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Electricity consumption, labour force participation rate and economic growth in Kenya: an empirical investigation

This study examines the dynamic causal relationship between electricity consumption and economic growth in Kenya during the period of 1972-2006. Unlike most of the previous works, the current study incorporates the labor force participation rate as an intermittent variable in the bivariate causality setting between electricity consumption and economic growth – thereby creating a simple trivariate causality model. Using cointegration and error-correction models, the study finds a distinct unidirectional causal flow from electricity consumption to economic growth in Kenya. In addition, the study finds that both economic growth and electricity consumption Granger-cause labor force participation in Kenya. The results apply irrespective of whether the causality is estimated in the short run or in the long run. The study, therefore, concludes that electricity consumption is a panacea for economic growth in Kenya and any energy conservation policies should be treated with extreme caution.

Keywords: Africa, Kenya, electricity consumption, labor force participation, economic growth.
JEL Classification: Q43, C32.

Introduction

The causal relationship between electricity consumption and economic growth has important implications, especially from a policy standpoint (see Asafu-Adjaye, 2000; Ghosh, 2002; Paul and Bhattacharya, 2004; Narayan and Smyth, 2005; Narayan and Singh, 2007). A unidirectional causality running from GDP to electricity consumption, for example, may imply that a country is not entirely dependent on electricity for its economic growth, and that energy conservation policies may be implemented with little or no adverse effects on economic growth. However, a unidirectional causality running from electricity consumption to economic growth implies that economic growth is dependent on electricity consumption, and a decrease in electricity consumption will unambiguously restrain economic growth (see also Narayan and Singh, 2007, p. 1142). The finding of no causality in either direction, i.e. the so-called 'neutrality hypothesis', on the other hand, implies that energy conservation policies have no effect on economic growth (see Asafu-Adjaye, 2000; Paul and Battacharya, 2004).

Although the causal relationship between electricity consumption and economic growth has attracted numerous empirical studies during the past three decades, the majority of the previous studies have concentrated mainly on Asia and Latin America, affording sub-Saharan African countries either very little or no coverage at all. Even where such studies have been undertaken, the empirical findings on the direction of causality between electricity consumption and economic growth have been largely inconclusive. Moreover, the majority of the previous studies are mainly based on a bivariate framework and may, therefore, suffer from the omission of variables bias. In other words, the introduction of a third variable affecting both electricity consumption and economic growth in the bivariate causality setting may not only alter the direction of causality between the two variables, but also the magnitude of the estimate. It is against this backdrop that current study attempts to examine the inter-temporal causal relationship between electricity consumption and economic growth in Kenya by incorporating the labor participation rate as a third explanatory variable in a bivariate setting – thereby, creating a simple trivariate causality model. The rest of the paper is structured as follows: Section 1 discusses energy policies in Kenya as well as the recent trends of electricity consumption in the country. Section 2 presents the literature review, while Section 3 deals with the empirical model specification, estimation technique and the empirical analysis of the regression results. The final section concludes the study.

1. An overview of energy sector in Kenya

The main sources of energy in Kenya include wood fuel, petroleum, hydropower and geothermal power. In addition, some renewable sources of energy such as solar and wind are currently being explored. Currently wood fuel provides about 68% of the total energy requirements, petroleum energy 20%, electricity 10%, while other alternative sources account for about 2%. A number of policies have been implemented since independence in order to address the energy needs in Kenya. The landmark policy paper that set the basis for development of the country was sessional paper No. 10 of 1965. The focus of this sessional paper was mainly on the Electric Power Act (CAP 314), which had been used to regulate the power sector for years. The second landmark paper was sessional paper No. 1 of 1986, which called for the establishment of the Department of Price and Monopoly Control (DPMC) within the Ministry of Finance (MOF) to monitor acts of restraint of trade and to enforce pricing in the various sectors including petroleum (UNEP, 2006: 16). The third significant policy move took place in 1997, when the Electric Power Act of 1997 was legislated to replace CAP314. The aim of this new legislation was to facilitate private sector participation in the provision of electricity. This led to the establishment of KENGEN in 1998. The Electric Power Act of 1997 also provided for rural electrification on a limited scale, using renewable energy technologies. Following the unprecedented power shortages in Kenya in 1999 and 2000, the country decided to formulate a comprehensive energy policy for the entire energy sector. The ultimate goal of this policy was to ensure an adequate, reliable, cost-effective and affordable energy supply for developmental needs, while at the same time paying attention to environmental protection and conservation.

The largest share of Kenya's electricity supply comes from hydroelectric power – even though the country has great potential to produce electrical energy using geothermal power. Although for a long time Kenya had been importing electricity from Uganda, the recent major supply shortages experienced in Uganda caused by the expansion of the industrial sector and the lack of investment in the electricity generation, recently forced Kenya to rely largely on its own electricity supply. In fact, it is Kenya that currently exports electricity to Uganda (UNEP, 2006: 6). The electricity demand in Kenya, just as in other developing countries, exceeds the supply. The situation is particularly acute during droughts when dam reservoirs are low or when some of the hydroelectric generating plants are out of service. Kenya's electricity consumption has been very erratic, especially during the last decade. For example, the electricity consumption per capita increased from 92.5 kWh in 1980 to 121.3 kWh in 1993. Between 1993 and 1996, the electricity consumption per capita increased significantly from 121.3 kWh in 1993 to 123.2 kWh in 1994, 125.1 kWh in 1995 and 128.1 kWh in 1996. Although the consumption decreased in 1997 to 126.2 kWh, it later increased to 127.4 kWh in 1998, before decreasing significantly to 118.0 kWh in 1999. In 2000, the electricity consumption per capita reached 105.9 kWh, the lowest consumption level since 1989. Between 2000 and 2002, the electricity consumption per capita increased steadily from 105.9 kWh to 120.3 kWh, respectively. Although the consumption somewhat decreased between 2002 and 2004, it later increased significantly between 2004 and 2007. Currently, the electricity consumption per capita is estimated at 154 kWh.

2. Literature review

The causal relationship between energy consumption and economic growth has been studied extensively, but with conflicting results. There are four views regarding the causal relationship between energy consumption and economic growth. The first view argues that energy consumption Granger-causes economic growth. The empirical work, which is consistent with this view includes studies such as Chang et al. (2001), Lee (2005), Narayan and Singh (2007), Yu and Choi (1985), Cheng (1997), Soytas and Sari (2003), Shiu and Lam (2004), Wolde-Rufael (2004), Wolde-Rufael (2006), Altinay and Karagol (2005), among others. The second view argues that it is economic growth that drives the energy consumption in many countries, and that as the economy grows the demand for energy from different sections of the economy increases. The empirical work, which is consistent with this view includes Kraft and Kraft (1978), Cheng (1999), Gosh (2002), Narayan and Smyth (2005) and Thoma (2004), among others. The third view, however, maintains that both electricity consumption and economic growth Granger-cause each other, i.e., that there is a bi-directional causality between electricity consumption and economic growth. This view has been widely supported by studies such as Masih and Masih (1997), Morimoto and Hope (2004), Paul and Bhattacharya (2004), Jumbe (2004), Soytas and Sari (2003), and Glasure and Lee (1997), among others.

Although the majority of previous studies have found a causal relationship between energy consumption and economic growth to exist, at least in one direction, the empirical findings of some previous studies have shown that no causality exists between energy consumption and economic growth. In other words, these studies maintain that energy consumption and economic growth are neutral with respect to each other. This finding has been supported by Akarca and Long (1980) for the case of the USA, Yu and Hwang (1984) for the case of the USA, Cheng (1995) for the case of the USA, and Cheng (1997) for the case of Mexico and Venezuela, among others. Table 1 shows the empirical findings of the causality between energy consumption and economic growth drawn from some previous studies.

Table 1. Selected empirical findings on the causality between energy consumption and economic growth

Author(s)	Region/Country	Direction of causality
A: Studies in favor of a unidirectional causality from energy consumption to economic growth		
Yu and Choi (1985)	USA, UK, Poland, Korea, Philippines	Energy consumption → GNP in Korea and Philippines
Masih and Masih (1996)	India, Pakistan, Malaysia, Singapore, Indonesia, Philippines	Energy consumption → Real income in India
Cheng (1997)	Brazil, Mexico and Venezuela	Energy consumption → GDP in Brazil
Yang (2000)	Taiwan	Electricity consumption → Real GDP
Asafu-Adjaye (2000)	Asian developing countries	Energy consumption → Income in India and Indonesia
Chang et al. (2001)	Taiwan	Energy consumption → Output
Soytas and Sari (2003)	G-7 countries and emerging markets	Energy consumption → GDP in Turkey, France, Germany and Japan
Shiu and Lam (2004)	China	Electricity consumption → Real GDP
Wolde-Rufael (2004)	Shanghai	Energy consumption → Real GDP
Lee (2005)	Developing countries	Energy consumption → GDP
Altinay and Karagol (2005)	Turkey	Electricity consumption → Economic growth
Wolde-Rufael (2006)	17 African countries	Electricity consumption → GDP in Benin, Democratic Republic of Congo and Tunisia
Narayan and Singh (2007)	Fiji Islands	Electricity consumption → GDP
Odhiambo (2009a)	Tanzania	Energy consumption → Economic growth
B: Studies in favor of a unidirectional causality from economic growth to energy consumption		
Kraft and Kraft (1978)	USA	GNP → Energy consumption
Abosedra and Baghestani (1989)	USA	GNP → Energy consumption
Cheng and Lai (1997)	Taiwan	GDP → Energy consumption
Masih and Masih (1996)	India, Pakistan, Malaysia, Singapore, Indonesia, Philippines	Real income → Energy consumption in Indonesia
Cheng (1999)	India	GDP → Energy consumption
Gosh (2002)	India	Economic growth → Electricity consumption
Soytas and Sari (2003)	G-7 countries and emerging markets	GDP → Energy consumption in Italy and Korea
Hatemi-J and Irandoust (2005)	Sweden	Economic growth → Energy consumption
Narayan and Smyth (2005)	Australia	Real income → Electricity consumption
Wolde-Rufael (2006)	17 African countries	Economic growth → Electricity consumption in Cameroon, Ghana, Nigeria, Senegal, Zambia and Zimbabwe
Yoo (2006)	4 ASEAN countries	Economic growth → Electricity consumption in Indonesia and Thailand
Mozumder and Marathe (2007)	Bangladesh	GDP → Electricity consumption
C: Studies in favor of a bi-directional causality between energy consumption and economic growth		
Masih and Masih (1996)	India, Pakistan, Malaysia, Singapore, Indonesia, Philippines	Energy consumption ↔ Real income in Pakistan
Masih and Masih (1997)	2 NICs: Korea and Taiwan	Energy consumption ↔ Real income
Glasure and Lee (1997)	South Korea and Singapore	Energy consumption ↔ GDP
Asafu-Adjaye (2000)	Asian developing countries	Energy consumption ↔ Income in Philippines and Thailand
Glasure (2002)	Korea	Energy consumption ↔ Economic growth
Soytas and Sari (2003)	G-7 countries and emerging markets	Energy consumption ↔ GDP in Argentina
Paul and Bhattacharya (2004)	India	Energy consumption ↔ Economic growth
Wolde-Rufael (2006)	17 African countries	Electricity consumption ↔ Economic growth in Egypt, Gabon and Morocco
Yoo (2006)	4 ASEAN countries	Electricity consumption ↔ Economic growth in Malaysia and Singapore
Odhiambo (2009b)	South Africa	Electricity consumption ↔ Economic growth
D: Studies in favor of neutrality between energy consumption and economic growth		
Akarca and Long (1980)	USA	Energy consumption [0] GNP
Yu and Hwang (1984)	USA	Energy consumption [0] GNP
Yu and Choi (1985)	USA, UK, Poland, Korea, Philippines	Energy consumption [0] GNP in USA, UK and Poland
Cheng (1995)	USA	Energy consumption [0] GNP

Table 1 (cont.). Selected empirical findings on the causality between energy consumption and economic growth

Author(s)	Region/Country	Direction of causality
Masih and Masih (1996)	India, Pakistan, Malaysia, Singapore, Indonesia, Philippines	Energy consumption [0] Income in Malaysia, Singapore, Philippines
Cheng (1997)	Brazil, Mexico and Venezuela	Energy consumption [0] Economic growth in Mexico and Venezuela
Wolde-Rufael (2006)	17 African countries	Electricity consumption [0] Economic growth in Algeria, Congo (Rep), Kenya, South Africa and Sudan

Notes: →; ↔ and [0] denote unidirectional causality, bidirectional causality and neutrality (no causality), respectively.

3. Estimation techniques and empirical analysis

3.1. Empirical model specification. In this section, a dynamic Granger causality test is used to examine the direction of causality between electricity consumption and economic growth in Kenya. The Granger causality method is chosen in this paper over other alternative techniques because of its favorable response to both large and small samples (see Odhiambo, 2008). Unfortunately, causality studies based on a bivariate framework have been found to be very unreliable, as the introduction of a third important variable can change both the inference and the magnitude of the estimates (see also Caporale and Pittis, 1997; Caporale et al., 2004; Odhiambo, 2008). Given the weakness associated with the bivariate causality framework, the current study examines the causal relationship between electricity consumption and economic growth by incorporating the labor force participation rate as an intermittent variable in the bivariate framework – thereby, creating a simple trivariate model. The trivariate Granger causality model between electricity consumption, labor force participation and economic growth based on the error-correction mechanism can be expressed as follows:

$$\Delta Ly/N_t = \lambda_0 + \sum_{i=1}^{m} \lambda_{1i} \Delta Ly/N_{t-i} + \sum_{i=1}^{n} \lambda_{2i} \Delta LEC_{t-i} + \sum_{i=1}^{n} \lambda_{3i} \Delta LLABF_{t-i} + \lambda_4 ECM_{t-1} + \mu_t \quad (1),$$

$$\Delta LEC_t = \varphi_0 + \sum_{i=1}^{m} \varphi_{1i} \Delta Ly/N_{t-i} + \sum_{i=1}^{n} \varphi_{2i} \Delta LEC_{t-i} + \sum_{i=1}^{n} \varphi_{3i} \Delta LLABF_{t-i} + \varphi_4 ECM_{t-1} + \varepsilon_t \quad (2),$$

$$\Delta LLABF_t = \delta_0 + \sum_{i=1}^{m} \delta_{1i} \Delta Ly/N_{t-i} + \sum_{i=1}^{n} \delta_{2i} \Delta LEC_{t-i} + \sum_{i=1}^{n} \delta_{3i} \Delta LLABF_{t-i} + \delta_4 ECM_{t-1} + \nu_t \quad (3),$$

where y/N_{t-1} = real per capita income (y/N); EC_{t-1} = electricity consumption per capita; $LABF_{t-1}$ = labour force participation rate[1]; ECM_{t-1} = error correction term lagged one period; Δ = difference operator; μ, ε and ν = mutually uncorrelated white noise residuals.

In addition to indicating the direction of causality amongst variables, the error-correction mechanism also enables us to distinguish between short-run and long-run Granger causality. The F-test and the explanatory variables indicate the "short-run" causal effects, whereas the "long-run" causal relationship is implied through the significance of the t-test of the lagged error-correction term. Based on the equations (1)-(3), the following causal relationships can be derived between electricity consumption, labor force participation and economic growth.

All the data used in this study were obtained from the Global Development Indicators CD-ROM, 2007.

Table 2. Causal flow between electricity consumption, labor force participation and economic growth

Causal flow	Conditions
(1) Electricity consumption (EC) → Economic growth (y/N)	$\lambda_{2i} \neq 0$; $\lambda_4 \neq 0$
(2) Economic growth (y/N) → Electricity consumption (EC)	$\varphi_{1i} \neq 0$; $\varphi_4 \neq 0$
(3) Labor force participation (LABF) → Electricity consumption (EC)	$\varphi_{3i} \neq 0$; $\varphi_4 \neq 0$
(4) Electricity consumption (EC)→ Labor force participation (LABF)	$\delta_{2i} \neq 0$; $\delta_4 \neq 0$
(5) Economic growth (y/N) → Labor force participation (LABF)	$\delta_{1i} \neq 0$; $\delta_4 \neq 0$
(6) Labor force participation (LABF) → Economic growth (y/N)	$\lambda_{3i} \neq 0$; $\lambda_4 \neq 0$

3.2. Empirical analysis. *3.2.1. Stationarity test.* The results of the stationarity tests at levels (not presented here) show that all the variables are non-stationary at levels. Having found that the variables are not stationary at levels, the next step is to difference the variables once in order to perform stationarity tests on differenced variables. The results of the stationarity tests on differenced variables – based on the Phillips-Perron, DF-GLS and Ng-Perron tests – are presented in Tables 3 and 4.

[1] See also Narayan and Smyth (2005).

Table 3. Stationarity tests of variables on first difference − DF-GLS TEST

Variable	No trend	Trend	Stationarity status
DLy/N	-2.1500**	3.3718**	Stationary
DLEC	-5.5902***	-5.8988***	Stationary
DLLABF	-3.6015***	-7.2106***	Stationary

Note: 1) Critical values are based on Elliot-Rothenberg-Stock (1996, Table 1). 2) ** and *** denote statistical significance at the 5% and 1% levels, respectively.

Table 4. Stationarity tests of variables on first difference – Phillips-Perron (PP) test

Variable	No trend	Trend	Stationarity status
DLy/N	-5.2204***	-4.9931***	Stationary
DLEC/N	-6.0045***	-6.2327***	Stationary
DLLABF	-6.5378***	-6.9677***	Stationary

Note: 1) The truncation lag is based on Newey and West (1987) bandwidth. 2) *** denotes statistical significance at the 1% level.

The results reported in Tables 3 and 4 show that after differencing the variables once, all the variables were confirmed to be stationary. The DF-GLS and Phillips-Perron tests applied to the first difference of the data series reject the null hypothesis of non-stationarity for all the variables used in this study. It is, therefore, worth concluding that all the variables used in this study are integrated of order one.

3.2.2. Cointegration test. Having confirmed that all variables included in the causality test are integrated of order one, the next step is to test for the existence of a cointegration relationship between electricity consumption (EC), labor force participation (LABF) and economic growth (y/N). For this purpose, the study uses the Johansen-Juselius (maximum likelihood) cointegration test procedure. The results of the Johansen-Juselius cointegration test are presented in Table 5.

Table 5. Maximum likelihood cointegration test

Trace test				Maximum eigenvalue test			
Null	Alternative	Statistics	95% Critical value	Null	Alternative	Statistics	95% Critical value
Cointegration between Ly/N, LEC/N and LLABF							
r = 0	r ≥ 1	38.72	29.7	r = 0	r = 1	30.8	21.0
r ≤ 1	r ≥ 2	8.64	15.4	r ≤ 1	r = 2	8.615	14.1
r ≤ 2	r = 3	0.025	3.8	r ≤ 2	r = 3	0.025	3.8

Notes: 1) r stands for the number of cointegrating vectors. 2) The lag structure of VAR is determined by the highest values of the Akaike information criterion and Schwartz Bayesian Criterion.

The results of the Johansen-Juselius cointegration test reported in Table 5 indicate the existence of a stable long-run relationship between electricity consumption (EC), the labor participation rate (LLABF) and economic growth (y/N). Both the trace test and the maximum eigenvalue statistics reject the null hypothesis of no cointegration. Specifically, the results show that there is a unique cointegrating vector between electricity consumption, labor force participation and economic growth.

3.2.3. Analysis of causality test based on error correction-model. The results of the general (over-parameterized) causality tests between financial development, economic growth and poverty (not presented here) are difficult to interpret and many variables are not significant − as expected. The electricity consumption (EC), the labor participation (LABF) and economic growth (y/N) equations are, therefore, reduced until the preferred models are obtained. A summary of the results of the preferred models of the causality test between EC, LABF and y/N are displayed in Table 6.

Table 6. Causality test between DLy/N, DLEC and DLLABF

Variables in equation	Dependent variables		
	ΔLy/N	**ΔLEC**	**ΔLLABF**
Constant	0.0075(1.383)	0.0195(1.314)	0.0029(-1.831)
ΔLy/N	-	1.1667(1.803)*	-
ΔLy/N-1	0.5010(3.718)***	-0.6796(-1.220)	0.0529(1.225)
ΔLy/N-2	0.3011(1.654)	-0.6534(-1.099)	0.0389(0.889)
ΔLy/N-3	-	-0.1547(-0.271)	-
ΔLy/N-5	-	-	0.1374(2.776)***

Table 6 (cont.). Causality test between DLy/N, DLEC and DLLABF

Variables in equation	Dependent variables		
	ΔLy/N		ΔLy/N
ΔLEC	0.1491(2.383)**	-	-
ΔLEC-2	-0.0389(-0.545)	-	-
ΔLEC-4	-0.0187(-0.272)	-0.1533(-0.712)	0.0346(2.118)**
ΔLEC-5	-	-	0.0218(1.318)
ΔLLABF	-1.0867(-1.617)	0.5227(0.213)	-
ΔLLABF-1	-1.1303(-1.508)	-	-
ΔLLABF-2	0.1877(0.297)	-	0.4289(2.374)**
ΔLLABF-3	-	2.3612(0.976)	0.5869(2.533)**
ΔLLABF-4	-	-1.8585(-1.121)	-
ΔLLABF-5	-	-1.6470(-1.166)	0.2851(2.640)***
ECM_{-1}	-0.5290(-3.895)***	0.8705(1.582)	-0.1061(-2.412)**
F-Test	5.5243 [0.0009]	1.1311 [0.3929]	3.8536 [0.0064]
R^2	0.7235	0.3859	0.6461
DW	2.08	2.03	1.68
AR	0.3940398 [0.6804]	0.74015[0.4927]	0.43007 [0.6573]
ARCH	0.0018413 [0.9663]	2.81410 [0.1129]	0.00317 [0.9558]
RESET	0.0539840[0.8189]	0.85943 [0.3669]	1.81390 [0.1948]

Notes: 1) *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. 2) The numbers in parentheses represent t-statistics.

The empirical results reported in Table 6 show that there is a distinct unidirectional causal flow from electricity consumption to economic growth, both in the short run and in the long run. The long-run causality from electricity consumption to economic growth is supported by the coefficient of the lagged error-correction term in the economic growth function, which is negative and statistically significant, as expected. The short-run causality from electricity consumption to economic growth is, however, supported by the F-test and the coefficient of the electricity consumption variable in the economic growth function, which are both statistically significant. The reverse causality from economic growth to electricity consumption, however, is rejected by the lagged error-correction term and the F-statistic in the electricity function, which are both statistically insignificant. The results also show that both economic growth and electricity consumption Granger-cause labor force participation in Kenya. The unidirectional causality from economic growth to labor force participation is supported by the error-correction term, the F-statistic and the coefficient of the lagged economic growth variable in the labor force participation function, which are all statistically significant. Likewise, the unidirectional causality from electricity to labor participation is supported by the lagged error-correction term, the F-statistic and the coefficient of the lagged electricity variable in the labor force participation function, which are all statistically significant, as expected. The results apply irrespective of whether the causality is estimated in the short run or in the long run. A summary of the causality test between the three variables is presented in Table 7.

Table 7. Summary of causality tests

Variables	Causality	General conclusion
ΔLy/N (dependent variable), ΔLEC and ΔLLABF	- There is a distinct unidirectional causal flow from electricity consumption to economic growth.	- Electricity consumption Granger-causes economic growth.
ΔLEC (dependent variable), ΔLy/N and ΔLLABF	- There is no causal flow from either electricity consumption or labor participation to electricity consumption.	- Neither economic growth nor labor force participation Granger-cause electricity consumption.
ΔLLABF (dependent variable), ΔLy/N and ΔLEC	- There is a unidirectional causal flow from both economic growth and electricity consumption to labor force participation.	- Both electricity consumption and economic growth Granger-cause labor force participation.

Conclusion

This study attempts to examine the causal relationship between electricity consumption and economic growth in Kenya. The majority of the previous studies on this subject are mainly based on a bivariate causality framework and may, therefore, suffer from the omission of variables bias. In other words, the introduction of a third variable affecting both electricity consumption and economic growth in the bivariate setting may not only alter the direction of causality between the two variables, but also the magnitude of the estimate. Given this limitation, the current study incorporates the labor force participation rate as an intermittent variable in a bivariate model between electricity consumption and economic growth – thereby creating a simple trivariate causality framework. Using cointegration and error-correction models, the study finds a distinct unidirectional causal flow from electricity consumption to economic growth. The results also show that both economic growth and electricity consumption Granger-cause labor force participation in Kenya. The results apply irrespective of whether the causality is estimated in the short run or in the long run. The study, therefore, concludes that electricity consumption is a panacea for long-run economic growth in Kenya and energy conservation policies should be treated with extreme caution.

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