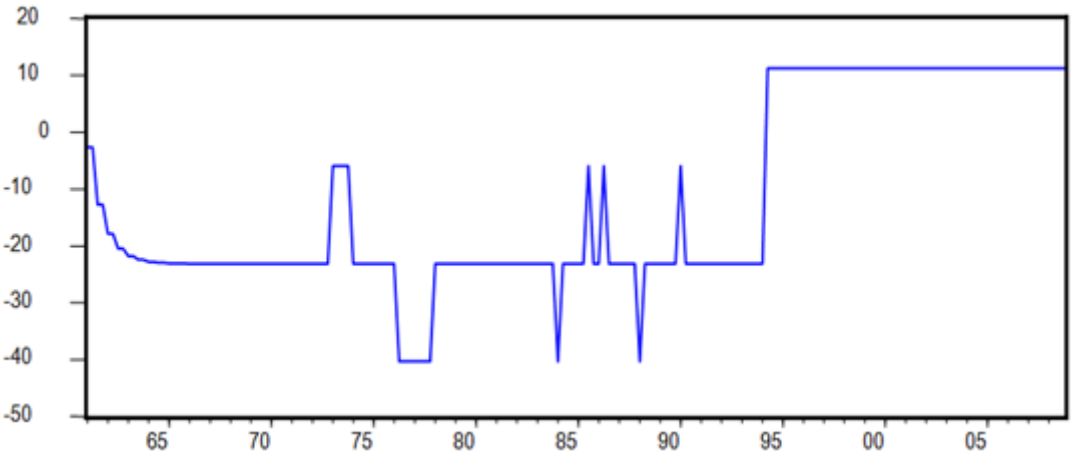

Figure 4. Plot showing the forecast of the best fit intervention model for *REALNKF* over time.
Note: Effectiveness of the embargoes on foreign capital flows (1961-I, 2008-IV).

4. SUMMARY AND CONCLUSIONS

This paper examines the effectiveness of the financial embargo on South Africa. We discussed that during the financial embargo, the macroeconomic variables, such as the average growth rate of investment, and capital and

output per worker declined significantly. The theoretical framework is a simple neoclassical growth model calibrated to South African conditions. The South African embargo event is modelled by limiting the country's ability to borrow through imposing a proportional tax on foreign borrowings to capture the disinvestment during the embargo period, and by assuming apartheid as a constant tax on foreign borrowings to South Africa, we incorporate the effect of the embargo on South African apartheid.

Our results, based on the logit approach and intervention model, indicate that (i) there is a negative relationship between financial isolation and foreign investment, and (ii) there is a negative link between the embargo and the degree of apartheid. Overall, the results indicate that the financial embargo was effective in dismantling South African apartheid.

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Appendix A. Solving the Model

First Assumption:

$M_t = mB$, thus,

$$H_t = [u(c_t) - \lambda_t\{c_t - mc_t + i_t - mi_t + \rho d_t - m\rho d_t - f(k_t) + m f(k_t)\} + \lambda_t q_t i_t]e^{-\rho t} \quad (1)$$

Second Assumption:

$$H_t = [u(c_t) - \lambda_t\{c_t + i_t + \rho d_t - f(k_t) - M_t + \lambda_t q_t i_t - \lambda_t g_t A]\, e^{-\rho t} \quad (2)$$

where, A is the apartheid variable.

Solutions under the first assumption:

Necessary and sufficient conditions:

$$(i)\ \partial H_t / \partial c_t = e^{-\rho t} u'(c_t) - \lambda_t e^{-\rho t}(1 - m) = 0. \quad (3)$$

Therefore, $u'(c_t) = \lambda_t (1 - m)$. (4)

The shadow value of foreign debt λ_t minus the degree of the financial embargo times the shadow value of foreign debt λ_t m equals the marginal utility of consumption $u'(c_t)$.

$$Thus, c_t = 1/[\lambda_t (1 - m)], (5)$$

$$(ii)\ \partial H_t / \partial i_t = -e^{-\rho t}\lambda_t\{(1-m)\} + e^{-\rho t}\lambda_t q_t = 0. \quad (6)$$

$$Thus, q_t = (1-m), 1 > m \geq 0. \quad (7)$$

The shadow value of the capital stock q_t equals 1 minus the degree of the financial embargo m:

$$(iii)\ \partial(-\lambda_t e^{-\rho t}) / \partial t = -\partial H_t / \partial d_t = \lambda_t e^{-\rho t}\rho(1-m). \quad (8)$$

Note that:

$$\partial(-\lambda_t e^{-\rho t}) / \partial t = \lambda_t \rho e^{-\rho t} - e^{-\rho t}\lambda_t = \lambda_t e^{-\rho t}\rho(1-m). \quad (9)$$

This equation will lead to:

$$\lambda_t / \lambda_t = \rho m. \quad (10)$$

$$\text{Thus, } \lambda_t - \rho m \lambda_t = 0. \quad (11)'$$

This is a difference equation. In order to solve it, we need to multiply both sides by the integrating factor, $e^{-\int(\rho m)t} = e^{-(\rho m)t+co}$, where C_o is the constant. Therefore,

$$e^{-(\rho m)t}(\lambda_t - \rho m \lambda_t) = 0. \quad (12)$$

Note that the left-hand side of this equation is the derivative of the integration factor times λ_t, so the equation can be rewritten as:

$$d[e^{-(\rho m)t}\lambda_t] = 0. \quad (13)$$

By taking the integration of both sides, Equation 12 becomes:

$$\int d[e^{-(\rho m)t}\lambda_t].dt = \int 0\,.dt \quad (14)'$$

$$Then, e^{-(\rho m)t}\lambda_t = C_{o,} \quad (15)$$

where, C_o is the constant. Thus,

$$\lambda_t = e^{-(\rho m)t}C_{o,} \quad (16)$$

If $t = 0$, then $\lambda_o = C_{o,}$

From (5), we have:

$c_t = e^{-(\rho m)t}\lambda_o^{-1}(1-m)^{-1}$, (17)

When $t = 0$, then, $c_o = \lambda_o^{-1}(1-m)^{-1}$ (18)

where, c_o is consumption at time zero.

Thus, $c_t = e^{-(\rho m)t}c_o$ (19)

However, we need to know c_o in order to determine the right consumption path. Thus, we integrate the dynamic budget constraint to get the intertemporal budget constraint. To do that, we need to perform the following steps:

We rewrite first the dynamic budget constraint in the standard form for a linear first-order differential equation as the following:

$$d_t - \rho d_t + m\rho d_t = c_t - mc_t + i_t - mi_t - f(k_t) + m f(k_t), \quad (20)$$

$$d_t - (1-m)\rho d_t = c_t - mc_t + i_t - mi_t - f(k_t) + m f(k_t), \quad (21)$$

By multiplying both sides of the equation by the integration factor $e^{-\int(1-m)\rho.dt} = e^{-(1-m)\rho.c0}$, we obtain:

$$e^{-(1-m)\rho t}d_t - e^{-(1-m)\rho t}(1-m)\rho d_t = e^{-(1-m)\rho t}[(1-m)c_t + (1-m)i_t - (1-m)f(k_t)],$$

The left-hand side of the equation is the derivative with respect to t of the integration factor times d_t so we can re-write it to:

$$d[e^{-(1-m)\rho t}d_t[d_t = e^{-(1-m)\rho}[(1-m)c_t + (1-m)i_t - (1-m)f(k_t)]. \quad (22)$$

We integrate over the interval from 0 to ∞:

$$[e^{-(1-m)\rho t}dt]\infty = \int_o^{\infty} e^{-(1-m)\rho t}[(1-m)ct + (1-m)it - (1-m)f(kt)].dt. \quad (23)'$$

Use the transversality condition, $\lim_{T\to\infty} lim\, e^{-(1-m)\rho t}d^T = 0$, to obtain,

$$\int_0^{\infty} e^{-(1-m)\rho t}(1-m)c_t\,.dt = \int_0^{\infty} e^{-(1-m)\rho t}(1-m)[f(k_t) - i_t].dt - d0\,, \quad (24)'$$

With (17) then,

∞ ∞

$$\int_0 e^{-(1-m)\rho t}\,(1-m)c_t\,.dt \;=\; \int_0 e^{-(1-m)\rho t}\,(1-m)\,[\,f(k_t)-i_t].dt \;-\; d_o\,, \tag{25}$$

Thus,

$$\int e^{-\rho t}\,(1-m)c_o\,.dt \;=\; \int_o^{\infty} e^{-(1-m)\rho t}\,(1-m)\,[\,f(k_t)-i_t].dt - d_o\,, \tag{26}$$

We can take $(1-m)\,c_0$ out of the integration since it is constant, therefore,

$$(1-m)c_o \int_0^{\infty} e^{-\rho t}.dt \;=\; \int_0^{\infty} e^{-(1-m)\rho t}\,(1-m)\,[\,f(k_t)-i_t].dt - d_o \tag{27}$$

$$(1-m)c_o\;[e^{-\rho t}/-\rho_t]_0 \;=\; \int_0 e^{-(1-m)\rho t}\,(1-m)\,[\,f(k_t)-i_t].dt - d_o\,, \tag{28}$$

Thus,

$$(1-m)c_o\;[\lim_{T\to\infty} e^{-\rho t}-(1/-\rho)] \;=\; \int_0^{\infty,} e^{-(1-m)\rho t}\,(1-m)\,[\,f(k_t)-i_t].dt - d_o\,, \tag{29}$$

$$(1-m)c_o\,[0+(1/\rho] = \int_0^{\infty} e^{-(1-m)\rho t}(1-m)\,[\,f(k_t)-i_t].dt - d_o\,, \tag{30}$$

Thus,

$$c_o\,(1\text{-}m)/\,\rho = \int_0^{\infty} e^{-(1-m)\rho t}(1-m)\,[f(k_t)-i_t].dt - d_o\,, \tag{31}$$

Thus,

$$c_o = [\rho/(1-m)]\int_0^{\infty} e^{-(1-m)\rho t}\,(1-m)\,[\,f(k_t)-i_t].dt - d_o\,, \tag{32}$$

With (17) then,

$$c_t = e^{-(m\rho)t}\,\{\,[\rho/(1-m)]\int_0^{\infty} e^{-(1-m)\rho t}\,(1-m)\,[\,f(k_t)-i_t].dt - d_o\}\,, \tag{33}$$

With (10) therefore,

$$\dot{\lambda}_t = d\,\lambda_t / d_t = d[(u'(c_t))/(1-m)] / dt = d[(1/(1-m)]/dt = [(1/(1-m)]\cdot[(u''(c_t)\partial(c_t)]/dt, \qquad \partial c_t/\partial t = c_t,$$

Thus,

$$\dot{\lambda}_t = [(1/(1-m)]\,u''(c_t).\,\dot{c}_t, \qquad \lambda_t = [u'(c_t)/(1-m)],$$

Thus,

$$\dot{\lambda}_t / \lambda_t = [u''(c_t)c_t/u'(c_t)]\,.\,(\dot{c}_t/c_t), \quad [u''(c_t)c_t/u'(c_t)] = 1 \text{ as long as } u(c_t) = ln\,(c_t), \qquad \text{since } \dot{\lambda}_t / \lambda_t = \rho m,$$

Thus,

$$\dot{c}_t/c_t = \rho m. \tag{34}$$

Note that if the degree of the financial embargo m = 0, the growth rate of the consumption will also equal zero, and consumption will be constant. To find the optimal saving, set:

$$S_t/N_t = f(k_t) - c_t - \rho d, \tag{35}$$

With (30) gives:

$$S_t/N_t = f(k_t) - \{\,e^{-(m\rho)t}\,\{\,[\rho/(1-m)]\int_0^{\infty} e^{-(1-m)\rho t}\,(1-m)\,[\,f(k_t)-i_t].dt - d_o\}\} - \rho d, \tag{36}$$

Thus,

$$S_t/N_t = f(k_t) - \{\,e^{-(m\rho)t}\,\{\,[\rho/(1-m)]\int_0^{\infty} e^{-(1-m)\rho t}\,(1-m)\,[\,f(k_t)-i_t].dt\} + (\rho m/(1-m))d, \tag{37}$$

Since, $e^{-(m\rho)t} d_o = dt$.

Note that if the degree of the financial embargo is zero, the optimal saving will not depend on the level of foreign debt in this model and q_t will equal 1. Hence i will equal zero and saving will also equal zero. Also note that with 1>m>0, the change in optimal saving with respect to the level of debt will equal m/(1-m). Thus, if d decreases by 1, optimal saving will decrease by m/(1-m).

$$(iv)\ \partial(\lambda_t q_t e^{-\rho t}) / \partial t = -\partial H_t / \partial K_t = -e^{-\rho t}\lambda_t f'(k_t) + e^{-\rho t}\lambda_t m f'(k_t), \quad (38)$$

$$\partial(\lambda_t q_t e^{-\rho t}) / \partial t = -\partial H_t / \partial K_t = -e^{-\rho t}\lambda_t (1-m) f'(k_t), \quad (39)$$

From (iv), we get:

$$\partial(\lambda_t q_t e^{-\rho t}) / \partial t = \lambda_t (-q_t \rho e^{-\rho t} + e^{-\rho t} q_t) + q_t e^{-\rho t}\lambda_t = -e^{-\rho t}\lambda_t f'(k_t) (1-m), \quad (40)$$

By dividing both sides by $e^{-\rho t}\lambda_t$, then,

$$q_t - \rho q_t + q_t(\lambda_t / \lambda_t) = -f'(k_t) (1-m), \quad (41)$$

From (7), $q_t = 0$, with (38),

$$f'(k_t) = \rho - \rho m \quad (42)$$

Note that if the degree of the financial embargo is zero, the result will be the static equilibrium condition. For optimal capital stock, the marginal product of capital equals the interest rate. If the degree of the financial embargo is 1, then the interest rate will be zero. This implies that all capital will flow out of the country, which is unreasonable. For that reason, it is necessary to impose the condition of $m < 1$. However, when the degree of the financial embargo increases the interest rate decreases and the capital flows out of the country.

The Solution under the Second Assumption

The Hamiltonian will be:

$$H_t = [u(c_t) - \lambda_t \{c_t + i_t + \rho d_t - f(k_t) - M\} + \lambda_t q_t i_t - \lambda_t g_t Apartheid] e^{-\rho t})$$

We will have the same optimal solutions without imposing an installation cost for investment. The household controlled by the interest groups (whites) in the economy will benefit from maximizing the apartheid system since it gives them more power in the economy:

$$(v)\ \partial Ht / \partial(Apartheid) = e^{-\rho t})\ \lambda_t a - e^{-\rho t}\lambda_t g_t = 0. \quad (43)$$

This leads to the following equation:

$$g_t = a, \quad (44)'$$

where $a = dM / dA$, i.e., when apartheid increases, sanctions increase by a.

According to (40)', the shadow cost of the apartheid g_t equals the responsiveness of sanctions to the apartheid system a. If the responsiveness of the international sanctions to the apartheid system is zero, then the shadow cost of the apartheid system becomes zero.

$$(iv)\ \partial(\lambda_t g_t e^{-\rho t}) / \partial t = \partial H_t / \partial M_t = e^{-\rho t}\lambda_t \quad (45)$$

Equation 41 leads to:

$$\lambda_t(e^{-\rho t}\rho g_t + e^{-\rho t} g_t) + e^{-\rho t} g_t \lambda_t = e^{-\rho t}\lambda_t. \quad (46)$$

Note that from the solution of a case without imposing an adjustment cost for investment, we obtain $\lambda_t / \lambda_t = 0$. Since a is constant and $g_t = a$, thus the growth in g_t equals zero as well. Thus (42) becomes:

$$= 1/a \quad (47)$$

Equation 43 is a very important result. According to the assumptions of the model, r equals the interest rate, which in turn equals the wage rate of whites. This implies that when the responsiveness of the international sanctions to the apartheid increases, the wage rate of whites decreases. On the other hand, the reduction of the interest rate will lead to an unattractive environment for foreign investors, i.e., capital will flow out of the country.