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Empirical Testing of the Gibson Paradox in Selected African Countries

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Abstract

This study examines the relationship between nominal interest rates and prices in ten African countries. The objective is to test for the validity of the Gibson paradox in the African context. Recognizing the possibility of spurious regression results, we first undertook unit root tests and found that the variables are I (1) series. Next, we employed the bounds testing approach to co integration. The results provide empirical support for the Gibson paradox in seven out of the ten countries: Cote d'Ivoire, Gambia, Ghana, Kenya, Nigeria, Senegal and South Africa. This suggests that nominal interest rate is an effective tool for the moderation of long-run general price levels. We found a negative relationship between interest rates and prices in Benin and Cameroon, and no significant relationship in Gabon.

Keywords: Gibson paradox, prices, interest rates, African countries.

JEL Codes: C32, E31, E40, O55.

I. Introduction

In 1923, Alfred Herbert Gibson, a British economist, observeda positive correlation between the general level of prices and the nominal interest rate during the gold standard period. This relationship was coined as the Gibson paradox by Keynes (1930), because it was contrary to the view held by most economic theories at the time, which predicted a negative correlation. Monetary theory expects a correlation between nominal interest rates and the rate of change, rather than the level, of prices. The Gibson paradox seems to contradict the long-run neutrality and super neutrality of money propositions. Keynes (1930) commented that the Gibson paradox was "one of the most completely established facts in the whole field of quantitative economics. Since then, the paradox has been the topic of a host of studies attempting to provideempirical supports and theoretical possible explanations (see Fisher, 1930; Keynes, 1930; Wicksell, 1936; Sargent, 1977; Shiller and Siegel, 1977; Barsky and summers, 1988).

Empirically, the evidence regarding this "price puzzle" is mixed. For instance, Klein (1995) for US, Sertletis and Zestos (1999) for eight members of the European Union Dowd and Harrison (2000) for the UK, found supporting evidence for the Gibson paradox. However, Atkins and Serletis (2003) for Canada, Italy, Norway, Sweden, the UK and the US, Sinha (2002) for India and Halicioglu (2004) for Turkey found no support for the paradox.

Most of the empirical studies on the Gibson paradox focuson developed countries. There is not previous paper for African countries, apart from Ogbonna (2014) which indicates that the Gibson paradoxholds for Nigeria. Thus, the present study aims at contributing to the existing literature to this end. It examines the existence of the positive relationship between nominal interest rates and prices in a sample of ten African countries. In doing so, it also uses the Pesaran *et al.* (2001) bounds testing approach to the analysis of long-run level relationships. This approach is particularly relevant as it is capable of uncovering a long-run relationship between a I (1) series and another series which can be I (0).

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The remainder of the paper is organized as follows. Section 2 describes the econometric methodology of the study. Section 3 analyses the empirical results and Section 4 provides summary and suggests topics for further research.

2. Data and econometric methodology

2.1 Data and model specification

The Gibson relationship is described as follows:

$$\log(p_t) = \alpha + \beta i_t + \mu_t \quad (1)$$

where i_t represents the nominal interest rates in period t, and $\log(p)$ is the natural logarithm of the price levels.

The study uses annual data for a sample of ten African countries, namely Benin, Cameroon, Cote d'Ivoire, Gabon, Gambia, Ghana, Kenya, Nigeria, Senegal and South Africa. The variables under study are nominal deposit interest rate and inflation rate. Inflation rate is computed as the annual percentage change of the consumer price index. The data are taken from the World Development Indicators of the World Bank. Data are annual and the sample size is different depending on the availability of the data.

2.2 Bounds testing approach to cointegration

Several econometric methods have been developed to investigate the long-run relationship between two or more time series variables. However, in this work, we use the autoregressive distributed lag (ARDL) bounds test developed by Pesaran *et al.* (2001). This technique has certain econometric advantages over standard methods. It can be applied irrespective of whether the regressors are I (0) or I (1). This allows us to avoid the problem associated with conflicting results of the conventional unit root tests and the low power of these tests in small samples. It also solves the endogeneity problems and the inability to test hypotheses on the estimated coefficients in the long-run associated with the Engle-Granger two-step method.

The bounds test begins with an unrestricted vector autoregressive (VAR) in levels:

$$Y_t = \mu + \sum_{j=1}^{p} \phi_j Y_{t-j} + \varepsilon_t \quad (4)$$

Where $Y_t = [\log(p_t) \quad i_t]'$. The vector of error terms $\varepsilon = [\varepsilon_i, \quad \varepsilon_\pi]' \sim \mathrm{N}(0, \Omega)$ where Ω is positive definite and given by:

$$\Omega = \begin{bmatrix} \omega_{ii} & \omega_{i\pi} \\ \omega_{i\pi} & \omega_{\pi\pi} \end{bmatrix} \quad (5)$$

Manipulation of Eq.(4) allows this VAR model to be re-specified as a vector error correction model (VECM):

$$\Delta Y_t = \mu + \lambda Y_{t-1} + \sum_{j=1}^{p-1} \gamma_j \Delta Y_{t-j} + \varepsilon_t \quad (6)$$

Where the short-run coefficients are given by:

$$\gamma_j = \begin{bmatrix} \gamma_{ii,j} & \gamma_{i\pi,j} \\ \gamma_{\pi i,j} & \gamma_{\pi\pi,j} \end{bmatrix} = -\sum_{k=j+1}^{p} \phi_k \quad (7)$$

The coefficient λ is the long-run multiplier matrix and is given by:

$$\lambda = \begin{bmatrix} \lambda_{ii} & \lambda_{i\pi} \\ \lambda_{\pi i} & \lambda_{\pi\pi} \end{bmatrix} = -\left(I_2 - \sum_{j=1}^{p} \phi_j \right) \quad (8)$$

Where I_2 is a 2 x 2 identity matrix. The diagonal elements of the matrix λ are left unrestricted, allowing for the possibility that the series can be either I(0) or I(1). The bounds test procedure allows for the testing of at most one long-run relationship and so requires a zero restriction on one of the off diagonals of the matrix λ. As we test for the Fisher effect, we impose the assumption that $\lambda_{\pi i} = 0$. Under this assumption, the equation for the nominal interest rate from Eq.(6) can be written as:

$$\Delta i_t = \theta_0 + \theta_1 i_{t-1} + \theta_2 \log(p_{t-1}) + \sum_{i=1}^{m} \gamma_{1i} \Delta i_{t-i} + \sum_{i=0}^{n} \gamma_{2i} \Delta \log(p_{t-i}) + \mu_t \quad (9)$$

The presence of cointegration between nominal interest rate and prices is tested by restricting the lagged levels variables and intercept in the above equation equal to zero, i.e. $\theta_1 = \theta_2 = 0$. This hypothesis is tested by the mean of the *F*-statistic. Pesaran*et al*. (2001) suggested applying the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of recursive of squares of recursive residuals (CUSUMSQ) tests to assess the parameter constancy of the model. Once cointegration is found, the long-run coefficienton prices is computed as the coefficient of the one lagged level price variable divided by the coefficient of interest rate and then multiplied by a negative sign.

2.3 Causality analysis

To provide more knowledge on the relationship between nominal interest rate and price levels, this study further examines the direction of causality between the two variables using the Granger causality analysis. In the presence of a long-run relationship, Granger-causality test requires the inclusion of a lagged error correction term within a vector error correction model (VECM). Accordingly, Granger- causality analysis involves estimating the following equations:

$$\Delta \log(p_t) = \varphi_1 + \sum_{j=1}^{p} \beta_{1j} \Delta \log(p_{t-j}) + \sum_{j=1}^{p} \gamma_{1j} \Delta i_{t-j} + \lambda_1 ECT_{t-1} + e_{1t} \quad (10)$$

$$\Delta i_t = \varphi_2 + \sum_{j=1}^{p} \beta_{2j} \Delta \log(p_{t-j}) + \sum_{j=1}^{p} \gamma_{2j} \Delta i_{t-j} + \lambda_2 ECT_{t-1} + e_{2t} \quad (11)$$

In both equations, $ECTt_{-1}$stands for the residuals of the long-run relationship. Coefficients on ECT_{t-1}capture the speed of adjustment of the variables in response to a deviation from their long-run equilibrium path. The significance of the differenced explanatory variables based on F-statistics or Wald-statistics indicates the existence of short-run causal effects, whereas the significance of ECT_{t-1} based on t-statistics indicates the existence of long-run causality.

3. Empirical results

As a first step of our empirical analysis, we test for the order of integration of the two series. This step is important in order to ensure that no variable is integrated of order two or higher. Moreover, the bounds test requires the dependent variable to be a I(1) series. To this end, we perform two well-known unit root tests—the PP test of Phillips-Perron (1988) and the KPSS test of Kwiatkowski et *al.* (1992). These tests have been performed under the models with constant and trend for the level series and with constant for series in first difference.The results of these tests displayed in Table 1show that nominal interest rates and prices are I (1) for all countries.

Table 1: Results of unit root tests

Country	Period	Phillips-Perron Test				KPSS Test			
		i	p	Δi	Δp	i	p	Δi	Δp
Benin	1971-2013	-3.37	-2.01	-6.59*	-4.35*	0.14	0.12	0.18	0.25
Cameroon	1979-2013	-3.33	-2.27	-6.33*	-4.28*	0.12	0.18*	0.20	0.40
Cote d'Ivoire	1970-2013	-2.92	-0.95	-6.68*	-3.76*	0.15*	0.19*	0.18	0.42
Gabon	1979-2013	-3.07	-3.45	-6.26*	-4.52*	0.12	0.10	0.26	0.22
Gambia	1978-2013	-2.13	-1.21	-6.01*	-2.87	0.13	0.15*	0.40	0.29
Ghana	1978-2013	-1.61	-2.19	-6.14*	-4.20*	0.17*	0.20*	0.14	0.07
Kenya	1970-2013	-1.76	-1.75	-6.17*	-4.01*	0.17*	0.11	0.13	0.10
Nigeria	1970-2013	-1.87	-1.36	-8.13*	-3.07*	0.18*	0.10	0.21	0.15
Senegal	1970-2013	-2.92	-1.57	-6.68*	-4.46*	0.15*	0.20*	0.18	0.05
South Africa	1977-2013	-1.53	-0.49	-4.00*	-3.73*	0.19*	0.19*	0.50*	0.10

Notes: i and π are the symbols for nominal interest rate and inflation rate, respectively. * denotes rejection of the null hypothesis at the 5% level.

Next, we apply the bounds test to examine the long-run relationship between the two variables. The results are reported in Table 2. The F-test statistics suggest that the null hypothesis of no cointegration between interest rates and prices cannot be rejected, at the 5% level, for all countries except Gabon. This implies that nominal interest rates and prices do not move to far away from each other in the long-run. Evidence of cointegration is found for Benin andKenyawhen interest rate is used as the dependent variable. The results show evidence rejecting the null of no cointegration in Gambia, Ghana and Nigeria when price is used as the dependent variable. In the case of Cameroon, Cote d'Ivoire, Senegal and South Africa, the bounds test indicates cointegration regardless the variable used as the dependent variable.

Table 2: Results of bounds test for cointegration

Countries	**Finterest**	**FPrice**	**Cointegration?**
Benin	6.733 (3)*	2.893 (3)	Yes
Cameroon	11.963 (4)*	8.241 (4)*	Yes
Côte d'Ivoire	26.931 (3)*	7.534 (4)*	Yes
Gabon	2.840 (3)	5.213 (3)	No
Gambia	1.829 (3)	10.556 (3)*	Yes
Ghana	1.313 (3)	11.970 (4)*	Yes
Kenya	14.723 (3)*	2.760 (4)	Yes
Nigeria	2.968 (3)	8.667 (3)*	Yes
Senegal	7.419 (4)*	9.482 (4)*	Yes
South Africa	11.005 (4)*	10.409 (4)*	Yes

Note: Lag length on each variable is selected using the general-to-specific approach, with maximum lag set to five F-statistics are compared with critical values taken from Pesaran et al. (2001: 300-301). * denotes significance at the 5% level.

Given the evidence of cointegration, we present the estimation results concerning the long-run coefficients. The results are reported in Table 3. As can be seen, the relationship between nominal interest rates and the price levels is positive in seven countries, namely Cote d'Ivoire, Gambia, Ghana, Kenya, Nigeria, Senegal and South Africa. For Cote d'Ivoire and Kenya nominal interest rates move more than one-for-one with price levels. For Gambia, Ghana, Nigeria, Senegal and South Africa, price levels move less than one-for-one with interest rates. On the contrary, nominal interest rate and price are negatively related in Benin and Cameroon.

Table 3: Long-run relationship between nominal interest rates and prices

Country	Dependen	Gibson equation		
		Consta	Price	Interest ra
Benin	Interest ra	10.42 (	-1.28 (-2	-
Camero	Interest ra	18.74 (	-2.36 (-1	-
Cote d'I	Interest ra	1.43 (1	1.43 (4.4	-
Gabon	-	-	-	-
Gambia	Price	1.84 (3		0.22 (5.26
Ghana	Price	-2.28 (-	-	0.04 (7.03
Kenya	Interest ra	-13.26	4.17 (3.0	-
Nigeria	Price	0.73 (0	-	0.48 (6.52
Senegal	Price	2.35 (9	-	0.12 (4.13
South A	Price	1.12 (6	-	0.07 (7.87

Note: *(**) denotes significance at the 5% (10%) level.

The existence of cointegration between two variables suggests that there must be Granger-causality in at least one direction, but it does not indicate the direction of causality. Table 4 reports the causality test results. In the long-run, prices Granger-causenominal interest rates in Benin and Kenya, whereas nominal interest rates cause prices in Gambia, Ghana and Nigeria. There exists bidirectional long-run causality between nominal interest rate and price in Cote d'Ivoire, Senegal and South Africa. In the short-run, the results suggest causality running from prices to interest rate in Cameroon, Gabon, Gambia, and Kenya. Also, a one-way causality running from interest rate to price is found in Benin, Cote d'Ivoire, Senegal and South Africa. Evidence for Nigeria indicates bidirectional causality between interest rates and prices.

Table 4: Granger-causality test results

Countries	Null hypothesis of Short-run causality		Long-run causality: ECTt-1=0	
	Price does not cause Interest rate	Interest rate does not cause price	Interest rate	Price
Benin	0.494 (0.495)	9.098 (0.002)*	-0.433 (-4.451)*	-0.010 (-1.376)
Cameroon	95.431 (0.000)*	0.834 (0.361)	-0.279 (-7.059)*	-0.015 (-1.509)
Cote d'Ivoire	3.986 (0.407)	66.642 (0.000)*	-0.113 (-2.367)*	-0.095 (-2.325)*
Gabon	54.042 (0.000)*	4.076 (0.395)	-	-
Gambia	3.076 (0.079)**	0.126 (0.721)	0.843 (1.439)	-0.049 (-2.468)*
Ghana	0.408 (0.522)	1.100 (0.294)	0.299 (0.148)	-0.268 (-4.727)*
Kenya	23.997 (0.000)*	3.337 (0.503)	-0.367 (-5.083)*	-0.001 (-0.668)
Nigeria	10.925 (0.004)*	9.065 (0.010)*	-0.393 (-1.475)	-0.031 (-3.646)*
Senegal	0.032 (0.857)	13.583 (0.000)*	-0.159 (-4.556)*	-0.249 (-5.026)*
South Africa	3.935 (0.558)	33.587 (0.000)*	-0.227 (-8.265)*	-0.264 (-5.551)*

Note: Statistics for Short-run causality are Chi2 with p-values in parentheses. Statistics for long-run causality are coefficients on ECTt-1 with t-statistics in parentheses. * and ** denote statisticalsignificance at the 5% and 10% levels, respectively.

The results of this paper provide empirical support for the Gibson paradox in seven out of the ten countries under study, namely Cote d'Ivoire, Gambia, Ghana, Kenya, Nigeria, Senegal and South Africa. In these countries nominal interest rate and prices are positively related in the long run. However, changes in nominal interest rate increase the price levels in Gambia, Ghana, Nigeria, portraying nominal interest rate as an effective tool for the moderation of long-run general price levels. For Senegal and South Africa, the relationship between nominal interest rates and price levelsis positive and the causal link flows in both directions, suggesting that increased interest rates lead to increased price levels and vice versa.

4. Conclusion

This study examined the long-run relationship between prices and nominal interest rates in ten African countries. The objective was to test for the validity of the Gibson paradoxin the African context. We first undertook unit root tests and found that both deposit interest rates and inflation rates are integrated of order one. Next, we employed the bounds testing approach to cointegration. The results provide empirical support for the Gibson paradox in seven out of the ten countries, namely: Cote d'Ivoire, Gambia, Ghana, Kenya, Nigeria, Senegal and South Africa. This suggests that nominal interest rate is an effective tool for the moderation of long-run general price levels. We found a negative relationship between interest rates and prices in Benin and Cameroon, and no significant relationship in Gabon.

Empirical study can be conducted using different nominal interest rate variables to check the robustness of the findings of this study. Another interesting topic that has not been investigated in previous empirical studiesis the presence of structural changes and nonlinearities in the relationship between interest rate and price. Structural changes and nonlinearities may occur due to oil price shocks, financial crises, shifts in monetary policy, changes in preferences, technological changes and political instability. It is well known that structural changes lower the power of standard test of stationarity and cointegration. We intend to investigate these issues in future research.

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