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Financial inclusion and underground economy nexus in West Africa: Evidence from dynamic heterogeneous panel techniques

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Abstract
We employ dynamic heterogeneous panel estimation techniques which include Dynamic Fixed Effects (DFE), Mean Group (MG), and Pooled Mean Group (PMG) estimators to explore the underground economy (UE) and financial inclusion (FI) relation for ten West African nations during the 2004-2021 period. Applying Pedroni cointegration test, the results present evidence of a long-term relation between UE and FI (alongside corruption, inflation rate, money supply, agricultural output, and trade). The results of panel estimation portray a long-term significant positive influence of FI on UE, but a short-term significant negative relation between FI and UE. In addition, corruption, money supply, and international trade have a long-term significant negative influence on UE, while inflation supports long-term expansion of UE. Also, a short-term significant negative relation exists between inflation (and trade) and UE, while a short-term significant positive relation is found between money supply and UE. The results of Dumitrescu-Hurlin causality test signal a one-way causality from FI to UE. Therefore, policies geared towards enhancing FI, reducing corruption and money supply, and improving international trade are recommended to reduce UE.
Keywords: Underground economy; Financial inclusion; PMG; West Africa
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1 Introduction

A large body of research have demonstrated that the incidence and size of shadow or underground economy (henceforth the UE)[1] have far-reaching dire economic, social and political consequences on a nation. In certain circles, it is believed that the incidence of UE offers some potential benefits. For instance, by creating jobs and providing profit opportunities for businesses, UE functions as an insurance policy against economic volatility, potentially reducing social pressure on the state and boosting the overall economy (Ishak and Farzanegan 2022). Moreover, since almost two-third of the incomes generated in the UE are immediately spent in the official economy, expansion in the UE can promote activities in the official economy, leading to an improvement in overall economic performance (Schneider and Enste 2002). Besides, rising UE may offer a leeway from distortionary activities of the state (such as corruption), leading to greater economic activities in the formal economy (Choi and Thum 2005; Ishak and Farzanegan 2022).

However, researchers including Schneider and Enste (2002) argued that persistently growing UE can set off a "destructive cycle" which by far outweighs whatever perceived benefits of UE. Since transactions in the UE escapes taxation, expansion in the UE erodes the tax base, thus, aiding the decline in tax revenue. The losses in revenue lead to reduction in resources available to the state, putting more financial pressures on government to provide public services and embark on developmental projects (Dell'Anno et al. 2018; Mazhar and Méon 2017). Whereas the fall in public revenue may compel government to either reduce its spending or raise taxes, such an attempt can drive more individuals to the UE or encourage existing participants (in the UE) to work more (Asiedu and Stengos 2014; Schneider and Enste 2002). Large UE is also associated with inaccurate, unreliable and incomplete official statistics (on unemployment rate, labour force, inflation rate, income level, and consumption), leading to ineffectiveness of economic policies (Dell'Anno and Adu 2020). Moreover, since the production costs of firms operating in the UE are usually lower – because of the absence of taxes and the cheap nature of labour input – compared to those in the formal economy, the expansion in UE tends to promote unfair price competition in output and input markets, encouraging distortion in resource allocation, and resulting in significant welfare losses (Asiedu and Stengos 2014).

Globally, the incidence and size of UE has remained a cause for concern. For instance, Medina and Schneider (2019) reported that UE accounts for about 30.9% of global GDP, with the size ranging from less than 20% in developed OECD nations, to almost 38% and 39% of GDP in developing Latin America and Sub-Saharan Africa (SSA) nations, respectively, in the year 2017. This signals that the incidence of UE is more pronounced in developing nations, and it is often seen as an obstacle to their development (Jacolin et al. 2021). Interestingly, Medina and Schneider (2019) showed that between 1991 and 2017, on average, almost 40% of the GDP of the 16 West African nations was attributed to UE activities, with the size hovering between 32.84% and 56.78%. This portrays that UE activities are thriving rapidly in the region.

Like in most developing nations, activities in UE in West Africa range from small-scale street vending and unregistered business to illicit trade, tax evasion and corruption. Factors including high level of poverty, income inequality and unemployment, weak institutional framework (limited rule of law, pervasiveness of corruption, and inadequate regulatory systems), bureaucratic inefficiencies, complex regulations, and less access to finance have been fingered as stimulators of UE activities in the region (Dell'Anno and Adu 2020; Ogbuabor and Malaolu 2013). The thriving of the UE pre-supposes that West Africa will have to contend with persistent decline in tax revenue, ineffective economic and social policies and programmes, and dismal economic

[1]In this paper, we follow the definition of an underground economy (UE) (or shadow economy) presented by Ahumada et al. (2007) and Medina and Schneider (2018). Their definition of UE covers all "undeclared, under-declared, non-measured and under-registered" production and transactions that intentionally avoid all forms of "taxes, minimum wages, safety standards, social security contributions, maximum working hours, dodge administrative procedures, and void all legal labour market standards", including "illegal transactions connected with crime and corruption and legal but non-market activities."

outcomes. Besides, the emergence of health challenges like COVID-19 and the Ebola, including falling commodity (like crude oil) prices aggravate public revenue problem, while fiscal sustainability is becoming a serious concern for sustained growth and development in West Africa (Sennoga and Balma 2022). Large fiscal deficits and mounting public debts in some countries is also fuelling fears about the possibility of a new debt crisis in the region (Kararach et al. 2020; Sennoga and Balma 2022).

Recently, FI[2] gained prominence on the global policy agenda for sustainable development due to its potential to reduce activities in the UE. This argument is supported by the observed productivity and profitability gains associated with FI. Research has shown that the exclusive use of cash for transactions is a significant factor contributing to the low productivity of firms in the UE (La Porta and Shleifer 2014). Thus, by facilitating a more secure, fluid and cheaper transaction, it is argued that the adoption of formal financial products and services, such as mobile money and other electronic payment systems, has the potential to enhance the productivity and profitability of such firms (Beck et al. 2018; Jacolin et al. 2021; Klapper 2017). With the resulting productivity gains, firms in the UE would be incentivized to transition to the formal sector, where they can more efficiently capitalize on these benefits (Lahura and Vargas 2023). Furthermore, due to the exploitative nature of informal sources of credit like money lenders (Sarma and Pais 2011), the accessibility of affordable formal credit facilities also tends to facilitate the transition of UE firms to the formal sector, thus the reduction in the size of the UE.

The ongoing debate on the capacity of an improvement in FI in reducing the size and incidence of UE has seen an increasing interest in empirical exploration of FI and UE relation by scholars. Research on FI-UE connection is limited, but few studies on their nexus suggest that improvements in FI are connected to reductions in the size and incidence of UE in developed, developing and emerging economies, including African countries (Ajide 2021; Jacolin et al. 2021; Lahura and Vargas 2023). Also, there is dearth of research concentrating on this relation in West Africa despite the sizable incidence of UE and low level of FI. Thus, the primary goal of this research is to explore FI-UE relation in West Africa.

Our research is relevant for a number of reasons. First, it is the pioneering effort to examine FI and UE relation in the region. Second, departing from the existing studies, we develop a robust and comprehensive measure of FI using two-stage Principal Component Analysis (PCA) method. Thus, it overcomes the shortcomings of studies using selected indicators of FI like the number of bank branches, ATM per 1000 adults, account ownership, and so on, and improves on those that adopted FI index generated through non-parametric approach based on subjective weight assignment (Ajide 2021; Elsherif 2019). In essence, we use a composite FI index which ensures that the extent of FI is adequately captured, and provides an opportunity to draw valid conclusion.

Third, using DFE, MG and PMG estimators which accommodate both dynamic short- and long-term relations between FI and UE including a possible heterogeneous dynamic adjustment process, leads to better understanding in the movements of the variables. Also, employing the heterogeneous panel causality test of Dumitrescu-Hurlin (2012) yields added information on causal relation between FI and UE.

The rest of this paper is organised as follows. The next section provides literature review on FI and UE relation. Section three discusses the methodology and data, while the results are presented and discussed in section four. Lastly, the conclusion and policy implications of the study are provided in section five.

2 Review of theoretical and empirical literature

Becker's (1968) economics of crime theory lays a crucial theoretical foundation for analysing the FI-UE relationship. In its fundamental premise, the theory posits that economic agents

[2]FI is a broad concept. But it generally refers to the process of ensuring the "ease of access, availability and usage of useful and affordable financial products and services (payments, savings, loans, insurance, credit, etc.) by individuals and business" (Abu et al. 2022).

(individuals) evaluate the benefits of legal actions in comparison to engaging in illegal activities, while considering associated costs such as punishment and the likelihood of detection (Ajide 2021; Aljassmi et al. 2023). Within this framework, it has been argued that the productivity and profitability benefits associated with formal financial services and products could incentivise firms and individuals against going underground (Ajide 2021). In other words, the literature on the FI-UE nexus demonstrates that an enhancement in FI level can impact the size and occurrence of the UE through three transmission channels: reduction in cash demand, augmented access to credit, and growth of the formal sector.

The first channel involves a reduction in the size and incidence of UE following productivity gains associated with the decline in cash-demand on account of the adoption of formal financial services and products. It is also argued that the low productivity of firms in the UE is not only because they are associated with subsistence, but also due to their reliance on cash as the sole means of payment (Jacolin et al. 2021; La Porta and Shleifer 2014). In parallel, by ensuring a more secure, fluid and cheaper transaction, increased access and usage of formal financial services and products raises firms' productivity and profitability (Beck et al., 2018; Jacolin et al. 2021; Klapper 2017). Therefore, due to the associated efficiency gains of FI, unproductive firms in the UE will be stimulated to transit to the formal sector to enable them effectively exploit these benefits, resulting to reduction in the size and incidence of UE. Second, the access to credit channel advances that the improvement in FI level and the resulting increase in the access to quality and relevant credit facilities (which is a major obstacle to firms) will lower the size and incidence of UE. Lastly, the formal sector's growth channel involves the indirect influence of FI on UE via the growth of the formal economy (Jacolin et al. 2021; Lahura and Vargas 2023). For instance, following the increased access and usage of formal financial services and products by firms in the formal sector, the associated productivity and profitability will indirectly influence the UE through increased demand for formal workers. Generally, the increasing demand for labour will cause a fall in the participation of workers in the UE.

The foregoing arguments can be summarised in the following testable hypothesis:

H1. An improvement in the access to financial products and services significant drive down the size of UE, ceteris paribus.

On the empirical front, research on FI and UE relation both in developed and developing countries is scarce. Most studies centre on financial development (FD) and UE relation (for a detailed review, see Capasso et al. 2022; Rahman et al. 2022). Although FI is an integral component and dimension of FD, the importance of exploring the specific relation between FI and UE cannot be overemphasized. Besides, evidence suggests that a country may be financially developed but not financially inclusive due to the presence of massive income inequalities and poverty (Lenka 2021). Interestingly, the few studies on FI-UE connection, analyzed the relation from different perspectives. For example, Elsherif (2019) adopted the panel Fixed Effects Two-Stage Least Squares (2SLS) estimator to explore FI and UE connection in 20 emerging nations from 2004 and 2014, and found an insignificant relation between them. In contrast, using a sample of 101 nations and employing the Fixed Effects (FE) estimator and propensity score-matching methods to explore the influence of FI (mobile money, and mobile credit and savings) on UE during the 2000-2015 period, Jacolin et al. (2021) reported that an improvement in FI causes reductions in the size of UE.

Similarly, employing Fully Modified OLS (FMOLS) and dynamic OLS (DOLS) estimators to investigate FI and UE relation in 152 countries over the 1991-2017 period, Lahura and Vargas (2023) established a significant negative relation between UE and indicators of FI (number of bank branches, ATM, and bank accounts). Likewise, Ajide (2021) used Random Effects (RE), Panel Corrected Standard Error (PCSE), instrumental variable 2SLS and FMOLS techniques, including Toda-Yamamoto (TY) causality approach, to assess the UE-FI connection in 13 African countries (including three in West African - Nigeria, Ghana, and Sierra Leone) during the 2005-2015 period. The results confirmed that FI reduces UE activities, and there is a two-way causality between them.

It is evident that empirical research on FI and UE relation is scarce despite the size of UE in West Africa, and the plethora of evidences demonstrating the capacity of FI as a veritable tool for reducing the size of UE. Whereas Ajide (2021) included three West African states in his study, the conclusion may be limited due to the absence of sizable number of countries from the region. Therefore, the present study contributes to the growing literature by specifically assessing the effect of FI on UE in West African between 2004 and 2021.

Moreover, using a composite FI index and three estimation methods (DFE, MG and PMG), there is a high likelihood that our study generates more robust and consistent results including drawing valid conclusion.

3 Method and econometric procedures

3.1 The model

The main thrust of the present study is to explore the impact of FI on UE in West Africa. Relying on Becker's economics of crime theory and following the modelling pattern adopted in Ajide (2021), an econometric model demonstrating the relationship between UE and FI is specified as:

$$UE_{it} = \alpha_1 FI_{i,t} + \varphi' Z_{i,t} + \mu_i + \eta_t + \varepsilon_{it} \quad (1)$$

where $i = 1,2, \ldots, N$ is the number of groups (countries), and $t = 1, 2 \ldots, T$ denotes time. UE is underground economy, FI denotes financial inclusion, and Z is a set of control variables (i.e., corruption, money supply, inflation rate, agricultural output and trade). μ_i represents unobserved country-specific effect, and η_t is time-specific effect. ε_{it} is the stochastic error term (also disturbance term), the difference between the observed value of the dependent variable and the value predicted by the model (that is, the determinants of UE not captured in the model). α_1 and φ are slope coefficients. In this study, UE included all "undeclared, under-declared, non-measured and under-registered" production and transactions that intentionally avoid all forms of "taxes, minimum wages, safety standards, social security contributions, maximum working hours, dodge administrative procedures, and void all legal labour market standards". Overall, due to the profitability and productivity benefits associated with FI, we expect an increase in FI to lead to a reduction in the size of UE, other things being equal.

3.2 Data

We use annual dataset for a panel of 10 selected West African nations (Benin republic, Burkina Faso, Cote d'Ivoire, Ghana, Guinea, Mali, Niger, Nigeria, Senegal and Togo) for the 2004-2021 period. The choice of these ten countries is based on data availability to ensure a balanced panel data. Data for UE (% of GDP) is collected from the global shadow economy database provided by Medina and Schneider (2019). The procedure of measuring FI is provided in the next sub-section. The control of corruption index obtained from the World Bank's WGI (World Governance Indicators) is the measure of corruption. The index that reflects perceived extent of petty and grand corruption in the government sector takes the values from -2.5 and 2.5, with a higher value signifying low level of corruption, and vice versa. To actually reflect corruption level and make interpretation straight-forward, the index is rescaled by subtracting the values of the index from 2.5 (the maximum possible value). Therefore, the index will range from 0 (not corrupt) to 5 (high corruption level). The data from money supply (% of GDP), inflation rate (annual % change), agricultural output (% of GDP), and trade (export + import % of GDP) are from World Bank's WDI (World Development Indicators).

3.2.1 Developing a composite financial inclusion index (FII)

Several approaches of measuring FI level have been proposed in the literature. They include use of surveys and macroeconomic indicators of FI like number of automatic teller machines (ATMs), bank branches, borrowers, depositors, savings, and domestic credit to GDP ratio, amongst others. But the bias and key information gaps associated with these approaches coupled with the multidimensional nature of FI gave rise to the development of a composite financial inclusion index (FII) to measure the dimensions and level of FI. There are basically two commonly used approaches of constructing a composite FII: the parametric and non-parametric methods. The

non-parametric approach assigns weights of importance of indicators exogenously based on researchers' intuitions, while parametric approach allocates the weights of importance of the indicators endogenously. Like other approaches, the non-parametric method is often criticized for its subjective weight assignment, hence the preference of the parametric approach, i.e., Principal Capital Analysis (PCA).

Following Camara and Tuesta (2014) and Nguyen (2020), a two-stage PCA approach is adopted to develop a composite FII. In the first stage, the PCA approach is used to estimate sub-indices of the three dimensions of financial inclusion (access/penetration, availability, usage dimensions) based on series of macroeconomic indicators of the dimensions[3]. In the second stage, the PCA procedure is used to generate the overall FII using the dimension sub-indices obtained in the first stage[4].

3.3 Estimation technique

To examine the UE and FI nexus, the DFE, Pesaran and Smith's (1995) MG, and Pesaran et al.'s (1999) PMG estimators[5] are adopted. The major difference between the DFE, MG and PMG lies in the treatment of the slope coefficients. Whereas the MG permits the intercept, short- and long-term slope coefficients, and error variance to vary across groups, the PMG allows the intercept, short-term slope coefficients, and error variance to differ across groups, but assumes homogenous long-term coefficients. In contrast, the DFE permits the intercept to differ across groups but assumes homogeneity of the short- and long-term slope coefficients. Since the DFE estimator does assume homogenous slope coefficients, it is initially used as the benchmark model, while both MG and PMG estimators which account for heterogeneous slope coefficients, are employed for robustness. One major advantage of these estimators is their ability to accommodate long-term equilibrium including a possible heterogeneous dynamic adjustment process (Ehigiamusoe et al. 2018).

Following Pesaran et al. (1999), a bivariate unrestricted error-correction representation of autoregressive distributed lagged (ARDL) (p, q) model is written as:

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij} y_{i,t-j} + \sum_{j=0}^{q} \vartheta_{ij}' x_{i,t-j} + \mu_i + \varepsilon_{it} \quad (2)$$

where x_{it} is a $k \times 1$ vector of independent variables. ϑ_i are the $k \times 1$coefficient vector. λ_{ij} are scalars. ε_t denotes error term.

Equation (2) can be re-parameterized and expressed in an error correction representation as:

$$\Delta y_{it} = \phi_i \left(y_{i,t-1} - \theta_i' x_{it}\right) + \sum_{j=1}^{p-1} \lambda_{ij}^{*} \Delta y_{i,t-1} + \sum_{j=0}^{q-1} \vartheta'^{*}_{ij} \Delta x_{i,t-j} + \mu_i + \varepsilon_{it} \quad (3)$$

[3] For instance, the access (penetration) dimension of FI is measured by two variables: the number of deposit accounts with commercial banks, credit unions and credit cooperatives (per 1,000 adults); and the number of registered mobile money accounts (per 1,000 adults). For availability dimension we used three indicators: the number of branches of commercial banks, credit unions, credit cooperatives, all microfinance institutions, and other deposit takers (per 100,000 adults); number of ATMs (per 100,000 adults); and the number of registered mobile money agent outlets (per 100,000 adults). Lastly, to measure the usage dimension of FI, we consider five variables: number of depositors with commercial banks, credit unions and credit cooperatives (per 1,000 adults); number of borrowers from commercial banks, credit unions, credit cooperatives, and all microfinance institutions (per 100,000 adults); outstanding deposits with commercial banks, credit unions, credit cooperatives, and other deposit takers (% of GDP); outstanding loans from commercial banks, credit unions, credit cooperatives, all microfinance institutions, and other deposit taker (% of GDP); and the value of mobile money transactions (% of GDP). All the data are sourced from the International Monetary Fund's (IMF) Financial Access Survey (FAS).

[4] To save space, the result of the PCA was not presented. However, they are available upon request.

[5] The DFE, MG and PMG estimators are appropriate for the study given the length of time series (T) and countries (N).

where Δ represents first difference operator. ϕ_i is the coefficient of the error correction term, and measures adjustment speed to long-term equilibrium, and θ_i' is the vector of long-term parameters. The optimal lag length (p,q) is determined by the Akaike Information Criterion (AIC). Upon estimating the DFE, MG and PMG models, the choice of the preferred model is guided by the Hausman test of homogeneity of long-term coefficients. Pesaran et al. (1999) claimed that the PMG estimates are more consistent and efficient than the MG if the long-term slope coefficients are homogeneous.

Prior to estimation, cross-sectional dependence (CSD) tests are conducted to ascertain the presence (or otherwise) of cross-sectional dependence among cross-sections (countries in the panel). For this purpose, four widely used CSD tests are adopted including the Breusch-Pagan LM test, Pesaran scaled LM test, Baltagi-Feng-Kao bias-corrected scaled LM CSD test, and the Pesaran general CSD test. Moreover, to determine the stationarity status of the series/data, panel unit root tests (PURTs) are conducted. They include first generation PURTs like Levin-Lin-Chu (LLC) test, Im-Pesaran-Shin (IPS) test, and the Augmented Dickey-Fuller (ADF)-Fisher test. The second generation cross-sectional augmented IPS (CIPS) test is also employed. The first and second-generation PURTs were both conducted to ensure a robust conclusion are made. In addition to these tests, the Pedroni (1999; 2004) panel cointegration test and the Dumitrescu-Hurlin (2012) heterogeneous panel causality tests are implemented to determine the presence of cointegrating (long-term) and causal relations between the variables, respectively.

4 Results and discussion

4.1 Summary of statistics and correlation analysis

The summary statistics and correlation analysis for the variables are presented in Table 1, providing valuable insights into the characteristics of the variables entering the UE model. On average, the size of the UE (% of GDP) across the 10 West African countries between 2004 and 2021 is 37.28 percent. Figure 1 illustrates the fluctuations in UE size across the countries, with Nigeria exhibiting the largest UE, while Senegal's is comparatively lower. In addition, with an average value of 1.11×10^{-9}, Figure 2 depicts the variations in the level of FII from 2004 to 2021, indicating a general upward trend from 2013 onwards in most countries. The FII plot also suggests that Ghana leads as the most financially included country in the group, whereas Niger falls significantly below the average value, indicating lower levels of financial inclusion. With regards to the control variables, the results of the summary statistics indicate that the mean values of corruption, money supply (% of GDP), inflation rate, agricultural output (% of GDP) and trade (% of GDP) are 3.13, 26.72%, 5.45%, 24.79% and 59.13%, respectively, during the 2004-2021 period. The corresponding standard deviations suggest that the data points of all the variables (except corruption) spread out around the mean values.

<<Figure 1 and 2 goes here>>

Moreover, the correlation analysis results portray that UE has a weak negative association with FII (-0.196) and money supply (-0.399), and also a weak but positive correlation with corruption index (0.276) and inflation rate (0.217), and the relationships are statistically significant at 1 percent level. Also, a moderate negative and significant correlation exists between UE and trade (-0.507), at 1 percent level, and a weak positive, but insignificant correlation is found for UE and agricultural output (0.026).

<<Table 1 goes here>>

4.2 Cross-section dependence tests and panel unit root tests results

Before estimating the UE and FI relation, both cross-section dependence (CSD) and panel unit root tests are conducted. These tests are crucial for ensuring that the assumptions underlying panel data analysis are met, and for selecting appropriate models and estimation techniques. The results of four CSD tests (i.e., Breusch-Pagan LM CSD test, Pesaran scaled LM tests, Pesaran CSD test, and Baltagi-Feng-Kao Bias-corrected Scaled LM CSD test) computed for each variable (Table 2) suggest the rejection of the null hypothesis of "no CSD" for all the variables (except agricultural

output and trade based on Pesaran CSD test), thus, implying the presence of interdependence amongst the cross-sections (countries). This is not surprising given the existence of high levels of social, political and economic interdependence amongst West African nations.

<<Table 2 goes here>>

Given the presence of the cross-sectional dependence in our data, we employed (in addition to the first generation PURTs) the second-generation unit root tests which allows for cross-sectional dependence. The results of panel unit root tests (Table 3) present mixed outcomes. Specifically, the first-generation PURTs reveal inflation rate to be stationary at level, while UE, FII, corruption, money supply and agricultural output became stationary after their first difference. Moreover, whereas LLC test signals that trade is integrated to order zero [I(0)], IPS and ADF-Fisher test portray that trade is integrated to order 1 [I(1)]. The second-generation tests (after accounting for cross-section dependence) report similar results except for corruption that is stationary at level.

<<Table 3 goes here>>

4.3 Cointegration test

To investigate the presence of cointegrating (long-run) relationship between the series, we employed the Pedroni cointegration technique. From the cointegration test results summarised in Table 4, the significance of the six statistics provides sufficient evidence to reject the null hypothesis (of no cointegration among the variables) at 5%, thus signalling evidence of a long-term relation amongst the variables.

<<Table 4 goes here>>

4.4 Results of estimation

The estimation results with optimal lag-length ARDL (1,1,1,1,1,1,1) suggested by AIC (Table 5) show that PMG is preferred over MG and DFE estimators based on the Hausman test. This portrays that the intercept, short-term slope coefficients, and adjustment speed differ across cross-sections, while the long-term slope coefficient is the same across the cross-sections. Hence, emphasis is on PMG results.

The results show that FI has a significant positive influence on UE during the long-term, and a short-term significant negative influence on UE, at 1% level and 5% level, respectively. An increase in FI by 1% reduces the size of UE by 2.1% during the short-term, and causes an expansion in UE by 1.7% during the long-term. The short-term negative influence of FI supports the findings of prior research that FI reduces the size of UE (Ajide 2021; Elsherif 2019; Jacolin et al. 2021; Lahura and Vargas 2023). The short-term inverse relation between FI and UE, and long-term positive influence of FI on UE suggest a non-linear and somewhat U-shaped connection between the variables. The short-term negative relation suggests that rising level of FI creates opportunities for individuals (majority of who are low-income earners and account for a sizable proportion of participants in the UE) to have increased access to quality and affordable financial products and services (such as credit facilities and insurance), leading to transition (from UE) to the formal sector and a reduction in the size of the UE.

One notable implication of transition to the formal economy is the expansion in the tax base, and possible increase in tax revenue. As the financial sector develops and the policy environment becomes more conducive for formalisation, the increase in FI level is likely to increase the tax burden which is a motivating factor to participate in the UE. In essence, efforts to raise the level of FI and increase tax revenue can push many back to the UE, leading to an expansion in the size of UE. If the net benefit of operating in the formal economy is significantly lower than what is obtainable in the UE, the rate of transition back to the UE is expected to be rapid. This position is perhaps accentuated by the pervasiveness of factors including weak institutions, double taxation, high unemployment, poverty, and income inequality in West Africa, all of which encourage continuous participation in the UE.

<<Table 5 goes here>>

The results also portray that corruption has a long-term significant negative influence on UE, suggesting that corruption and UE are substitutes in West Africa. A unit increase in corruption

level leads to a decline in UE during the long-term by 6.92%. This negative relation supports previous research findings (Choi and Thum 2010; Dreher et al. 2009, 2011; Rose-Ackerman 1997; Virta 2010). Although the outcome suggests that rising corruption dissuades individuals and firms from operating in the UE, it does not necessarily mean that lack of corruption control will results in the disappearance of UE activities. In fact, these activities continue to thrive but in the official economy since payment of bribes can enable individuals and firms overcome the factors which hitherto drive them to the UE.

In addition, money supply is shown to have a long-term significant negative influence on UE, but a short-term significant negative impact on UE. Increasing money supply by 1% leads to a long-term decline in UE by 0.224%, but raises UE by 0.208% during the short-term. Given that excessive use of cash in all transactions is a main feature of UE, rising money supply will promote the expansion of activities in the sector during the short-term. The long-term adverse effect of money supply on UE validates the outcome of past research (Khan et al., 2021). Thus, expansion in activities in the formal economy owing to increased money supply, inadvertently leads to the shrinkage of the UE.

Also, inflation is found to have a long-term significant positive influence on UE, while it is negatively and significantly related to UE during the short-term, at 1% level and 10% level, respectively. A 1% increase in inflation causes UE to decrease by 0.09% during the short-term, while it supports expansion in UE by 0.63% during the long-term. Rising inflation does not only signal economic instability, it breeds distrust in the formal (financial) sector. Therefore, despite lowering the size of UE minimally during the short-term, sustained increase in inflation rate will encourage more persons to participate in the UE, leading to an expansion of the sector during the long-term. Given the low cost of production in the UE (due to the absence of tax and cheap labour input), the decision of firms to go underground could equally to slow growth in the formal sector as a result of the unfair price competition which such development promotes.

Furthermore, a significant negative relation between international trade and UE was discovered in both short- and long-term. A 1% increase in international trade lowers the size of UE by 0.157% and 0.10%, during the long- and short-term, at 1% level and 10% level, respectively. The findings corroborate previous research (Khan et al. 2021). One of the many reasons why some participate in the UE is due to the absence of sufficient opportunities in the formal economy. Therefore, since the expansion in international trade roughly translates to increases in investment and employment opportunities, the size of UE will reduce. Lastly, the error correction term (ECT) coefficient is smaller than one, correctly signed and significant at 1%, suggesting that about 14.1% disequilibrium in UE during the short-term is corrected within a year.

4.5 Results of causality test

We implement the heterogeneous panel causality test of Dumitrescu and Hurlin (2012) to determine the direction of causality between the variables. The results of the tests summarised in Table 6 signal that the null hypothesis of no homogenous causality is rejected at 10%, and portray a one-way causality from FI to UE. This outcome lays credence to previous research (Ajide 2021). Moreover, a one-way causality was found from corruption to UE, from UE to money supply, and feedback between UE and agricultural output at 10%. A pictorial representation of the causality test results is equally summarized in Figure 3.

<<Table 6 goes here>>

<<Figure 3 goes here>>

5 Conclusion and recommendations

We explore the influence of FI on UE in 10 West African nations during the 2004-2021 period. Adopting the Pedroni cointegration test, a long-term relation between UE and FI (alongside corruption, inflation rate, money supply, agricultural output, and trade) was established. The results of PMG portray the presence of a long-term significant positive relation between FI and UE, and a short-term significant inverse relation between FI and UE. In addition, corruption, money

supply, and international trade have a long-term significant negative influence on UE, while inflation encourages the expansion of UE. Also, a short-term significant negative relation exists between UE and inflation (and trade), but a significant positive relation exists between UE and money supply during the short-term. Furthermore, a one-way causal relation from FI to UE was found.

Given the empirical outcomes, it can be concluded that an improvement in FI serves as a veritable tool for reducing the size of UE in West Africa. Based on the findings, we recommend strategies to improve FI, reduce corruption and money supply, and enhance international trade. Specifically, governments and/or policymakers are encouraged to implement policies that will raise FI level in the region. This can be done via introducing reforms in the financial sector to simplify the process of accessing and using financial services and products. The central banks and regulatory agencies should address problems of the high costs associated with formal financial services, cumbersome documentation and stringent requirements for microcredit facilities which greatly impede the use and access to financial services and products. Moreover, efforts geared towards broadening the coverage, reach and presence of financial institutions (banks and non-banks) will go a long way in ensuring that individuals (especially rural dwellers) have access to financial institutions and credit facilities. In addition, given the interdependence amongst West African nations, a regional-level strategy may be adopted to improve the level of FI. However, given the tendency of difference in factors impeding FI across countries, the adoption of a country-specific strategy is equally encouraged. Regardless, governments in the region are advised to adopt pragmatic measures capable of improving the efficiency of the formal financial institutions and equally effective in moving individuals from informal sector to the formal economy.

Secondly, given that corruption and UE are substitutes, governments are advised to develop and/or adopt measures to reduce corruption in the region. The level of corruption can be significantly reduced, and the UE activities lessened by removing operational red tape, simplifying cumbersome regulations in the bureaucratic system, raising the income level of civil servants, promoting greater freedom of expression, entrenching the rule of law, improving the efficiency in the legal system, and providing adequate funding to anti-graft agencies.

Third, monetary authorities are encouraged to address the issues of inflation in the region as it encourages movement to the UE. Also, adequate control of money supply that checks price level from rising can equally help in curtailing the growth in the size of UE. Since all transactions in the UE are settled in cash, a reduction in money supply matched with the gradual and intentional policy shift from a cash-based economy to cash-less economy will drastically reduce the size of the UE as most transactions will have to pass through the formal financial sector. Lastly, policymakers should address problems impeding international trade. This can include a review of the exchange rate policy and an improvement in manufacturing, agricultural and industrial sectors to boost the region's export. This will promote employment opportunities and reduce the labour available to the UE.

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Table 1 Descriptive statistics and correlation matrix

	UE_{it}	FII_{it}	$CORR_{it}$	MS_{it}	INF_{it}	AGR_{it}	$TRADE_{it}$
Mean	37.281	$1.11\times10^{-9\dagger}$	3.131	26.724	5.451	24.794	59.128
Std. Dev.	7.751	1.538	0.378	9.041	6.583	7.589	19.699
Min.	10.8	-3.021	2.441	9.034	-3.233	12.246	16.352
Max.	61.4	5.066	3.883	51.682	34.695	42.524	132.383
UE_{it}	1.000						
FII_{it}	-0.196***	1.000					
$CORR_{it}$	0.276***	-0.376***	1.000				
MS_{it}	-0.399***	0.678***	-0.328***	1.000			
INF_{it}	0.217***	-0.091	0.256***	-0.245***	1.000		
AGR_{it}	0.026	-0.189**	0.115	-0.179**	-0.133*	1.000	
$TRADE_{it}$	-0.507***	0.106	0.050	0.367***	0.112	-0.0002	1.000

Note: †The mean value of FII is presented in scientific notation. This implies an extremely small value, highlighting the substantial disparities among the countries. Asterisks (***), (**) and (*) denotes statistical significance at 1%, 5% and 10% levels, respectively.
Source: Authors' computation using Eviews 12.

Table 2 Results of cross-section dependence tests

CSD Tests	UE_{it}	FII_{it}	$CORR_{it}$	MS_{it}	INF_{it}	AGR_{it}	$TRADE_{it}$
Breusch-Pagan LM	332.351***	617.859***	177.144***	399.404***	233.546***	197.463***	187.024***
Pesaran scaled LM	30.289***	60.385***	13.929***	37.357***	19.875***	16.071***	14.971***
Pesaran CD	16.133***	23.624***	4.908***	17.754***	12.466***	0.646	1.0682
BFKbias-corrected scaled LM	29.995***	60.385***	13.635***	37.063***	19.580***	15.777***	14.677***

Note: H_0: no cross-section dependence (correlation). $df = 45$. Asterisks (***) denote significance at 1% level. BFK is Baltagi, Feng and Kao (2012) Bias-corrected Scaled LM CSD test.
Source: Authors' computation using Eviews 12

Table 3 Panel unit root tests

	First generation tests			Second generation test
	LLC	IPS	ADF-Fisher	CIPS
UE_{it}	-0.246	0.141	25.236	-1.257
FII_{it}	6.280	6.855	4.268	-1.317
$CORR_{it}$	-0.224	-0.446	22.779	-2.434**
MS_{it}	2.827	2.606	22.929	-1.532
INF_{it}	-5.727***	-4.649***	61.846***	-3.192***
AGR_{it}	-1.130	0.353	20.886	-1.546
$TRADE_{it}$	-1.886**	-0.447	23.419	-1.532
$\Delta UECO_{it}$	-4.793***	-4.206***	55.749***	-2.775***
ΔFII_{it}	0.323	0.134	28.919*	-2.725***
$\Delta CORR_{it}$	-11.662***	-9.201***	106.849***	–
ΔMS_{it}	-7.482***	-6.248***	74.332***	-3.609***
ΔINF_{it}	–	–	–	–
ΔAGR_{it}	-12.495***	-9.487***	112.275***	-3.400***

$\Delta TRADE_{it}$	–	-9.785***	114.559***	-4.011***

Note: Δ is first differenced notation; LLC denotes Levin-Lin-Chu test, IPS is Im-Pesaran-Shin test, and CIPS is Pesaran's (2007) cross-sectional augmented IPS (CIPS) test. Asterisks (***), (**) and (*) denotes statistical significance at 1%, 5% and 10% levels, respectively.
Source: Authors' computation using Eviews 12 (LLC, IPS and ADF-Fisher tests) and Stata 14 (CIPS – *xtcips* package).

Table 4 Pedroni panel cointegration test results

Null hypothesis: no cointegration		Panel	Group
Test Statistic	v-stat.	-0.7125	–
	ρ-stat.	2.299**	3.53***
	t-stat.	-3.643***	-5.009***
	ADF-stat.	2.657**	4.889***

Note: v-stat. is variance ratio statistic. ρ-stat. is non-parametric Phillips-Perron (PP) ρ type statistic. t-stat. is a non-parametric PP type t-statistic. ADF-stat. is a DF type t-statistic. Asterisks (***) and (**) denotes statistical significance at 1% and 5% levels, respectively.
Source: Authors' computation using Eviews 12.

Table 5 Estimation results of underground economy and financial inclusion relation

Variables	Dependent Variable: ΔUE_{it}		
	DFE (I)	MG (II)	PMG (III)
Panel A: Long-run Estimates			
FII_{it}	-0.127 (6.178)	0.479 (4.009)	1.742 (0.583)***
$CORR_{it}$	-12.588 (37.159)	7.642 (18.187)	-6.922 (1.212)***
MS_{it}	-1.009 (2.019)	0.043 (0.937)	-0.224 (0.071)***
INF_{it}	-1.662 (3.159)	-0.479 (0.409)	0.627 (0.121)***
AGR_{it}	-0.718 (2.001)	-2.312 (1.540)*	-0.052 (0.082)
$TRADE_{it}$	-0.115 (0.508)	-0.899 (0.556)*	-0.157 (0.036)***
ECT	-0.038 (0.062)	-0.867 (0.214)***	-0.141 (0.079)**
Panel B: Short-run Estimates			
ΔFII_{it}	-1.418 (0.919)*	0.414 (1.669)	-2.086 (0.867)**
$\Delta CORR_{it}$	0.721 (1.589)	1.257 (3.713)	-1.206 (1.972)
ΔMS_{it}	0.244 (0.076)***	0.189 (0.271)	0.208 (0.057)**
ΔINF_{it}	0.0104 (0.048)	-0.009 (0.103)	-0.089 (0.052)*
ΔAGR_{it}	0.025 (0.073)	0.192 (0.239)	-0.029 (0.091)
$\Delta TRADE_{it}$	-0.027 (0.021)	0.069 (0.075)	-0.1002 (0.056)*
Constant	4.772 (4.907)	95.852 (36.337)***	10.466 (5.932)*
Hausman test [Prob.]	2.14 [0.906]	1.95 [0.924]	–
Observations	180	180	180
No. of countries	10	10	10
Log likelihood	–	–	-225.856

Note: The optimal lag-length is suggested by AIC. DFE = Dynamic Fixed Effects; MG = Mean Group; and PMG = Pooled Mean Group. Values in (.) are standard error and [.] is probability value. Asterisks (***), (**) and (*) denotes statistical significance at 1%, 5% and 10% levels, respectively.
Source: Authors' Computation using Stata 14

Table 6 Results of Dumitrescu-Hurlin panel causality test

	UE_{it}	FII_{it}	$CORR_{it}$	MS_{it}	INF_{it}	AGR_{it}	$TRADE_{it}$
UE_{it}	–	2.536	2.679	4.788**	3.530	3.830*	3.027
FII_{it}	4.254*	–	5.313***	4.718**	4.502**	6.771***	6.436***
$CORR_{it}$	4.636**	2.196	–	3.198	4.064*	6.003***	3.630
MS_{it}	3.245	2.453	4.749**	–	4.331**	4.378**	4.445**
INF_{it}	2.308	1.855	3.929*	4.484**	–	4.699**	2.989

AGR_{it}	4.106*	1.497	5.060***	2.075	4.252*	–	3.892*
$TRADE_{it}$	3.046	2.141	2.872	4.302**	3.859*	6.605***	–

Note: H_0: x_{it} does not homogeneously cause y_{it}. Asterisks (***), (**) and (*) denotes statistical significance at 1%, 5% and 10% levels, respectively.
Source: Authors' Computation using Eviews 12

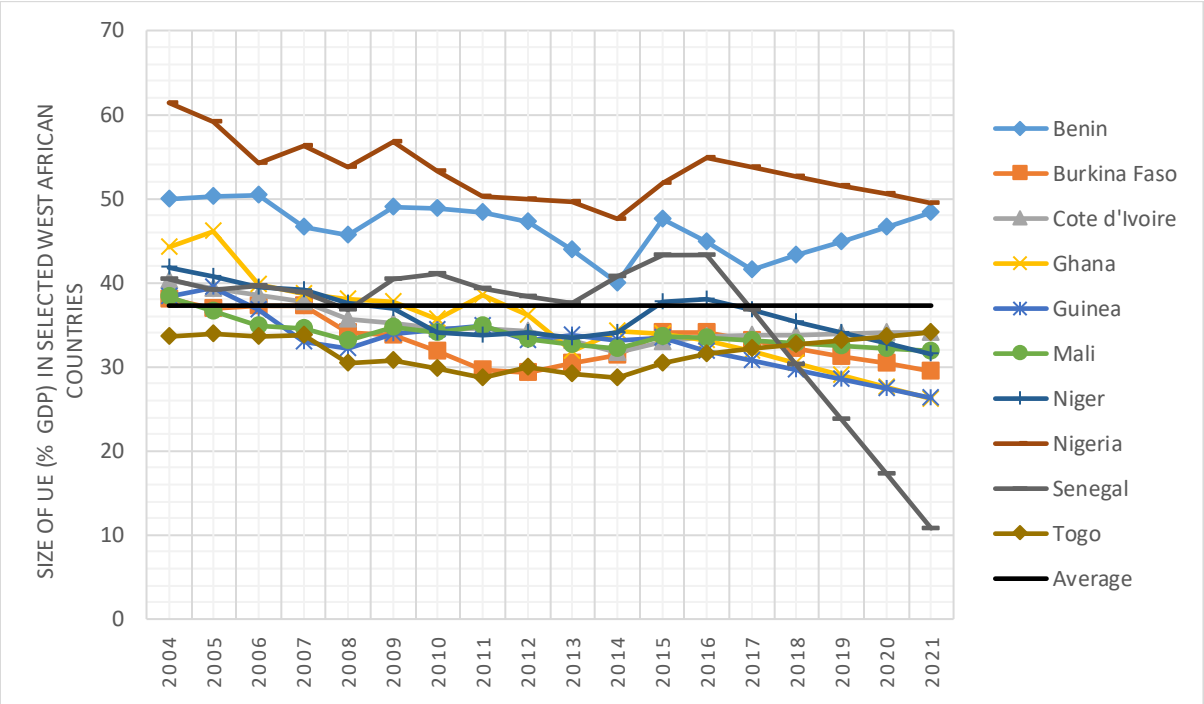

Fig 1 Plot of the size of UE (% of GDP) of selected West African countries
Source: Authors' computation based on Medina and Schneider (2019).

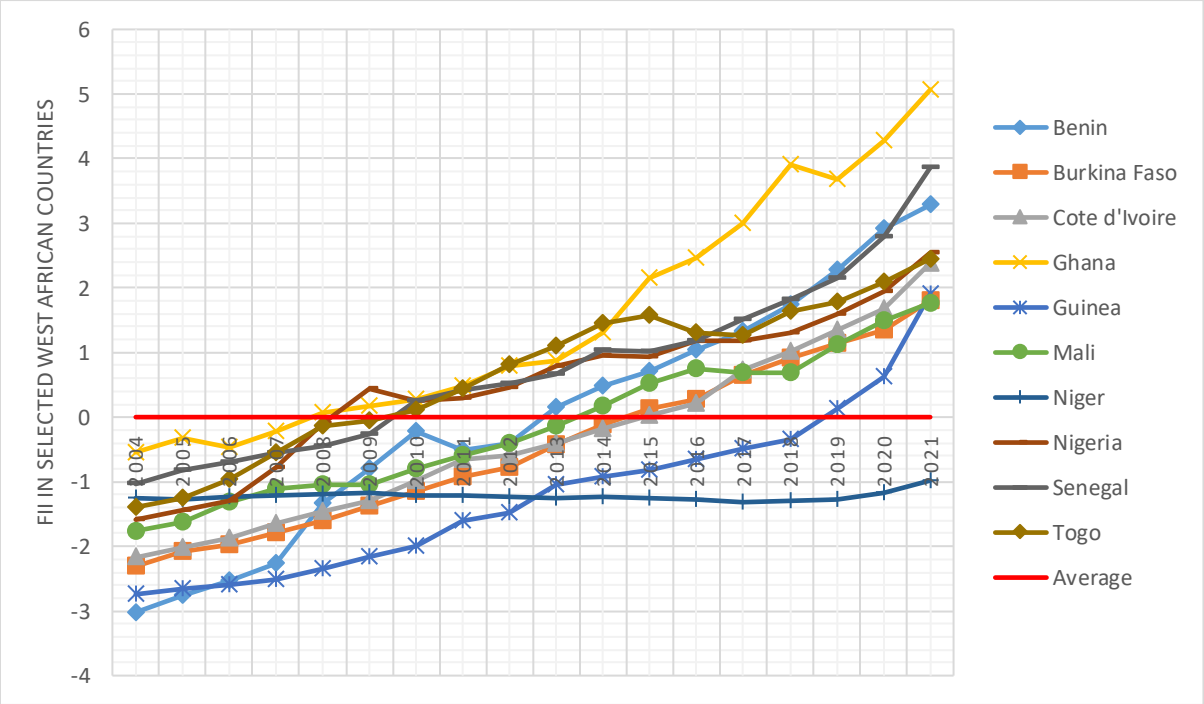

Fig 2 Plot of financial inclusion index (FIII) of selected West African countries
Source: Authors' computation.

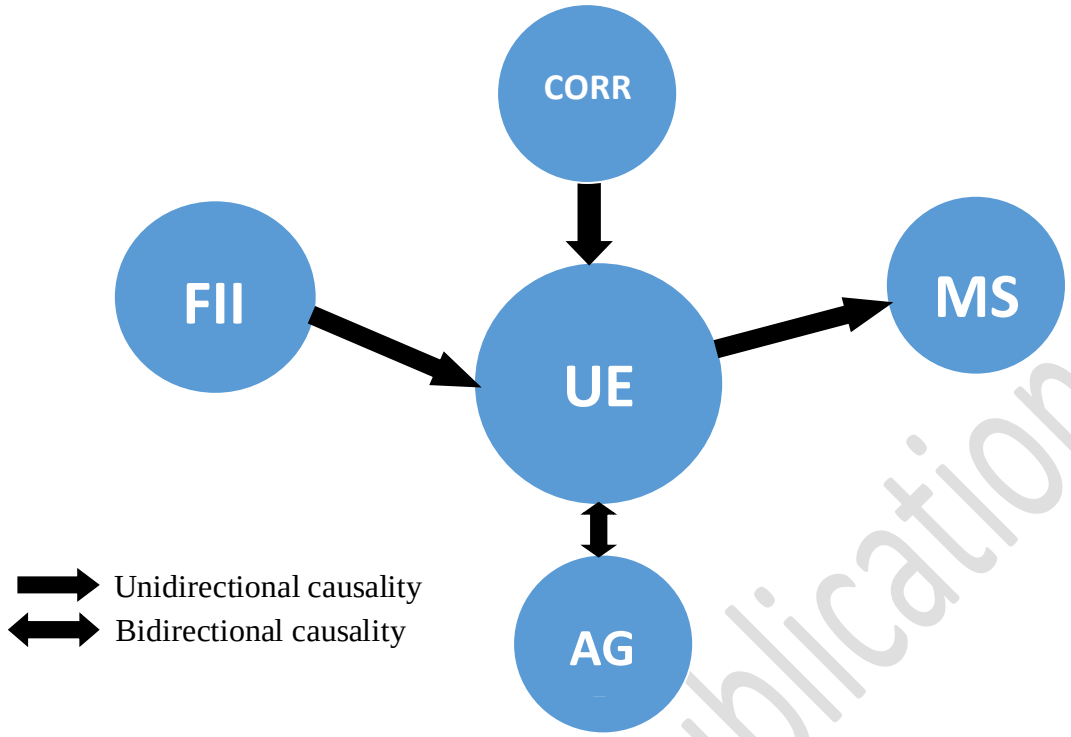

Fig 3 Pictorial representation of the causal relationships obtained from the Dumitrescu-Hurlin panel causality test, where the arrow indicates the direction of causality.
Source: Authors' Computation