

Shared Sectoral Growth: Evidence from Côte d'Ivoire, Ghana, and Zimbabwe[†]

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Abstract

This paper examines agriculture, industry and service sector growth in Côte d'Ivoire, Ghana, and Zimbabwe over more than three decades. The analyses find at least one long-run sectoral relationship in each country. This indicates the existence of a large degree of interdependence in long-run sectoral growth, implying that the sectors “grow together” or, similarly, that there are externalities or spillovers between sectors. This also provides evidence against the basic dual economy model, which implies that a long-run relation cannot exist between agricultural and industrial output. The impulse response and short-run sectoral growth analyses support these results, as both imply the existence of a positive link between growth in industry and growth in agriculture. Policy implications are also discussed; these include directing more attention towards the interdependencies in sectoral growth broadly defined. In particular, our findings have implications for the design of education and health programs, as well. This improved understanding of intersectoral dynamics at all levels may facilitate policy implementation aimed at increasing economic growth—and thereby ultimately improving peoples’ livelihoods—in Africa.

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1. Introduction

With the increased interest in growth theory, empirical work on economic growth has expanded enormously in the last few decades. Most of this literature mainly focuses on the determinants of aggregate economic growth, however, while there has been less emphasis on sectoral economic growth. The sectoral growth literature builds mainly on the dual economy model originating from Lewis (1954) and Hirschmann (1958). This model seeks to explain economic growth by emphasizing the roles of agriculture and industry and the interplay between them.¹ The dual economy model views the agricultural sector as merely the basis of an emerging economy, a generator of the capital necessary for take-off toward the second stage of economic development, industrialization. Under this view, once industrialization has taken place, the agricultural sector more or less becomes redundant.

The dual economy literature generally rules out two—in our view—potentially important issues about the later stages of economic development. First, the literature largely do not consider the possibility that agriculture may be an important growth-promoting factor once the economy had advanced beyond the initial agricultural stage. Second, it rules out feedback mechanisms between agriculture and industry. Some recent contributions in the sectoral growth literature dispute this view of the dual economy model. Gopinath, Roe, and Shane (1996), for example, examine the possible link between agriculture and food processing. Productivity gains in agriculture are allowed to feed back into the food processing industry, where they lead to cheaper inputs. Lower priced inputs lead in turn to increased derived demand for primary agricultural products, thus partly mitigating the price decline. The two sectors evolve interdependently over time, contrary to what the dual economy model predicts. Martin and Mitra (1998) analyze total

¹ Several recent studies build upon a framework along the lines of this classical dualistic framework. In Canning (1988), growth comes about through migration of labor from agriculture into industry. Depending on the magnitude of the increasing returns in industry, and assuming that the economy does not take-off near subsistence level, the economy may exhibit sustained long-run growth. Matsuyama (1992) let growth emerge as learning-by-doing in manufacturing. Assuming an income elasticity of demand for agricultural goods less than unity, a positive association between agricultural productivity and economy-wide growth is found for the case of a closed economy. In an open economy scenario, however, a negative link is found, implying that focusing on the agricultural sector would slow down the overall growth of an economy. Several case studies exist. For example, Skott and Larudee (1998) focuses on Mexico and Storm (1997) analyzes the case of India. For a notable exception to the empirical dual economy literature, see Yao (1996), which analyzes sectoral growth in China along similar lines as those employed here.

factor productivity growth and convergence in agriculture and manufacturing for a large sample of countries at all levels of economic development. They find less convergence in manufacturing productivity than in agricultural productivity. Also, they find the rate of productivity growth to be higher in agriculture than in manufacturing. This, too, is contrary to the traditional view that productivity growth is higher in industry than in agriculture (Syrquin, 1986). If that belief is wrong, there are important consequences for developing economies, which have historically implemented policies based on this view, resulting in strong policy biases against investment in the agricultural sector (Krueger, Schiff, and Valdes, 1992).

In this paper, we investigate the applicability of the dual economy model to Sub-Saharan Africa. Specifically, we examine the role of agriculture in generating economic growth and possible dynamics between agriculture and industry—allowing for services to be part of this relationship—in Côte d’Ivoire, Zimbabwe, and Ghana over more than three decades. Three main questions motivate the analysis. First, do the agricultural, industrial, and services sectors evolve interdependently in the long run, thus contradicting the basic dual economy model? Second, if they do, is there a link between agricultural and industrial growth, again contradicting the dual economy model? Third, do sectors adjust toward a long-run equilibrium after having been exposed to economic shocks? The answer to these questions will indicate whether the policy bias against the agricultural sector historically is valid or whether it should be abandoned in favor of a more diverse policy strategy across sectors.

Section two presents the economic model and the econometric framework applied in the paper. Section three describes the data and preliminary data analysis. Section four analyzes sectoral growth, applying the co-integration framework and impulse response techniques, and estimates a short-run sectoral growth model. Section five concludes, discusses policy implications and provides directions for further research.

2. Methodology

In analyzing sectoral growth in Sub-Saharan Africa, we focus on the question of whether, contrary to the dual economy model, sectors evolve interdependently, focusing in particular on the dynamics between agriculture and industry. A priori the analysis should ascribe importance to such exogenous events as droughts, trade shocks, and policy

changes, which are all likely to affect sectoral growth. These issues must be explicitly incorporated in the economic model. These considerations give rise to the following simple model:

$$y_j = y(y_a, y_i, y_s, \gamma) \quad (1)$$

where y_j denotes the economic size of sector j , $j = \{a \text{ (agriculture)}, i \text{ (industry)}, s \text{ (services)}\}$. The variable γ denotes all other factors that may affect sectoral growth, such as institutional setting, legislation, and internal and external shocks.

In order to estimate the model given by (1), we need to quantify the economic size of the sectors. We define the economic size of a sector by its output. The residual of a statistical regression model captures factors other than the output from other sectors, which may affect sectoral output. Hence, the current output of a sector depends on the past production of that sector as well as that of the other sectors.

We apply the econometric framework of co-integration (originating with Engle and Granger 1987), which allows testing economic hypotheses regarding possible sectoral interdependencies by testing parameter restrictions. Evidence of a long-run relation among the growth of sectors would indicate a large degree of interdependence in long-run sectoral growth in Sub-Saharan Africa and would thus provide evidence questioning the validity of the dual economy model.

Because of the possibility of more than one co-integrating relation, we apply full information maximum likelihood (FIML) techniques to test for the order of the co-integrating rank (Johansen 1988, 1991).²

Consider the vector auto regression (VAR):

$$x_t = \rho + \sum_{i=1}^I \xi_i x_{t-i} + \varepsilon_t, \quad \varepsilon_t \sim \text{NIID}(\mathbf{0}, \Omega^2) \quad (2)$$

where x_t and ε_t are $1 \times p$ vectors, ξ_i is a $p \times p$ coefficient matrix, and ρ is a $1 \times p$ vector of constants. First-order differencing and re-arranging equation 2 yield the following error correction model (ECM):

$$\Delta x_t = \rho + \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \Pi x_{t-k} + \varepsilon_t, \quad \varepsilon_t \sim \text{NIID}(\mathbf{0}, \Omega^2) \quad (3)$$

² In the case of more than two variables in the co-integrating relation, the estimated co-integrating vector may not be unique (Engle and Granger, 1987).

where $\Gamma_1 = \Pi_1 - I$, $\Gamma_2 = \Pi_2 + \Gamma_1$, $\Gamma_3 = \Pi_3 + \Gamma_2$, etc. Hence, $\Pi = I - \Pi_1 - \dots - \Pi_k$. The rank of the Π matrix determines whether the series co-integrate. There are three possible cases. In the first case, $\text{rank}(\Pi) = p$, which is full rank, where x_t is stationary and there is no co-integration since a necessary condition for the series to exhibit co-integration is that at least two of the series be integrated. In the second case, $\text{rank}(\Pi) = 0$ and Δx_t is stationary and, again, there is no co-integration. Hence, the model must be respecified in first-order differences, that is, as a difference VAR. In the third case, $\text{rank}(\Pi) = r < p$, implying reduced rank, and the series co-integrate, with the number of co-integrating relations given by r .

We use the Johansen (1988, 1991) procedure, thus estimating all linear combinations of the lagged variables in levels that are highly correlated with the first-order differences. If Π has reduced rank r , that is, if $0 < r < p$, it may be split into two $p \times r$ matrices α and β , such that $-\Pi = \alpha\beta'$. We estimate the ECM system (equation 3), subject to the restriction that $-\Pi = \alpha\beta'$ for $r = 0, 1, \dots, p-1$, by means of maximum likelihood. This is followed by a test for the order of r .³

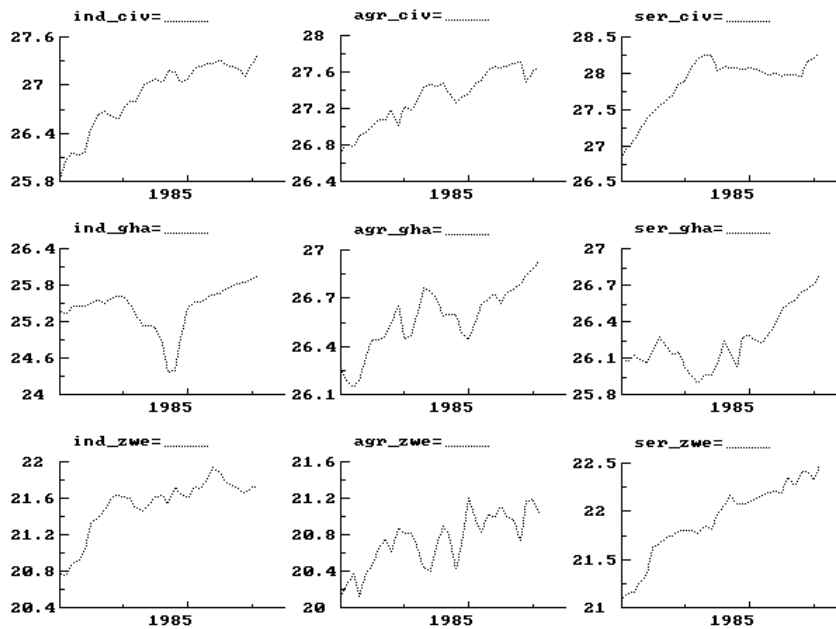
Until the test for the co-integrating rank, the analysis involves multidimensional Wiener-processes. However, once the number of co-integrating relations, r , has been determined, $\beta'Y$ will be stationary, and further tests on the α and β matrices and deterministic terms will, conditional on r , be distributed χ^2 . The columns of β are the co-integrating parameter vectors or, correspondingly, the columns of β span the co-integrating space. Thus, any linear combination of these is also a co-integrating relation. The coefficients in α can be interpreted as factor loadings measuring the relative importance of a deviation from equilibrium on a given endogenous variable. Factor loadings are short-run parameters; thus, we have partitioned Π into short- and long-run parameters.

³ Note that the squared values of the above-mentioned canonical correlations correspond to the eigenvalues of Π , implying that the problem at hand is an eigenvalue problem, that is, determining the number of eigenvalues that are significantly different from zero. The estimated eigenvalues are ranked according to their magnitudes and the co-integrating rank can be determined by performing a nonstandard distributed likelihood-ratio test, using the result (from linear algebra) that the rank of a matrix equals the number of eigenvalues different from zero.

3. Three Sub-Saharan African Economies

This section describes the data used in the empirical analysis and provides a sketch of the economies of Côte d'Ivoire, Ghana, and Zimbabwe. The data used in the analysis are the (log) real GDP in the industry, agriculture, and service sectors from the World Bank African Regional Database for 1965-97 (figure 1).⁵ The plots reveal an overall positive trend in all output series.⁶ First-order differences of the series (not shown) appear stationary, indicating that the series are integrated of order one, I(1). This is further supported by results from augmented Dickey-Fuller tests (see the appendix). Therefore, the series may possibly co-integrate.

Figure 1. Sectoral GDP for Côte d'Ivoire, Zimbabwe and Ghana



Note: The series are log(real GDP, factor prices) -- ind: industry, agr: agriculture, ser: service, civ: Cote d'Ivoire, zwe: Zimbabwe, gha: Ghana.
Source: World Bank African Regional Database.

The sectoral growth performance is closely related to the development of the three economies since 1965. All three countries have been through major economic crises

⁵ For Ghana, however, the series end in 1996.

⁶ Ghanaian industrial output experiences a major collapse in the early 1980s, which may make possible sub-sectoral relationships disappear. This proves to be the case in the co-integration analysis in the next section; accordingly, we propose disaggregating Ghanaian industrial output into the four subsectors manufacturing, construction, gas and water, and mining.

followed by structural adjustment programs aimed at restoring macroeconomic stability and increasing overall growth of the economy. In the following, we will briefly sketch the economic development of the three countries.

3.1. Côte d'Ivoire

Côte d'Ivoire has an income per capita of \$660 (in 1995). The agricultural sector accounts for 31 percent of GDP, and generates 70 percent of export revenues (table 1). Its main exports are cocoa, coffee, and timber. Starting in the early 1980s, Côte d'Ivoire experienced a severe economic and social crisis. The crisis began with macroeconomic imbalances that had grown to unsustainable levels: a budget deficit of about 10 percent of GDP and a current account deficit of about 17 percent of GDP. Public expenditures had increased markedly following the cocoa and coffee price booms of 1975-77, but then were not reduced as the booms ended. With the rapid build-up of external debt in the 1970s, Côte d'Ivoire started to encounter serious debt servicing problems. Tightly controlled and restrictive policies, including trade barriers and price interventions, began to create serious distortions in domestic markets in the 1980s. Most notably, these distortions resulted in inefficient resource allocation.

Table 1. Distribution of Gross Domestic Product in Côte d'Ivoire, Ghana, and Zimbabwe (percent)

Country	Agriculture		Industry		Services		Manufacturing	
	1980	1995	1980	1995	1980	1995	1980	1995
Côte d'Ivoire	27	31	20	20	53	50	13	18
Ghana	58	46	12	16	30	38	8	6
Zimbabwe	14	15	34	36	52	48	25	30

Source: World Bank (1997).

Adjustment policies introduced before 1987 were only partially successful in reducing the main internal and external imbalances. During the 1990s, the government initiated more widespread structural reforms, supported by the World Bank and the IMF. In 1994, a privatization law was adopted, which aimed at privatizing publicly owned enterprises. Restrictive wage policies combined with tax reform began to bring inflation under control. The government wage bill decreased significantly, from 10.7 percent of GDP in 1993 to 6.9 percent in 1995. Other policies included deregulation of the agricultural sector, aimed at reducing public intervention and obtaining more flexible producer prices. The structural reforms and high international prices for cocoa and coffee led to widespread increases in private investments.

3.2. Ghana

Ghana has an income per capita of \$390 (in 1995), which makes it the poorest of the three economies analyzed. The agricultural sector accounts for almost half of GDP (in 1995). Ghana has the least developed manufacturing sector, which accounts for only 6 percent of GDP (table 1). Its service sector is also less developed than that of Côte d'Ivoire and Zimbabwe, where the service sector accounts for around half of GDP.

The period from 1965 to the mid 1970s was characterized by expansion in agriculture and services, as Ghana maintained its position as the world's leading cocoa producer. From the mid-1970s to the mid-1980s, declining cocoa production and trade restrictions posed major obstacles to continued economic growth. Further, the return of more than a million Ghanaians from Nigeria in 1982-83 and a prolonged drought in 1982 accelerated the sectoral decline, resulting in historically low output levels in 1984 for all sectors. In response to the crisis, the government, with IMF and World Bank support, initiated the Economic Recovery Program (ERP) in 1983. The program aimed at restoring macroeconomic stability, encouraging savings and investment, creating an enabling environment for the private sector, and improving public sector management, including privatization of some of the many publicly owned enterprises.

Other changes also took place. The monopoly power of the Cocoa Board was broken, allowing farm produce prices to rise toward world market prices and, in turn, stimulating cocoa production. Trade liberalization measures were introduced, including an auction system for foreign exchange to replace a fixed exchange system with controls.

The changes resulted in increased investments in imported technology and spare parts, which had long been lagging because of the trade restrictions. Financial sector reforms were also introduced; in the late 1980s, ceilings on interest rates were removed and nonperforming assets of the banking system were written off (Montiel 1995). These measures led to increased economic activity in the Ghanaian economy, as revealed by the substantial positive trend in sectoral output for all series from 1985 onward (figure 1).

3.3. Zimbabwe

Zimbabwe has an income per capita of \$540 (in 1995). Zimbabwe pursued an import substitution strategy up until 1980. Worldwide economic sanctions were imposed on the regime during this so-called Unilateral Declaration of Independence period (1965-80). As a result of the sanctions, which closed Zimbabwe off from much of world trade, the country ended up with one of the most developed manufacturing sectors in Sub-Saharan Africa. In the early 1980s, mining, manufacturing, and agriculture each accounted for more than 20 percent of GDP, contrasting with many African economies, which are mainly based on agriculture.

Agricultural output in Zimbabwe is highly variable, a consequence of low and erratic rainfall and frequent droughts. Two particularly damaging droughts in 1991-92 and 1995 led to a drop in agricultural output. Recently, attention has been given to the development and promotion of more drought-resistant crops and improvements in water resource management. Also, reform programs were initiated after the declaration of independence in 1980. For agriculture these consisted largely of increased attention to smallholder agriculture.

The strict control of the Zimbabwean economy necessitated by the economic sanctions continued after the declaration of independence. During the 1980s, it became clear that this was not the road to prosperity as investments and export-led growth in both manufacturing and commercial agriculture were hampered. Furthermore, increased social service and military spending increased public deficits as the conflict with Mozambique became more visible by the late 1980s.

The government sought to increase growth by introducing a more flexible exchange rate policy and relaxing controls on investment and exports, leading up to the launching of the IMF and World Bank economic structural adjustment program in 1990.

This program further focused on deregulating the economy—prices, employment, wages, and trade—and on reducing the public deficit. Through this program, the Zimbabwean government wanted to send a signal of its policy shift from intervention and regulation toward deregulation and privatization (see Marquette 1997).

4. Sectoral Growth Analysis

To determine whether there are common sectoral components and feedback mechanisms in sectoral long-run growth in Sub-Saharan Africa, we examine the long-run properties of the series by performing co-integration and impulse response analysis. Specifically, we analyze whether there is a positive agriculture-industry link. We also examine the short-run properties of sectoral growth, including whether the sectors adjust when departing from long-run equilibrium growth.

4.1. Long-Run Sectoral Growth

The starting point is to formulate a parsimonious VAR that does not violate the design criteria. We experiment with various lag augmentations as well as a deterministic trend, while always ensuring that the specification criteria are fulfilled, that is, normally, identically, distributed residuals. For Zimbabwe, a specification with two lags and a trend is found to be suitable. For Ghana and Côte d'Ivoire, it is not possible to go below five lags without severely violating the specification criteria. For these two countries, we do not include a deterministic trend due to the risk of overfitting the model. These specifications are seen to be in accordance with the model specification criteria (table 2). In particular, there does not appear to be any serious autocorrelation problems. The next step is to test for co-integration in the parsimonious VAR. The eigenvalues and corresponding log-likelihoods from the estimation of the Π matrix from equation 3 and test statistics are presented in tables 3 and 4.

Table 2. Specification Tests for the Co-integration Vector Auto Regression

Country and industry	AR-test	Normality-test
Single-equation analysis		
<i>Côte d'Ivoire</i>		
	$F_{ar}(1, 11)$	$\chi^2_{normality}(2)$
Industry	0.354	2.027
Agriculture	0.236	3.864
Services	0.000	0.625
<i>Ghana</i>		
	$F_{ar}(1, 10)$	$\chi^2_{normality}(2)$
Industry	0.211	2.900
Agriculture	0.066	1.864
Services	0.557	0.947
<i>Zimbabwe</i>		
	$F_{ar}(1, 22)$	$\chi^2_{normality}(2)$
Industry	0.036	1.414
Agriculture	0.707	0.000
Services	0.083	0.525
Vector analysis		
<i>Côte d'Ivoire</i>		
	$F_{ar}(9, 17)$	$\chi^2_{normality}(6)$
	1.345	4.220
<i>Ghana</i>		
	$F_{ar}(9, 14)$	$\chi^2_{normality}(6)$
	0.740	6.630
<i>Zimbabwe</i>		
	$F_{ar}(9, 43)$	$\chi^2_{normality}(6)$
	1.782	1.170

Source: Authors' calculations.

Table 3. Eigenvalues and Log-Likelihoods

Rank	Côte d'Ivoire		Ghana		Zimbabwe	
	Eigenvalue	Log-likelihood	Eigenvalue	Log-likelihood	Eigenvalue	Log-likelihood
0		245.458		231.872		210.334
1	0.618	258.919	0.374	238.188	0.523	221.797
2	0.354	265.030	0.207	241.315	0.248	226.217
3	0.007	265.132	0.028	241.700	0.197	229.626

Source: Authors' calculations.

Table 4. Eigenvalues and Log-Likelihoods for Ghana, Sub-sectoral Specification

Rank	Eigenvalue	Log-likelihood
0		383.189
1	0.841	410.730
2	0.806	435.318
3	0.570	447.959
4	0.358	454.613
5	0.220	458.340
6	0.119	460.247

Source: Authors' calculations.

The findings reveal the existence of one co-integrating relationship in sectoral GDP for Côte d'Ivoire and Zimbabwe (table 5). For Ghana, no co-integration is present (table 5). This may be due to aggregation, as industry consists of the sub-sectors manufacturing, construction, gas and water, and mining. In particular, the proposed dynamics between the agricultural sector and food processing, which is part of manufacturing (Gopinath, Roe and Shane, 1996), may vanish during aggregation. Moreover, a possible relationship between agriculture and manufacturing would possibly vanish in the substantial fall in overall industry GDP for Ghana in the early 1980s (see figure 1). Specifying a model with industrial GDP disaggregated into sub-sectors could accommodate this possibility. Pursuing this possibility leads to a final specification with two lags and a deterministic trend. The test statistics resulting from the specification tests of this alternative model are presented in table 7. The overall impression is that this specification also appears to be well specified, with only minor signs of autocorrelation. The Johansen test for this alternative specification reveals the existence of two distinct co-integrating relationships. This result supports our earlier hypothesis of sub-sectoral dynamics possibly vanishing in the course of aggregation to the industry level.

Table 5. Test for Co-Integrating Rank, Aggregate Model

	Côte d'Ivoire		Ghana		Zimbabwe	
	λ_{\max}	Trace	λ_{\max}	Trace	λ_{\max}	Trace
$H_0: \text{rank}=p$						
$p=0$	26.92**	39.35**	12.63	19.66	22.93	38.58**
$p \leq 1$	12.22	12.42	6.254	7.024	8.841	15.66
$p \leq 2$	0.204	0.204	0.770	0.770	6.818**	6.818**

** Rejection at a 1 percent level of significance.

Source: Authors' calculations.

Table 6. Test for Co-Integrating Rank for Ghana, Sub-sectoral Specification

$H_0: \text{rank}=p$	λ_{\max}	Trace
$p=0$	55.08**	154.1**
$p \leq 1$	49.18**	99.03
$p \leq 2$	25.28	49.86
$p \leq 3$	13.31	24.58
$p \leq 4$	7.455	11.27
$p \leq 5$	3.814	3.814

** Rejection at a 1 percent level of significance.

Source: Authors' calculations.

Table 7. Specification Tests for Co-Integration Vector Auto Regression for Ghana, Sub-sectoral Specification

Industry			
<i>Single-equation analysis</i>			
	$F_{ar}(1, 15)$	$\chi^2_{normality}(2)$	$F_{arch}(1, 14)$
Manufacturing	0.081	1.298	0.000
Agriculture	4.021	5.369	1.423
Services	0.003	2.396	0.146
Mining	0.141	0.706	0.001
Construction	0.290	1.723	0.476
Gas and water	2.372	1.699	0.185
<i>Vector analysis</i>			
	$F_{ar}(36, 24)$	$\chi^2_{normality}(12)$	
	2.155*	13.222	

* Rejection at a 5 percent level of significance.

Source: Authors' calculations.

The co-integrating rank is restricted to one for Côte d'Ivoire, one for Zimbabwe, and two for Ghana. Tests—including over-identifying restrictions on the α and β vectors—may now be carried out, since estimated parameters follow standard distributions once the co-integrating rank has been “locked”. For α , the main test of interest is that of weak exogeneity of a particular variable with respect to β . This test is carried out by restricting the adjustment coefficients of the variable in question to zero, and amounts to testing whether the variable in question adjusts to deviations from equilibrium (which is the interpretation of the co-integrating relation). If all the α coefficients of a particular variable can be restricted to zero, then we may condition on this variable in the further analysis. That is, we may remove it from the left-hand side of the equation and it becomes exogenous to the remaining system. If this is the case, this particular variable drives the system of equations. Regarding β , there is no “right” size of the inter-sectoral dependency from a theoretical point of view, as long as the elasticities

are within the range $[-1, 1]$. We suggest testing for unit elasticity between sectors, which may be interpreted as “full sectoral spillover.”

For Ghana, hardly any of the elasticities are close to one; hence, unity restrictions give rise to very large changes in the other parameters. Therefore, we focus on the issue of exogeneity and take the estimated co-integrating restrictions as given. We apply the restrictions directly as error correction terms in the short-run analysis.⁸

Table 8 presents the findings. In each case, the first specification applies only a normalizing restriction (except for Ghana, which requires normalizing and identifying restrictions). The second specification is the over-identified, or testable, co-integrating vector. The restricted co-integrating relations are presented in tables 9 and 10.

For Côte d’Ivoire and Zimbabwe, we find an elasticity of unity between industry and agriculture, indicating full sectoral spillover from agriculture to industry following agricultural expansion. For Zimbabwe, service sector growth also spills over with a factor of unity. In the case of Côte d’Ivoire, the impact of the service sector is less than unity (25 percent).

Table 8. Tests of Co-Integrating Restrictions

Restriction(s)	Log-likelihood	χ^2 -stat.	Deg. of freedom
<i>Côte d’Ivoire</i>			
$\beta_{ind}=1$	258.919		
$\beta_{ind}=1-1\wedge\alpha_{ser}=0$	258.124	1.591	2
<i>Ghana</i>			
$\beta_{man}=1$	435.318		
$\beta_{man}=1\wedge\alpha_{agr}=\alpha_{ser}=\alpha_{con}=\alpha_{gas}=0$	428.053	14.53	8
<i>Zimbabwe</i>			
$\beta_{ind}=1$	221.797		
$\beta_{ind}=1\wedge\beta_{agr}=\beta_{ser}=-1\wedge\alpha_{ser}=0$	220.114	3.367	3

Note: In the subscripts for the variables in the restrictions, ind denotes industry; agr, agriculture; ser, service; man, manufacturing; min, mining; con, construction; and gas, gas and water. Note that for the case of Ghana, the tests implies restrictions on both of the β and α parameters, respectively, of the variable in question.

Source: Authors’ calculations.

⁸ The analysis has to apply identifying restrictions equaling the number of co-integrating restrictions minus one, that is, one in the present setting (this explains why all additional restrictions are testable in the case of one co-integrating relation, as this is exactly identified). We choose to restrict the parameter of construction in the first co-integrating relation to its estimated value, that is, take it as given. This merely means that further testing is conditional on this value being “true”, that is, it cannot be tested.

Table 9. Restricted Co-Integration Relations, Aggregate Model

Country	β -eigenvectors			α -coefficients		
	Industry	Agriculture	Services	Industry	Agriculture	Services
Côte d'Ivoire	1.000	-1.000	-0.248	-0.240	0.646	0.000
Zimbabwe	1.000	-1.000	-1.000	-0.1054	1.049	0.000

Source: Authors' calculations.

Table 10. Restricted Co-integration Relations for Ghana, Sub-sectoral Specification

Manufacturing	Agriculture	Services	Mining	Construction	Gas and water
<i>β-eigenvectors</i>					
1.000	-0.2494	0.8591	-0.2293	-0.7479	-0.0178
-2.657	1.000	-1.283	-3.720	3.762	2.959
<i>α-coefficients</i>					
-1.224	0.000	0.000	-0.3475	0.000	0.000
0.07737	0.000	0.000	0.4215	0.000	0.000

Source: Authors' calculations.

For both Côte d'Ivoire and Zimbabwe, the service sector is weakly exogenous to the system, implying that we may condition on services when modeling the $I(0)$ -space. The disaggregated specification for Ghana is found to be driven by agriculture, services, construction, and gas and water since these sectors are weakly exogenous to the system. Therefore, we may reduce this system to consist of only the equations for manufacturing and mining (we do that in the next subsection).

These findings imply the existence of a sectoral feedback mechanism; sectoral expansion or productivity gains in either the industrial or agricultural sector feed back into the other sector. Additionally, these findings support the hypothesis that economic growth in these countries is partly led by the service sector (Glasmair and Howland, 1994). One explanation of the positive link between agriculture and industry is that a larger and/or more productive agricultural sector can supply cheaper inputs for the food processing sector. This leads to an increased derived demand for primary agricultural products and, in turn, to increased agricultural sector demand for machinery and equipment produced by the industrial sector. Similarly, an expansion of the industrial sector requires increased input from agriculture.

The service sector plays an important role in sectoral growth, due both to its presence in the co-integrating relationship and to it being weakly exogenous to the system in all three cases. The expansion of the service sector has positive effects on industry and agriculture due to increased demand for agricultural and industrial sector input. This is true even though the service sector does not appear to utilize agricultural produce to the same extent as the food processing industry.

The inter-sectoral relationships can also be quantified by means of impulse response analysis, which traces the accumulated dynamic response of a hypothetical one-unit increase of each variable (Hamilton, 1994). The findings of the impulse response analysis support our earlier findings of a positive industry-agriculture link in sectoral economic growth (see figures 2, 3, and 4). For all three countries, there exists a positive impact on agricultural growth from an increase in the industrial sector (in Ghana: the manufacturing sector) over a ten-year period. For Côte d'Ivoire, the initial one-unit increase in industry leads to an increase of three units in the agricultural sector after 10 years. For Zimbabwe, the accumulated effect is almost two units, while for Ghana the increase is only one unit.

When investigating the agriculture-industry link in the other direction, that is, from agriculture to industry, there is at least an initial positive dynamic response in all three countries. In the case of Côte d'Ivoire, this response holds throughout the period; for Zimbabwe and Ghana, an adverse response follows after five to seven years. The service sector overall has a positive impact on the other sectors. For the remaining Ghanaian sub-sectors, the evidence is mixed.

Altogether, the results from the impulse response analysis support our earlier findings of a positive agriculture-industry link with service as an important growth-promoting factor. We now take the analysis a step further by modeling short-run sectoral growth.

Figure 2. Accumulated Sectoral Impulse Responses for Côte d'Ivoire

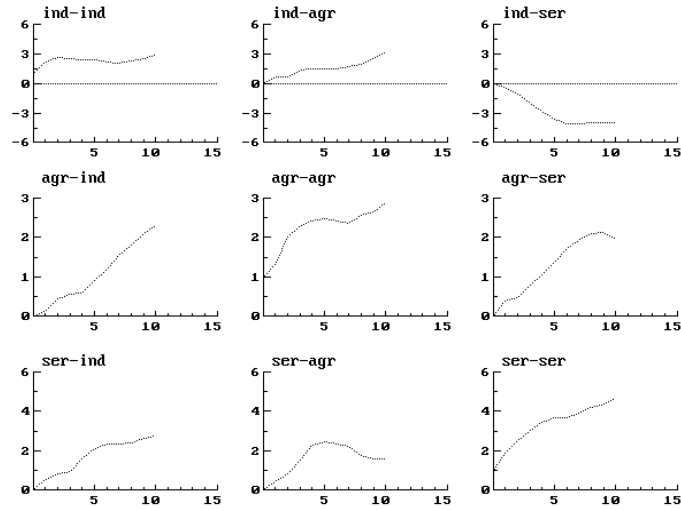


Figure 3. Accumulated Sectoral Impulse Responses for Ghana

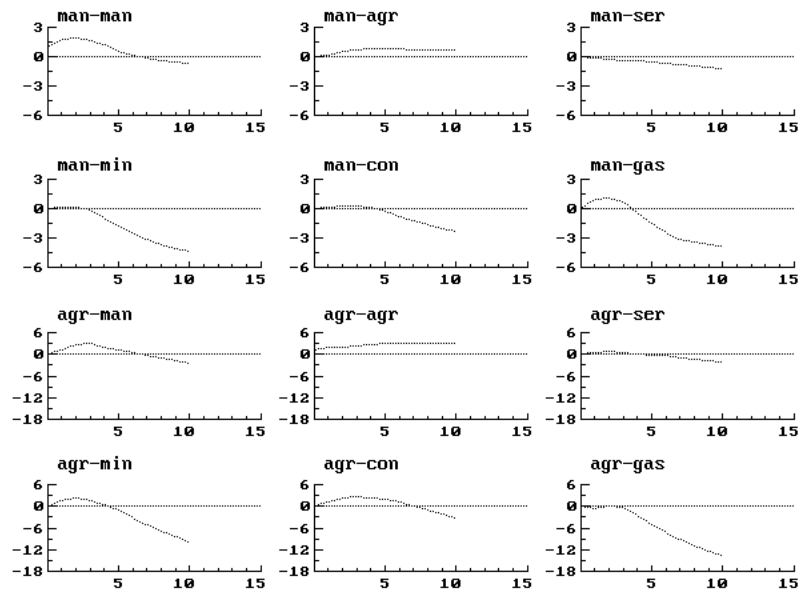


Figure 3, Continued.

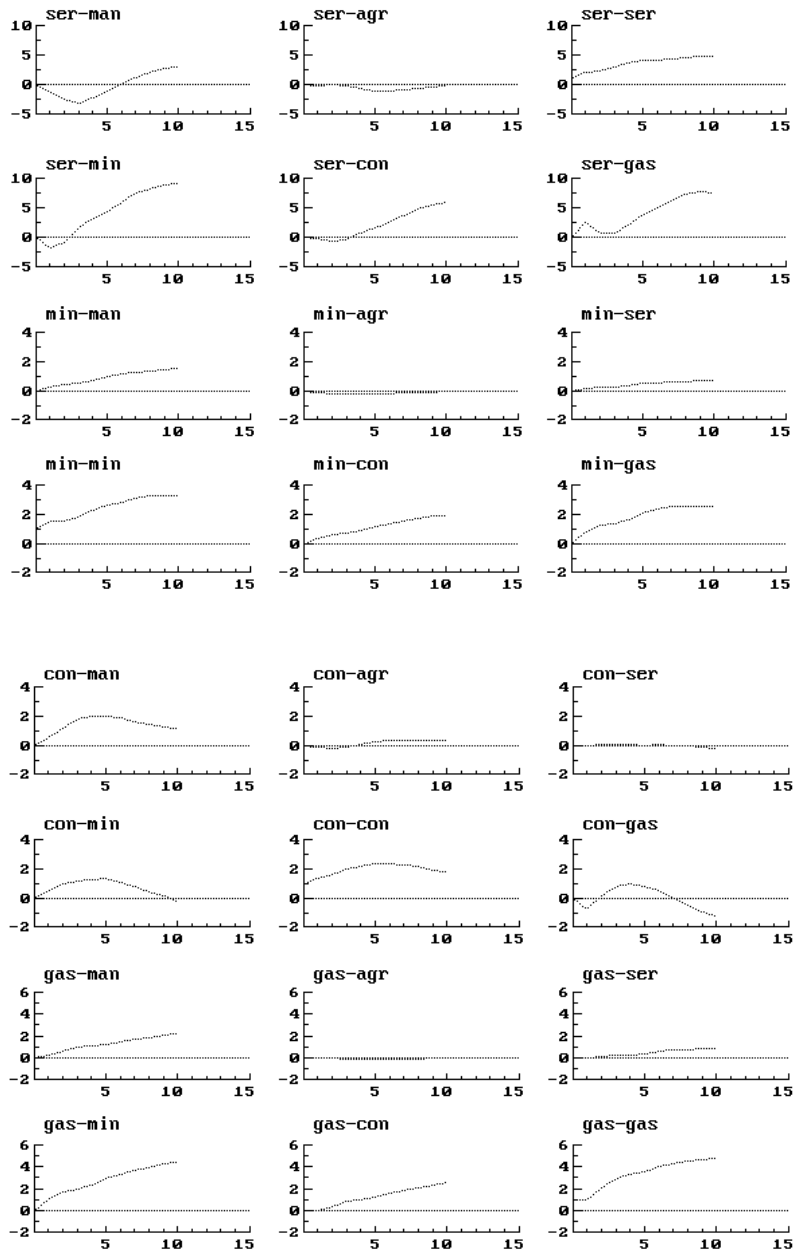
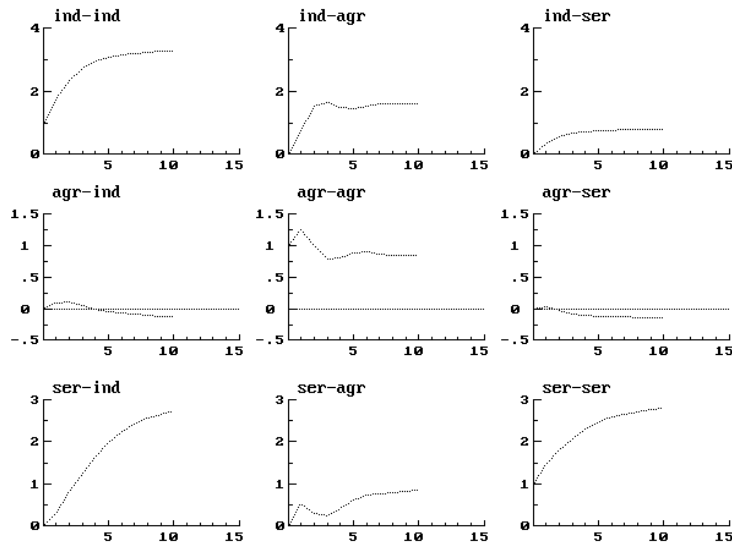


Figure 4. Accumulated Sectoral Impulse Responses for Zimbabwe



4.2. Short-Run Sectoral Growth

The co-integration analysis of the previous subsection allowed us to examine the long-run experience of the sectoral developments in the three countries. When moving to examining the short-run growth experience, however, we may take the long-run information of the series into account in analyzing short-run sectoral growth, as the restricted co-integration relations determined previously may be included as explanatory variables. The resulting model is a short-run Error-Correction Model (ECM).

The aim is to obtain a parsimonious model of short-run sectoral growth that is able to pass the specification tests. In the previous analysis, two lags (and a deterministic trend) were found to be appropriate for Ghana and Zimbabwe. A specification with one lag would be adequate because two lags in levels correspond to one lag in first-order differences. The same reasoning leads to an initial specification with four lags in the case of Côte d’Ivoire. However, when moving to first-order differences, the system for Côte d’Ivoire becomes severely afflicted by singularity problems, which persist at four, three, and two lags. Moving to one lag yields a specification with no singularity problems, which further passes the diagnostic tests (table 11). Because all three of the models already are relatively parsimonious and further reduction of individual variables affects the results of the diagnostic tests, we choose these specifications as our final, dynamic,

short-run models. Tables 11, 12, and 13 present the models and the findings of the diagnostic tests.

Table 11. Dynamic Short-Run Sector Growth Model for Côte d'Ivoire

Explanatory variable	Equation		Explanatory variable	Equation	
	Industry	Agriculture		Industry	Agriculture
Industry _{t-1}	0.214 (1.320)	0.040 (0.224)	Services _{t-1}	0.415 (2.042)	0.408 (1.815)
Agriculture _{t-1}	0.0199 (0.093)	-0.076 (-0.321)	CI _{t-1}	-0.351 (1.912)	0.194 (0.956)
Services _t	-0.329 (-1.856)	-0.202 (-1.030)	Constant	-2.548 (-1.899)	1.447 (0.975)

Diagnostics

Single equation analysis	σ	$F_{ar}(1, 24)$	$\chi^2_{normality}(2)$	$F_{arch}(1, 23)$
Industry	0.078	0.970	2.517	0.135
Agriculture	0.086	2.685	2.615	0.032
Vector analysis	$F_{ar}(4, 44) = 2.159, \chi^2_{normality}(4) = 5.073$			

Note: Values in parentheses are t-statistics. Subscripts denotes the time period, i.e. t: current period, t-1: lagged one period, CI denotes the restricted co-integrating relation.

Source: Authors' calculations.

Table 12. Dynamic Short-Run Sector Growth Model for Ghana

Explanatory variable	Equation		Explanatory variable	Equation	
	Manufacturing	Mining		Manufacturing	Mining
Manufacturing _{t-1}	0.947 (4.818)	1.435 (3.193)	Construction _{t-1}	-0.341 (-2.145)	-0.819 (-2.254)
Agriculture _t	0.151 (0.556)	-0.675 (-1.088)	Gas and water _t	0.101 (1.054)	0.172 (0.786)
Agriculture _{t-1}	0.708 (3.032)	0.536 (1.004)	Gas and water _{t-1}	0.037 (0.527)	-0.246 (-1.523)
Services _t	-0.663 (-2.551)	-1.347 (-2.266)	CI_1 _{t-1}	-1.374 (-7.461)	-0.337 (-0.801)
Services _{t-1}	0.010 (0.032)	-1.142 (-1.636)	CI_2 _{t-1}	0.020 (0.765)	0.425 (6.966)
Mining _{t-1}	0.148 (1.682)	0.746 (3.707)	Constant	21.245 (7.617)	7.627 (1.196)
Construction _t	0.457 (3.671)	0.750 (2.631)	Trend	0.008 (1.974)	-0.037 (-3.880)

Diagnostics

Single equation analysis	σ	$F_{ar}(1, 15)$	$\chi^2_{normality}(2)$	$F_{arch}(1, 14)$
Manufacturing	0.081	0.275	3.935	0.085
Mining	0.186	0.135	1.639	0.711
Vector analysis	$F_{ar}(4, 26) = 0.091, \chi^2_{normality}(4) = 5.230$			

Note: Values in parentheses are t-statistics. Subscripts denotes the time period, i.e. t: current period, t-1: lagged one period, CI denotes the restricted co-integrating relation.

Source: Authors' calculations.

Table 13. Dynamic Short-Run Sector Growth Model for Zimbabwe

Explanatory variable	Equation		Explanatory variable	Equation	
	Industry	Agriculture		Industry	Agriculture
Industry _{t-1}	0.009 (0.043)	0.027 (0.073)	CI _{t-1}	-0.105 (-0.827)	1.049 (4.459)
Agriculture _{t-1}	0.023 (0.217)	0.372 (1.943)	Constant	-2.084 (-0.798)	21.408 (4.445)
Services _t	0.212 (0.885)	-0.355 (-0.802)	Trend	-0.007 (-1.436)	0.042 (4.422)
Services _{t-1}	0.179 (0.774)	1.152 (2.706)			

Diagnostics

Single equation analysis	σ	$F_{ar}(1, 23)$	$\chi^2_{normality}(2)$	$F_{arch}(1, 22)$
Industry	0.083	0.033	0.369	0.048
Agriculture	0.072	0.748	2.210	5.775*
Vector analysis	$F_{ar}(4, 42) = 0.279$		$\chi^2_{normality}(4) = 5.230$	

* Rejection at a 5 percent level of significance.

Note: Values in parentheses are t-statistics. Subscripts denotes the time period, i.e. t: current period, t-1: lagged one period, CI denotes the restricted co-integrating relation.

Source: Authors' calculations.

Again, the importance of the agricultural sector is apparent. It has an overall positive impact on industrial growth (in Ghana: manufacturing growth). In Côte d'Ivoire and Zimbabwe, industry also has a positive impact on growth in the agricultural sector. These findings once again support the existence of a positive growth link between agriculture and industry. The positive dynamics between the agricultural and industrial sectors are the most robust findings across the three countries. For the service sector, there is evidence of a negative instantaneous impact, followed by a positive effect a year later. For the remaining Ghanaian sectors—mining, construction, and gas and water—there is mostly a positive impact.

There is some evidence of the industrial (Ghana: manufacturing) sector error correcting toward equilibrium, as the sign on the ECM term is negative, except for the second ECM term for Ghana. For agriculture, the parameter of the error correction term has the “wrong” sign (though only statistically significantly so for mining).⁹

For all three countries, there are significant long-run sectoral relationships among the industry, agriculture, and service sectors. These relationships imply the existence of

⁹ This implies that the various sectors adjust to deviations from equilibrium (which is the interpretation of the co-integrating relation): if the sector, following a positive shock, exceeds its long-run size, it will start adjusting toward its equilibrium size and vice versa for a negative shock. If they are positive, when experiencing a positive shock, the sectors react by expanding and would thus diverge over time. Similarly, following an adverse shock, they would start degenerating.

strong interdependencies in sectoral growth. These findings conflict with the basic dual economy model, which implies that there cannot exist a long-run relationship between growth in agriculture and industry. An overall positive agriculture-industry growth link is established for both the short and the long run. The service sector also proves important because it is weakly exogenous in all three cases, which implies that the service sector is an important growth-promoting sector.

5. Conclusion

This paper examined agriculture, industry and service sector growth in Côte d'Ivoire, Ghana, and Zimbabwe over more than three decades. The empirical analysis of the sectoral components of growth in GDP in these three economies revealed the existence of one long-run sectoral relationship in Côte d'Ivoire and Zimbabwe but no co-integrating relationship in Ghana at the aggregate level. Since this could be due to the level of aggregation, we pursued an alternative specification with industry disaggregated into four sub-sectors. This specification revealed the existence of two long-run relationships.

These findings point toward a large degree of interdependence in sectoral growth, in turn implying that the sectors “grew together” or, similarly, indicating the presence of externalities or spillovers between sectors. Furthermore, the results provide evidence against the basic dual economy model, which implies that a long-run relation cannot exist between agricultural and industrial output. These findings were supported by the impulse response and short-run analyses that both pointed to a positive link between growth in the industry and agriculture sectors.

So what are the implications of all of this? Stepping, first, a bit back in time, many developing countries looked toward the experiences of industrial economies in the period following World War II and adopted policies favoring the industrial sector, often times at the expense of the agricultural sector. Many African countries followed this road during the 1960s and 1970s. The analyses indicate that in Côte d'Ivoire, Zimbabwe, and Ghana, such a policy—focusing mainly on industry—is not optimal. It would be more effective and efficient to balance policies to include all sectors, whereby economy-wide growth would gain the maximum from the positive externalities of the growth of the individual sectors.

The main policy implication emerging from this study is that more attention should be paid to the inter-sectoral dynamics in Sub-Saharan African economies for two reasons. First, an adverse shock—for example, in agriculture following a drought—is likely to cause adverse effects in the other sectors of the economy. Hence, policymakers should try to accommodate not only the initial shock in the agricultural sector, but also its adverse effects on the other sectors. In practice, when a severe drought occurs, the majority of the attention is drawn toward the agricultural sector. Second, the presence of inter-sectoral dynamics indicates externalities from sectoral expansion, that is, when one sector grows it will have dynamic effects on the other sector(s). This should be taken into account when designing policy interventions at the sector/industry level by balancing funds across the agriculture, industry, and service sectors, rather than focusing on, say, one or two sectors, for example when providing public subsidies and/or “start-up programs”.

The implications go further than to aggregate sectoral/industrial policies, however. In particular, the results in this study have implications for the design of education and training programs, as well: if all three sectors “go together” over time—which essentially is the intuition behind the finding of (a) co-integrating relationship(s) in the three economies considered here—then *all* factors that feed into production should be balanced, not just the more obvious, aggregate factors such as public subsidies. Obviously, human capital is a large component of these inputs, including various types of formal education, non-formal education and vocational training. Also, the relevant education and training differ across the agriculture, industry, and service sectors: firm-specific on-the-job training may be more important in manufacturing, for example, while more traditional formal education may be more important for some services jobs. So, another implication of growth being shared between sectors over time imply is that the design of education and training programs also should be balanced, and not benefit some types or levels of education over others.¹⁰

Future research might want to examine sectoral dynamics—broadly defined—in more detail. In particular, it would be interesting to do more work in line with the sub-

¹⁰ As an example of what might happen if education policies are not balanced, see Blunch (2005), which examines the 1987 Education Sector Reform in Ghana. The Reform was mainly targeted at basic education (i.e. first nine years) and partially as a result of this, the study suggests, the quality of primary education increased following the Reform, while the quality of other levels and types of education decreased.

sectoral analyses for Ghana carried out in this paper and move to a level of aggregation lower still. For example, one might imagine investigating whether the dynamics persist at the sub-sub-sectoral level, involving, say, metal, wood, and textile firms in the manufacturing sector and similarly for the other industry sub-sectors and agriculture and services sub-sectors.

Another potentially interesting direction for future research coming out of the present study, we suggest, is—rather than to examine sectoral (sub-sectoral, sub-sub-sectoral, etc) developments simultaneously—to focus at one subset within one of the three sectors (or sub-sectors, and so on) and then examine the experiences within that subset. A recent study, for example, examines the experience of the Ghanaian education system and finds evidence that by overly focusing on basic education (i.e. the first nine years of education), the 1987 Education Sector Reform led to improvements in the quality of primary education, while the quality of all other levels and types of education decreased (Blunch, 2005). Future studies might want to explore this same issue for other countries, other types of interventions and other sectors/sub-sectors, say, health.

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Appendix

The augmented Dickey-Fuller (ADF) test starts out from the regression:

$$(A1) \quad \Delta z_t = a + bt + cz_{t-1} + \sum_{j=1}^J d_j \Delta z_{j-1} + \varepsilon_t$$

where $c = \rho - 1$.

The ADF test for a unit root against the (trend) stationary alternative is then:

H_0 : z has a unit root, $z \sim I(1)$, i.e. $c = 0$

H_1 : z is (trend) stationary, $z \sim I(0)$, i.e. $c < 0$.

From the results of the ADF regression (two lags) presented in table A1, there do not seem to be any serious problems with autocorrelation, although industry shows some indications of autocorrelation at a 5 percent level of significance.¹¹ The results of the ADF tests support the presence of a stochastic trend in the series, and thus support that the series are integrated of order one, $I(1)$. It should be noted, however, that the ADF test has low power, so that we will tend to under-reject the H_0 of integration even if it is false, especially in small samples.

¹¹ The ADF test is sensitive to the presence of autocorrelation; see, for example, Banerjee *et al* (1993).

Table A1. Augmented Dickey-Fuller Tests and Specification Tests for ADF Regressions

Country and sector	ADF unit root test	Test for autocorrelation
<i>Côte d'Ivoire</i>		
	ADF t-statistic =	$F_{ar}(1, 24) =$
Industry	-2.059	1.923
Agriculture	-3.043	1.548
Service	-2.478	0.310
<i>Ghana</i>		
	ADF t-statistic =	$F_{ar}(1, 23) =$
Manufacturing	-1.447	0.737
Agriculture	-2.533	1.110
Service	-0.785	1.083
Mining	-1.232	1.558
Construction	-0.949	3.510
Gas and water	-1.625	0.713
Industry	-1.140	6.173*
<i>Zimbabwe</i>		
	ADF t-statistic =	$F_{ar}(1, 24) =$
Industry	-2.328	5.428*
Agriculture	-2.634	0.133
Service	-3.437	3.860

* Rejection at a 5 percent level of significance.

Source: Authors' calculations.