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WPS4552

POLICY RESEARCH WORKING PAPER 4552

Productivity Growth and Economic Reform:

Evidence from Rwanda

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March 2008

Policy Research Working Paper 4552-

Abstract

Trade, financial, and exchange rate reforms are shown to have exerted a positive impact on the growth of total factor productivity in Rwanda during the period 1995-2003. Based on a constant returns-to-scale Cobb-Douglas production function, this paper regresses total factor productivity on indices of trade, financial, and exchange rate reforms. The analysis determines that trade reforms and financial reforms each contributed positively to improvements in total factor productivity. The data also suggest that the allocation of official development assistance to human capital made a significant contribution to productivity. In contrast, the appreciation of the real exchange rate of the late 1980's hindered productivity or the growth of TFP. Taken together, the findings for Rwanda presented in this paper show that the strong growth of the past decade has not just been due to a "bounce back" effect following the genocide. The results support the notion that policies favorable to trade development, a deepening of the financial sector, and formation of human capital have been effective for increasing aggregate productivity of the economy and stimulating growth in Rwanda. For sustained growth, the Rwandan authorities should continue to build on these policies, while also taking care to maintain an appropriate exchange rate.

This paper—a product of the Poverty Reduction and Economic Management 3 Division, Eastern Africa 2 Country Department—is part of the series of background papers that informed the Country Economic Memorandum, "Rwanda--Toward Sustained Growth and Competitiveness". Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The authors may be contacted at Kcoulibaly@worldbank.org, Kezemenari@worldbank.org, and duffyne@plattsburgh.edu.

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Produced by the Research Support Team

Productivity Growth and Economic Reform: Evidence from Rwanda

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Key words: Cointegration, total factor productivity, trade reforms, financial reforms, exchange rate reforms, human capital and official development assistance.

1. Background

Rwanda is a poor, small, densely populated and landlocked country in Central Africa, with about 8.5 million people. The country's economy is primarily subsistence-based, with industry and services generating about 21 percent and 38 percent of GDP, respectively. The agricultural sector, which accounts for about 41 percent of the GDP and employs about 90 percent of the population, remains the driving force of the economy. Rwanda's main exports are comprised of traditional commodities including coffee, tea, pyrethrum and minerals. New exports include hides, skins, fruits, vegetables, flowers, dried paper, cement, mineral water and some re-exports[2] (secondhand clothes, fuel for airplanes, and vehicles).

Rwanda experienced remarkable growth from 1995-03 compared to the 1980-89 period. Real GDP per capita, which grew on average 0.10 percent per year from 1980-1989, rose by more than 5 percent per year from 1995-2003. Two major events occurred during the period 1995-2003. First, Rwanda embarked on major trade, financial and exchange rate reforms that transformed the economy from an administered one, characterized by the imposition of severe restrictions on trade and foreign exchange transactions, to a market economy. Second, the ending of oppression brought about a resurgence in consumer and business confidence that created the conditions for a more dynamic economy to emerge. Collier (2004) presents evidence that post-conflict countries tend to realize extraordinary growth rates as long as there is some sign that war is truly over.[3] The evidence presented here shows that Rwanda did experience strong growth following the genocide, but that a significant amount of the growth is also explained by reforms undertaken by Government between 1995 and 2003.

The case of Rwanda presents a unique challenge to the researcher, as is true of all studies of post-conflict environments. Civil wars are typically much more devastating than international wars and Rwanda's was no exception. Yet, atypically Rwanda also showed very little signs of a so-called war overhang effect (Ansom, 2005). Part of the explanation may be the relatively large infusion of foreign aid targeted specifically to both human capital and enforcement of property rights. As discussed by Fred-Mensah (2004), the United Nations Development Project, the World Bank, and sources of bilateral aid contributed to the buildup of social capital that supported economic reform and stable growth.

The remaining part of the paper is organized as follows: Section 2 reviews the literature on the effects of economic reforms on productivity growth. Section 3 discusses the methodology and data, while Section 4 then estimates a long-run production function for Rwanda using a Vector Error Correction Model (VECM). This section also applies a battery of statistical tests to validate the estimation and uses a growth accounting framework to derive total factor productivity. Section 5 attempts to empirically link productivity changes with trade, financial, and exchange rate reforms, while concluding remarks and policy implications are presented in Section 6.

2. Literature Review

The literature has underlined the importance of productivity improvement in fostering economic growth in developing countries. From a theoretical standpoint, two views are advanced regarding the impact of economic reforms such as trade liberalization on productivity change. One view asserts that trade liberalization reduces productivity by

exposing the economy to superior foreign products that then lead to the closure of both new and established industries. The second view holds that trade liberalization fosters productivity growth. Thus, trade liberalization may have a positive impact on productivity for three reasons: (i) x-efficiency, (ii) returns to scale, and (iii) availability of foreign exchange reserves.

The proponents of x-efficiency argue that domestic firms in a protected economy enjoy monopoly power and excess profits due to the absence of foreign competition (Edwards, 1992; Nishimizu and Robinson, 1983; Tybout, 1991, 1992). In such an environment, firms fail to reach the minimum efficient scale of production or to produce the maximum amount of goods and services from their limited economic resources.[4] However, in a more open economy, greater foreign competition forces firms not only to increase efficiency by better allocating resources across sectors, but also to adopt newer and more efficient technology. This advanced technology decreases x-inefficiency, eliminates waste and generally reduces the cost of production. The x-efficiency argument recommends export expansion and import liberalization and therefore free trade as a key source of enhancing productivity.

The returns-to-scale argument claims that free trade widens markets and in turn decreases production costs (Kaldor, 1967; Tybout, 1992; Vedroom, 1947). Some firms, whose production is characterized by increasing returns to scale, require larger markets to attain competitiveness. Local markets may be too small, hindering growth in production. Trade liberalization opens opportunities for such firms to increase production since they can sell to both domestic and foreign markets. Unit cost of production then decreases further, stimulating an increase in exports as firms become more cost competitive.

Finally, the foreign exchange argument claims that increasing exports through free trade helps a developing nation access foreign exchange reserves (Chete and Adenikinju, 2002; Chumacero and Fuentes, 2002; Onjala, 2002). Funds are then available to import foreign goods that incorporate a more advanced technology relative to local capital. The higher quality of foreign capital can be used to enhance the production process and further increase productivity and cost competitiveness. Advocates of this thesis argue for policies that increase availability of imported inputs or the lowering of their cost.[5]

Despite these theoretical foundations, empirical studies have not produced a clear consensus regarding the impact of trade liberalization on productivity. Three main themes have emerged, with the first set finding positive correlation between trade liberalization and productivity growth at the sector level[6]. For instance, Austria (1998) found that trade and investment liberalization increased TFP in developing Asian and Latin American countries at the same time import substitution reduced productivity growth. Likewise, Urata and Yokota (1994) showed that trade liberalization generated a positive impact on TFP in Thailand through the intensity of domestic and international competition, wider choice of intermediate goods, expansion of output and R&D expenditures. Osada (1994) claimed that trade liberalization was more important than foreign direct investment in achieving TFP growth in Indonesia, while Ahmed (2003) found a positive impact of comprehensive trade liberalization on economic growth in Bangladesh.

In studies focusing on Africa Chete and Adenikinju (2002), for example, found a positive association between trade liberalization and TFP of aggregate manufacturing in

Nigeria during the period 1962-1985, as did Adenikinju and Alaba (1999) for subsectors of manufacturing in Nigeria. Onjala (2002) found that trade liberalization may have led to an improvement of productivity in both the agricultural and manufacturing sectors in Kenya for the period 1960-1995. In perhaps the most comprehensive African study Hassan et al. (2006) examined 41 sub-Saharan countries from 1960-2002 and found that there was little if any benefit to trade openness. They concluded that "simple dismantling of old trade barriers and investment, without an overall development strategy or supportive macroeconomic policies, cannot be the panacea for economic stagnation, for economic development requires comprehensive institutional reforms."

A second category of study (Tsao, 1985) found a negative link between trade liberalization and productivity change in some sectors of manufacturing, while a third set of studies uncovered no significant impact of trade liberalization on productivity (Havrylyshyn, 1990; Pack, 1988). Kajiwara (1994) found no significant effects in the Philippines, similar to Onjala's (2002) study of the Kenyan economy for the period 1960-1995. Others have found at best only a tenuous link (Bhagawati, 1988; Havrylyshyn, 1990; Nishimizu and Page, 1991; Tybout, 1991).

3. Method and Data Sources

We begin the empirical investigation by estimating a long-run production function for the period 1961-2003. We employ a standard Cobb-Douglas function that has been estimated using the Johansen cointegration methodology.[7] Following Vera-Martin (1999), co-integration analysis is the most appropriate technique to establish the behavior of economic time series for three reasons: First, cointegration solves the issue of whether to use the variables in levels or first differences to estimate output elasticity. Second,

cointegration brings together short- and long-run information in modeling the data through specification of an error correction model (ECM). Third, cointegration solves the problem of spurious regressions associated with trending time series.

The ratio form (equation 1) of the Cobb-Douglas production function assumes constant returns-to-scale. However, productivity improvements are captured through the parameter g, which indicates the constant rate (per year) of productivity (or, more correctly *total factor productivity*) improvement.

$$(1) \qquad Y = Ae^{gt}K^{\alpha},$$

where Y = GDP per worker, K = capital per worker, t indexes time, and A is the fixed component of total factor productivity (TFP); α is the long-run contribution of capital per worker to output per worker. Taking the natural log of both sides of equation (1) yields:

$$(2) \qquad y = a + gt + \alpha k + \varepsilon,$$

where lowercase variables correspond to logs of the uppercase variables and ε is the residual.

Using the Augmented Dickey-Fuller (ADF) test, the degree of stationarity is determined by testing for the existence of unit roots. If cointegration is affirmed, it is then required to test for the number of cointegrating vectors. These are determined using the trace (rank) test and the maximum eigenvalue test. Next, a vector error correction model is used to estimate (2), thereby providing an estimate of the nature of the equilibrium path that characterizes the Rwandan economic system. The optimal number of lags is computed according to the Schwarz information criterion, and misspecification tests are conducted to determine the existence of autocorrelation, kurtosis, skewness, and normality of the residuals. The appropriate number of lags are then incorporated into (2)

to obtain the parameter estimates, notably the capital share, α, and g, the trend growth rate of total factor productivity.

It should be noted that the method of deriving estimates for productivity has some weaknesses, as shown recently by Sena et al. (2005). First, it is measured as a residual and not a direct estimation of changes in the quality of the production factors. Second, the residual is affected by possible errors in the measurement of variables. A mistake in estimation of capital stock or labor can significantly change the estimate of productivity growth. Third, the method does not isolate the main factors that have contributed to productivity growth. It is impossible to identify whether improvement in productivity is due to the quality of capital stock, the quality of human capital stock, or managerial skill. Fourth, the share of each production factor is assumed to be constant. This assumption may not hold for developing countries which tend to move from labor-intensive to capital-intensive activities over time. Overall, the method determines in a relatively imprecise way the relative contribution of factor accumulation and the improvement in the quality of those factors.[8]

After obtaining estimates of the long-run capital share (α) and the trend growth parameter (g), we then develop estimates of TFP growth per period as follows[9]:

(3) $\%\Delta TFP = \%\Delta GDP - [\alpha_1.\%\Delta K + (1- \alpha_1).\%\Delta L]$

Alternatively, one may view this as the decomposition of output growth into the separate contributions of capital, labor, and factor productivity growth. Finally, we attempt to relate changes in productivity to changes in underlying economic conditions in Rwanda. In particular, we regress factors having to do with openness of the economy, the

exchange rate, financial reform, development assistance, and capital importation on our measurement of productivity change, %ΔTFP.

Measurement of variables

Output is measured by Gross Domestic Product (GDP) at constant prices published by the *Ministry of Finance and Economic Planning*. Direct employment series are not available, so labor is estimated by data on the economically active population (labor force) published by the International Labor Organization (ILO). Physical capital, as in most developing countries, is not readily available, but following a number of previous studies[10], the law of motion for capital stock is specified as follows: $K_t = ((1-\delta)*K_{t-1})+I_t$, where K_t denotes capital stock at period t, δ is the depreciation rate of capital stock and I_t is investment at period t. Following Ghura and Mercereau (2004), δ is set at 6 percent[11] and a capital-output ratio in 1960 was arbitrarily set at 1.5. Investment is proxied by gross capital formation that equates gross fixed capital formation with change in the inventories of capital stock. Gross capital formation and gross fixed capital formation are measured in local currency (constant price). The series on gross capital formation, gross fixed capital formation and change in stock of inventories are extracted from the World Bank database.

4. Estimation of Cointegration and Production Functions and Statistical Tests

Estimation of the production relation for the period 1961 to 2003 produced the following empirical result:

$$GDP/L = \text{const.} - .0075 * t + .43 * K/L,$$
$$\qquad\qquad (4.13) \qquad (6.73)$$

with t-statistics (absolute value) in parentheses[12]. The share coefficient, which reflects the contribution of physical capital to output per worker was $\alpha = 0.43$, and this falls into the range of values found in the literature (Table 1) for other developing countries. The point estimate of the annual growth rate of productivity is seen to be -.0075, and both coefficients were significant at the .01 level. This finding suggests that over the estimation period, productivity growth in Rwanda was negative.

Table 1

Previous Estimates of Capital Share in Underdeveloped Countries

	Akitoby et al. (2004)	Bosworth et al. (1995)	Sacerdoti et al. (1998)	Vera-Martin (1999)]			Sena et al. (2005)	Our findings
Share of capital in output	0.34	0.4	0.35	0.28	0.45	0.22	0.4	0.43
Country (ies)	Democratic Rep. of Congo	Developing Countries	West African Countries	Mali	Niger	Senegal	Morocco	Rwanda

Statistical tests

A series of statistical tests were used to validate the robustness of the estimated model. As in Sena et al. (2005) and Bougha-Hagbe (2006) we determined that the optimal number of lags was 5 according to the Schwarz information criterion. Then, incorporating the 5 lags, the Augmented Dickey-Fuller (ADF) procedure was used to determine the order of integration by testing the unit-root hypothesis in the level of variables and in their first differences. The null hypothesis is the presence of a unit-root. As seen in Table 2, for both variables, GDP/L and K/L, the critical values at the 1 and 5 percent levels are greater than the test statistic. Therefore, the unit-root cannot be rejected at either level. However, for the first differences of both variables, the critical values at

both the 1 and 5 percent levels are less than the test statistic. Therefore, the presence of a unit root in first differences can be rejected at the 1 and 5 percent levels. The ADF test thus shows that GDP/L and K/L are stationary in first differences, so that both variables are integrated on the order of 1, and are therefore good candidates for cointegration.

Trace and maximum-eigenvalue tests

The number of cointegrating vectors (CV's) is determined from the trace and maximum-eigenvalue tests, with the initial (null) hypothesis being the lack of a cointegrated vector in the system. As seen in Table 3, the trace statistic (105.79) is greater than the critical value of 25.87 at the 5 percent level, thus rejecting the null hypothesis of lack of long-run cointegration between GDP/L and K/L. This result is confirmed by testing a second null hypothesis, that there is at most one cointegrated vector, and as seen in Table 3 that hypothesis was not rejected. The maximum-eigenvalue test (Table 4), which used the same hypothesis test framework, also produced evidence of long-run co-integration between GDP/L and K/L.

Table 2

ADF Tests of Stationarity

Variables	Included in regression	Test statistic	1 % critical Value	5 % critical value	Conclusion	
log (levels)						
GDP / L	Constant	-1.92	-3.6	-2.93	Unit Root	I(1)
GDP / L	Constant, Trend	-2.02	-4.2	-3.5	Unit Root	I(1)
K / L	Constant	-0.54	-3.6	-2.93	Unit Root	I(1)
K / L	Constant, Trend	-2.01	-4.18	-3.52	Unit Root	I(1)
log (1st difference)						
Δ (GDP / L)	Constant	-6.4	-3.6	-2.93	Stationarity	I(0)
Δ (GDP / L)	Constant, Trend	-6.56	-4.2	-3.5	Stationarity	I(0)
Δ (K / L)	Constant	-6.4	-3.6	-2.93	Stationarity	I(0)
Δ (K / L)	Constant, Trend	-6.33	-4.19	-3.52	Stationarity	I(0)

Source: Authors' calculations.
Note: For the regression equations without a linear trend, critical values are from MacKinnon (1996).

Table 3

Cointegration Rank Test (Trace)

Hypothesized No. of CV's	Eigenvalue	Trace Statistic	0.05 Critical Value	p – value
None*	0.92	105.8	25.9	0.00
At most 1	0.2	8.70	12.5	0.19

Note: Trace test indicates 1 cointegrating vector at the 0.05 level

* = rejection of the hypothesis at the 0.05 level.

Table 4
Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CV's	Eigenvalue	Max-Eigenvalue Statistic	0.05 Critical Value	p - value
None*	0.92	97.1	19.38	0.00
At most 1	0.2	8.69	12.51	0.19

Note: Max-eigenvalue test indicates 1 cointegrating vector at the 0.05 level

* = rejection of the hypothesis at the 0.05 level.

A vector error correction model (ECM) was then employed to estimate the production function represented in equation (2). The short-run estimates are shown in Table 5, and the significance of the error-correction coefficient again confirms the existence of a cointegration relationship between the variables. It also means that GDP per worker reacts to changes in capital per worker and to deviations from the equilibrium path of the system. The value of the error-correction coefficient (-0.26) suggests that disequilibrium is corrected in almost four periods.

Several misspecification tests for the VECM were also performed (tables available on request). The multivariate LM statistics showed that the residuals were not auto-correlated for lags 1 through 5. The multivariate JB test confirmed that the residuals were normal; the multivariate test of skewness showed that the residuals were somewhat skewed, while the test for kurtosis indicated a lack of excess kurtosis.

Table 5
Short-run Estimates of the Vector Error Correction Model (5 lags)

	Δ (GDP / L)	Δ (K / L)
Error Correction	-0.26*	0.37*
	[-2.77]	[10.84]
Δ (GDP / L) (-1)	0.066	-0.16*
	[0.37]	[-2.43]
Δ (GDP / L) (-2)	0.29	-0.22*
	[1.80]	[-3.56]
Δ (GDP / L) (-3)	0.32*	-0.2*
	[2.03]	[-3.33]
Δ (GDP / L) (-4)	0.13	-0.2*
	[0.90]	[-3.75]
Δ (GDP / L) (-5)	-0.15	-0.17*
	[-1.14]	[-3.40]
Δ (K / L) (-1)	0.27	0.028
	[1.72]	[0.47]
Δ (K / L) (-2)	0.39*	0.1
	[2.58]	[1.80]
Δ (K / L) (-3)	-0.12	-0.4*
	[-0.83]	[-6.92]
Δ (K / L) (-4)	-0.1	-0.08
	[-0.74]	[-1.54]
Δ (K / L) (-5)	-0.07	0.07
	[-0.61]	[1.69]
Constant	0.009	0.013*
	[0.98]	[3.48]
Dummy 1994	-0.34*	0.39*
	[-6.22]	[18.87]

Note: t-statistics in parentheses,
* = significance at 5% level

Univariate tests

According to the weak exogeneity test, the null hypothesis that GDP/L and K/L could be weakly exogenous is rejected, as seen in Table 6 (p-value < .05). This means that there is an error correction term in the Vector Error Correction Model which tends to bring the system to the long-run equilibrium when it deviates from that equilibrium in the short-run. On the other hand, the exclusion test shows that GDP/L and K/L (and their lags) can not be excluded as explanatory variables in the Vector Error Correction Model (p-value < .05).

Table 6

Univariate Tests

	GDP / L	K / L
Weak exogeneity	9.95 [.0016]	62.43 [0.00]
Exclusion	74.98 [0.00]	34.49 [0.00]
Normality (JB)	2.38 [0.30]	3.49 [0.17]

Note: numbers in brackets are p-values

5. Productivity Performance and the Effects of Economic Reform

Estimates of total factor productivity

The estimate of capital's share obtained above, $\alpha = 0.43$ was used to find a direct measure of change in total factor productivity for the periods 1961-2003, 1980-1989, and 1995-2003. Table 7 reports the decomposition of output growth into the separate contributions of capital, labor, and total factor productivity (TFP).

Table 7
Decomposition of Real GDP Growth in Rwanda, $\alpha = 0.43$

		Contribution of:		
	Real GDP Growth	Physical Capital	Labor	TFP
1961-03	3.6	1.66	1.57	0.37
1980-89	3.22	3.73	1.86	-2.37
1995-03	11.5	0.45	3.27	7.78

Source: World Bank database and computed by authors.

The findings show some rather stark contrasts evident between periods. In particular, the residual calculation of TFP points to the possibility of a major shift in economic structure beginning in 1995. The year 1995 was selected because of the cataclysmic events of 1994, which reflected the culmination of several years of economic and political instability in Rwanda. The contribution of TFP may appear to have been slightly positive for the entire period, but that was likely due to the extraordinary leap in TFP that took place since 1995. In the post-1995 period TFP accounted for about two-

thirds of the increase in GDP, with labor producing most of the remainder. On the other hand, the sharp decline in the contribution of physical capital since the 1980s may be due to the destruction of capital stock during the early 1990s (Tahari et al., 2004). The more recent importance of TFP points to significant efficiency gains, which we speculate could be from improvements in the quality of human capital or from the effects of other economic reforms. These will be discussed in more detail below, but obvious examples would include government policies that put a stronger emphasis on education, and high-technology initiatives such as the Information and Communications Technologies (ICT) program.

Economic history of Rwanda – post 1960

From 1961 to 1990, Rwanda had an administered economy characterized by the imposition of severe restrictions on trade and foreign exchange transactions, as well as a fixed exchange rate (IMF, 2005). By the early 1990s the average tariff rate was 34.8 percent, with 5 different tariffs ranging from 0-60 percent. Every import and every importer was subject to a quota, and all import operations were subject to a license authorizing external currency disbursement (WTO, 2004). Exporters were to repatriate currency generated by the sale of exports, and export licenses were authorized only by the *Banque Nationale du Rwanda* (BNR). More importantly, all export earnings were transferred to and managed by the BNR. Likewise, BNR had to give prior approval for certain invisible transactions[13] including medical care, tourist trips and study abroad. Purchases of currencies from the BNR to finance these invisible transactions were subject to ceilings.

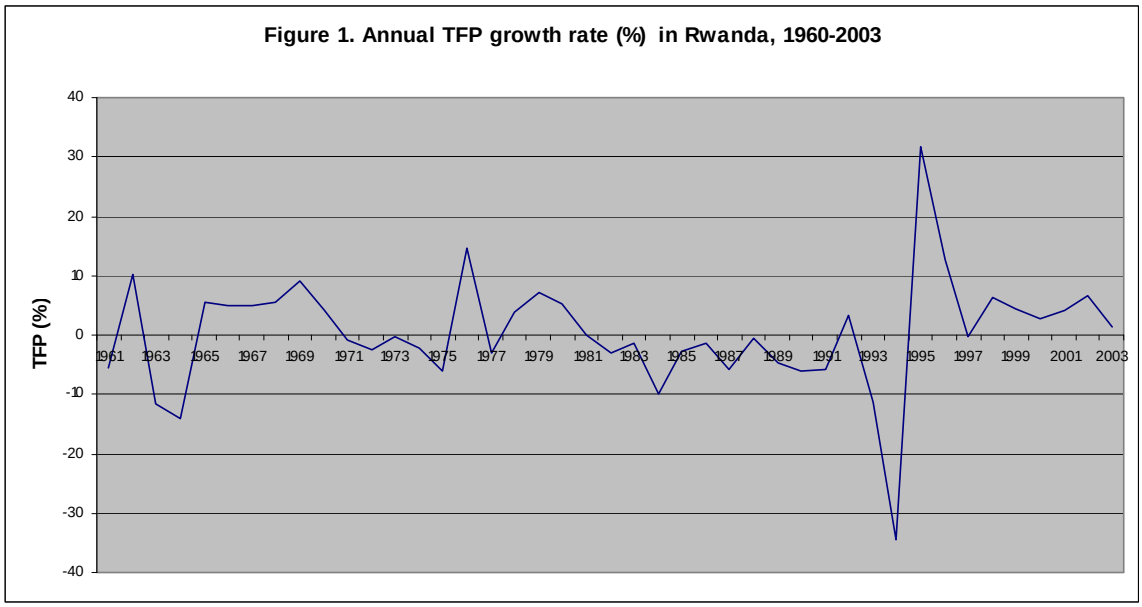
The period from 1991 until 1994 corresponds to the beginning of the removal of restrictions on trade and foreign exchange transactions, and the gradual revival of a market economy. While this period covers the first phase of trade reforms, it was also characterized by macroeconomic and political crisis in Rwanda. The culmination of civil war in 1994 led inevitably to the destruction of manpower[14], capital stock, and resources such as livestock, as well as a total absence of the state. In the process, much of what the World Bank refers to as "social capital" was destroyed. A climate of uncertainty became prevalent, so that the few businesses that did survive were reluctant to incur the sunk cost of capital expenditures made possible by the previous wave of trade reforms. Many established businesses failed to adjust their productive capacities and suffered from the resulting inefficiencies.

From 1995 until 2003 a new era emerged. Rwanda then embraced a market economy characterized by both a continuation of trade reforms and a liberalization of the monetary and financial regimes. Tariffs were reduced considerably with the average rate decreasing to 18 percent, and there remained four tariff bands with a maximum of up to 30 percent by 2003. Liberalization of the monetary and financial sector led to the adoption of new currency exchange regulations, the creation of new private commercial banks, and the privatization of banks that had been state-owned[15] (Coulibaly, 2005). Current account operations (imports, exports, services) were liberalized, and some of the previous restrictions on capital flows were either reduced or eliminated. The latter included the transfer of capital and revenues related to foreign direct investment (FDI)), and the allowance of free withdrawal from foreign exchange accounts in commercial banks (Kanimba, 2004). Flexible exchange rates were also introduced.

During this period (1995 – 2003), the commitment of the government to trade, financial, and exchange reform was much more credible and stable. Prices began to reflect real cost and value, rather than the arbitrary levels established by the government. Economic resources could thus be allocated much more effectively as firms adjusted their productive capacities and subsequently improved the overall competitiveness of the Rwandese economy. At the same time Rwanda was the recipient of substantial development aid from the World Bank and other entities. Moreover, from both a regional and historical point of view, after 1994 the influx of aid was relatively substantial-55% greater than other sub-Saharan countries. While it has often been speculated that diminishing returns to aid may exist over the long run, in the case of Rwanda the post-1994 aid seemed to have a much greater, and long-lasting impact (Collier, 2004).

Long-run behavior of TFP and indices of trade, finance, and currency

Figure 1 shows the behavior of the TFP growth rate for the entire period 1961 – 2003. Although there were periods of positive change prior to the early 1990s, there were also some periods of significant decline, particularly in the 1980s. Since 1994 the growth in productivity has appeared to stabilize at a positive level.



A standard measure of the extent of trade openness is the ratio of imports and exports to GDP (Austria, 1998). Table 8 shows that imports of goods and non factor services as a percent of GDP increased from almost 15% during the 1980-1989 period, to 27% during the 1995-2003 period, while capital imports increased from 3.9% to 6.5%.[16] The significant increase in each variable suggests that Rwanda also had the larger stock of foreign reserves necessary for importation. The overall trade ratio rose sharply from 26.7% during the 1980-89 period to 35.2% during the 1995-2003 period, yet the bulk of the change was due to increased imports.

The degree of tariff reduction can be seen most clearly from the trade tax ratio, which stood at almost 47 percent during the 1980-89 period, but then declined to 23.2 percent during the 1995-2003 period. This reflects an increasing openness and lower reliance on tariff and non-tariff barriers; in its stead the Rwandan government implemented a value-added tax.

Altogether, Table 8 shows that except for the export of goods and non-factor services[17], all the indicators of trade reform improved significantly between the two periods. One can speculate that greater imports forced domestic businesses to increase their efficiency of production in order to become more competitive, since they lost the price protection afforded by tariffs. More advanced technology was perhaps also introduced as reflected in the increased amount of capital importation, thus contributing to further reductions in the cost of production.

Table 8

Indices of trade reform

Period	TFP	Imp/GDP	Imp(cap)/GDP	Trade ratio	Trade-tax ratio	Exp/GDP
1980-89	-2.37	14.7	3.9	26.7	46.6	12
1995-03	7.78	27.0	6.5	35.2	23.2	8.2

Trade ratio: (Exports and imports of goods and services) / GDP
Trade tax ratio: Trade tax / total tax

A second set of quantitative indices measure financial reform (Table 9). These include the ratios of broad money (M2) and private sector credit to GDP, as well as the real interest rate. The M2 share of GDP rose from 14% during the 1980-89 period to 16% during 1995-2003. At the same time the private sector credit share rose from 7% to 9% while real interest rates dropped from 9% to 8.5%. One may surmise that financial reforms brought about a financial deepening that made economic resources available at a lower cost (Kanimba, 2004). These resources were channeled from the financial system to capital investment and helped improve the overall productivity of the economy. It should be noted, however, that previous studies have produced mixed results on the economic effects of financial development. Amiruddin et al. (2007) concluded that

statistical findings are often country-specific and dependent on the type of proxy used to measure financial development. In one of the few recent studies of sub-Saharan Africa Atindehou et al. (2005) found no effect of financial intermediation on economic development, attributing their finding to the prevalence of the informal sector in those countries.

Table 9

Indices of financial reforms

Period	TFP	M2/GDP	Priv.Cr./GDP	Real Int.
1980-89	-2.37	14.36	7.2	9.13
1995-03	7.78	16.32	9.2	8.5*

* 2003

Considering next the currency regime, it is important to note that in 1995 Rwanda established a fully liberalized and market-determined exchange rate system. The shift from a fixed exchange rate to a flexible exchange rate coincides with the period when productivity became positive, yet the real exchange rate[18] declined between the two periods from an average (index value) of 102.3 during 1980-1989 to 93.9 during 1995-2003. Policy was aimed at stabilizing and reducing the exchange rate through forex auctions so as to maintain the external competitiveness of the country's exports. The stability was supported by a continuous flow of foreign financial assistance. Official Development Assistance (ODA) as a share of GDP rose sharply from 10.8 percent during the 1989-89 period to 23.7 percent during the 1995-2003 period.

Empirical evidence: the linkage between TFP and economic reforms in Rwanda

In an effort to explain the behavior of total factor productivity, the yearly estimates of TFP growth obtained above were regressed upon several measures accounting for trade, currency, and financial conditions in Rwanda. They were:

CREDIT = (Private sector credit) / GDP

EXCHG = Real effective exchange rate

TAXES = (Tax revenue collected on international trade) / GDP

TRADE = (Exports + imports) / GDP

DUM94 = 1 for the year 1994, and 0 otherwise.

CAPITAL = (Imported capital) / GDP

ODA = [Official aid * (labor force * e^{RS})] / GDP.

Given the above variable definitions, the following model was estimated:

(5) $TFP_t = F(CREDIT_t, EXCHG_t, TAXES_t, TRADE_t, DUM94, CAPITAL, ODA)$.

With the exception of ODA, all of the variables are frequently used in the development literature. ODA is a control variable that combines the interaction of human capital and official development assistance. The estimate of human capital (labor force * e^{RS}) applies improvements to education (e^{RS}, where S = average educational attainment in years of schooling and R = average return to education) to the size of the labor force. The return to education is assumed to be 10 percent per year, and estimates of average educational attainment were provided by the Poverty Reduction and Economic Management Total Factor Productivity Toolkit compiled by Sandeep Mahajan in 2001 and available at the World Bank. Due to data restrictions the earlier 1961-1970 period

was deleted, leaving annual data for only the period 1971-2003. Three variations of the basic model were estimated and the regression results are summarized below in Table 10.

The variable CREDIT is seen to have exerted a positive effect on TFP[19]. This suggests that financial reforms did lead to a financial deepening by making economic resources available throughout the economy, particularly in the private sector. A number of factors may have contributed: the creation of new commercial banks[20] and of cooperative banks, better financial conditions characterized by positive real interest rates (due to lower inflation), and the existence of a more stable overall banking system. The economic resources made available to the private sector were supplied at a lower cost, with the real interest rate decreasing from 9.13 percent to 8.5 percent since the 1980s. The associated improvement in TFP could then partly be explained by the fact that private sector credits increased from 7 percent to 8 percent of GDP over the same period. The real effective exchange rate had a negative and statistically significant impact on TFP. This could be due to two reasons: First, the appreciation of the real effective exchange rate in the late 1980s made the tradable goods from Rwanda less competitive than those from overseas. This may have led to the decline of exports from 12 percent (as a share of GDP) during 1980-89 to 8 percent during 1995-2003. Second, the appreciation of the real effective exchange rate in the 1980s made imports cheaper, contributing to an increase in the volume of imports. This may have discouraged some local production and subsequently decreased the demand for capital improvements.

Table 10
Determinants of TFP growth

	Dependent variable: TFP_t		
	Model		
	1	2	3
Independent variables			
Constant	-0.089	0.05	-2.07***
	(-0.56)	(0.34)	(-2.3)
CREDIT	0.064***	0.038***	0.024***
	(3.36)	(2.58)	(2.37)
EXCHG	-0.0074***	-0.0065***	-0.0034***
	(-3.56)	(-3.95)	(-2.33)
TAXES	0.0049***	0.0051***	0.0054***
	(2.34)	(3.3)	(4.54)
TRADE	0.0038	-0.0035	-0.0036
	(1.32)	(-0.93)	(-0.90)
DUM94	-0.43***	-0.24**	-0.43***
	(-3.93)	(-1.69)	(-2.48)
CAPITAL		0.045***	0.03**
		(2.8)	(1.83)
ODA			0.11***
			(2.45)
R-square (adj)	0.74	0.82	0.85
Durbin-Watson	1.95	2	2
Estimation period	1971-2003	1971-2003	1971-2003

t-statistics in parentheses

** and *** denote significance at 10 % or 1%

The tax variable (TAXES) exerted a positive and significant effect on TFP. Revenues are the product of imports and tax rates, but while tax rates declined due to trade liberalization, import volume increased, thus increasing international trade revenues after 1995. The positive connection between revenue and productivity suggests that revenues collected on taxes from international trade were used to finance productive projects, which led to an improvement in total factor productivity.

The variable TRADE, which reflects the degree of openness to outside economies, surprisingly did not appear to have a significant impact on TFP, with its

coefficient being positive or negative, and statistically insignificant. However, the positive significance of CAPITAL in model 3 illustrates that capital imports must be distinguished from overall trade improvements. This result was not surprising, given the importance of new capital in incorporating new technology and, in many cases, greater productive efficiency.

The variable ODA, which allows for improvements in human capital, was both positive and significant, as expected. Since 1994, most aid received by Rwanda from the international community has been used to build schools, pay teachers, provide school furniture, build hospitals, and also purchase computers for workers and students. Such spending on education and health, along with increased training of civil servants (especially in stabilizing the legal system and the enforcement of property rights), has contributed significantly to productivity growth. Murenzi and Hughes (2006) reinforce the notion that knowledge transfer and integration of technology will be important contributors to further economic development in Rwanda.

Lastly and not surprising, the 1994 dummy variable, measuring the economic effects of the political events at that time, was both negative and significant, indicating a decrease in productivity growth, as seen earlier in Figure 1.

6. Conclusion

Our research was an attempt to assess the economic efficiency of the Rwandese economy since 1961 and to demonstrate the important contribution to the growth, resulting from key reforms implemented over the period 1995 to 2003. Despite the generally poor quality of the data, we believe that several insights were obtained that (1)

enable us to better understand the dynamic changes that have taken place, (2) allow us to assess the impact of recent economic reform and the success of the new economic regime existing since 1995, and (3) give us some basis for making future policy recommendations in order to achieve continued economic growth.

Although considerable time was spent detailing the economic history of Rwanda, vis-à-vis institutional frameworks, and in developing an empirical estimate of the macro "production function", we believe the most important contribution of the research was in relating overall efficiency improvements to several important economic factors. In particular, we examined the underlying relationships between indices that measured trade, financial and exchange-rate liberalization and the overall productivity growth of the economy. We have shown that trade reforms, financial reforms, and the development of human capital positively contributed to TFP growth from 1971-2003. In contrast, exchange rate reforms seemed to have hindered the growth of TFP, most likely because the resulting high exchange rate came at the expense of decreased exports.

Overall, aside from the expected recovery in economic growth following a crisis, we argue that economic reforms implemented by the Government contributed substantially to productivity growth in Rwanda. This finding can have broader implications for developing nations attempting to transition out of conflict and reconstruction to lay the foundation for sustained growth. The Rwandan case suggests that policies favorable to trade development, a deepening of the financial sector and an appropriate exchange rate, if well implemented, can be effective measures for increasing aggregate productivity and stimulating economic growth. In addition, the evidence showed that the allocation of official development assistance towards rebuilding human

capital (that has often been depleted following a conflict situation) could be very effective in enhancing economic growth. The overall success of the post-conflict Rwandese economy can be attributed to development policies and financial assistance that built on a foundation of reconstruction, development of human resources, macroeconomic stabilization, and the establishment of new financial institutions.

Our research appears to be one of the first attempts at uncovering production relations existing in Rwanda, and identifying policies to accelerate transition from post-conflict reconstruction to growth. The ever-present challenge to development is how to increase competitiveness by raising imports, while promoting a domestic economic structure that simultaneously increases exports. But as suggested for example by Zagha and Nankani (2005), judicious investment in targeted industries could solve both problems, since increased diversification has often been observed to result in both greater economic stability and a much faster rate of growth.

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[1] The authors would like to thank Jacques Bougha-Hagbe, Robert Lucas, Aart Kraay and Matthias Cinyabuguma for providing helpful comments on the paper.
[2] Which are oriented toward neighboring countries such as The Democratic Republic of Congo and Burundi.
[3] Mozambique is a classic example.
[4] Some x-inefficiencies exist.
[5] Which could be an increase in foreign aid or an export-led development strategy.
[6] See Bergsman (1991), Condon et al. (1985), Krueger & Tuncer (1982), Nishimizu & Robinson (1983), Page (1980), and Pitt & Lee (1981)..
[7] Similar to Johansen and Juselius (1990) and Johansen (1988, 1991).
[8] A more difficult theoretical matter is the issue of separating scale economies and technological improvement from productivity change. Here, we assume constant returns to scale and subsume technological change in 'total factor productivity' which is made necessary by the lack of data on the quality of capital and labor inputs.
[9] A similar method was used by Ghosh and Kraay (2000), Akitoby & Cinyabuguma (2004), and Sena et al. (2005).
[10] See Akitoby & Cinyabuguma (2004), Nehru & Dhareshwar (1993), Sena et al. (2005), and Urata & Yokota (1994).
[11] A 10 percent rate of depreciation was also tested but the results did not differ significantly.
[12] It is assumed that the error term ε is stationary. The estimation is done in levels using the cointegration technique on a dataset covering the period 1961-2003.
[13] These transactions include medical care, tourist trips and study abroad. The purchase of currencies to finance these transactions was subject to ceilings
[14] Lopez and Wodon (2005) estimate that 800,000 people lost their lives between April and June 1994 and three million people sought refuge in nearby countries.

[15] Rwanda had 3 commercial banks prior to 1995. However, the country currently has 6 commercial banks.
[16] Due to data restrictions and to the severe economic dislocation of the early 1990s, we have chosen to exclude that data and to only study the time immediately before and after the early 1990s.
[17] Exports of goods and non factor services over GDP which was expected to increase as trade liberalization progressed declined over the 2 periods 1980-89 and 1995-03. The result is counter-intuitive and is due to the fact that coffee production which constituted the main export of Rwanda decreases significantly in value and volume for three main reasons: lack of maintenance of coffee trees, ageing of coffee trees, and rejection of farmers to grow and harvest coffee which is being substituted with food crop production between 1990 and 1994.

[18] The real effective exchange rate is defined as $E^*(P_{D/}P)$ where E is the nominal effective exchange rate (the number of units of $ to get one unit of Franc Rwanda), P_D is the domestic price, and P_F is the foreign price. Here an increase in the real effective exchange rate is an appreciation.
[19] Note that broad money (M2) was also tested instead of private sector credit, but the results did not change significantly.
[20] See footnote 14.