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## Research Article

# Common Currency and Intra-Regional Trade in the Central African Monetary Community (CEMAC)

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## ABSTRACT

We applied the threshold autoregressive and difference-in-differences techniques to examine the effects of adopting a common currency on bilateral trade flows between member states of the Central African Economic and Monetary Community (CEMAC) customs union, over the period from 1980 to 2013. We found evidence of a sample split—a probable indication of the presence of a single threshold corresponding to the year 1994 when the *Coopération financière en Afrique centrale* (CFA) franc, a common currency, was introduced in CEMAC. Our results also show that the adoption of the CFA franc did not contribute to growth in CEMAC intra-regional trade. The results are robust in that they take into account country fixed effects and suggest a turning point after 1994, between the common currency and the flow of intra-regional trade. More generally, our results provide evidence against the claim that a common currency leads to increased intra-regional trade.

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## 1. INTRODUCTION

The impact of a common currency on trade is an important topic in literature on international trade. The issue remains controversial, especially at a time when the true benefits of increasing integration with regional blocs are being debated by policymakers. Since World War II, 123 countries have been involved in a currency union at some point, and by 2015, 83 countries continued to be involved in one. This shows that currency unions are an important institutional arrangement to facilitate international trade and reduce trade costs (Chen and Novy, 2018). The effects of a common currency on intra-regional trade depend on the objectives of member states and whether the union is among developed economies, developing economies, or a mixture of both. The impact of the *Coopération financière en Afrique centrale* (Financial Cooperation in Central Africa, CFA) franc on intra-regional trade has been one of great concern because of the obstacles encountered by member states regarding their commitment to implementing regional objectives. CFA is a French acronym.

The CFA franc zone dates back to 1945, as an outgrowth of the economic and financial arrangements under which France administered its colonies. The CFA refers to two currencies: the Central African CFA franc and the West African CFA franc. These are two separate currencies used by the Central African Economic and Monetary Community, also known as *Communauté Économique des États d'Afrique Centrale* (CEMAC), and the West African Economic and Monetary Union, also commonly known as *Union Économique et Monétaire Ouest Africaine*. The six members in Central Africa are Cameroon, the Central African Republic, Chad, the Republic of the Congo, Equatorial Guinea, and Gabon, which all use the *franc de la Coopération financière en Afrique Centrale* and have their own central bank, the *Banque des États de l'Afrique Centrale* in Yaoundé, Cameroon (Bénassy-Quéré and Coupet, 2005).

The creation of a common currency in CEMAC was intended to facilitate commercial exchange and reduce the transaction costs of member states, enabling the region to benefit from lower prices and increased intra-regional trade. Although a currency union can lead to lower transaction costs, the effect on all bilateral trading relationships will not be the same for all member states. Countries with small import shares are more likely to be sensitive to changes in trade costs. Currency unions are not randomly assigned and are usually the outcome of a political process. However, instruments for currency-union membership are difficult to find and several attempts have been made, according to the literature, but have proved disappointing (Chen and Novy, 2018).

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Although the CEMAC trade bloc is a customs union, the uneven application of regional rules and policies has constrained the region's intra-regional trade. This is compounded by poor structural reforms and tariff policies that member states rarely adopt. In spite of the historical advantages and a favourable natural-resource endowment, enhanced intra-regional trade has proven to be a challenging goal in CEMAC ([Gankou and Ntah, 2008](#)). Although low intra-regional trade is a feature of many regional groupings in the developing world, the level in CEMAC is lower, even in comparison to their regional counterpart—the French West African Economic and Monetary Union (WAEMU)—and other trade blocs in Africa.

This paper makes policy and methodological contributions to the existing literature. Firstly, it sheds light on whether a common currency enhances trade, especially given the tendency of many African countries to adopt such an approach, as in the case of the Economic Community of West African States and the African Continental Free Trade Area. Secondly, we provide equations that capture the dynamic behaviour of time-series data that switch from one regime to another—a likely phenomenon that linear models fail to capture. Because the proportions of trade flow from member states in a regional bloc are expected to be correlated in general, the equations for predicting these are likely to be interrelated. These are accounted for by adopting the difference-in-differences (diff-in-diff) technique. The findings of this study contribute to the debate on the effects of a common currency on intra-regional trade flow.

The remainder of this paper is organised as follows. [Section 2](#) presents a brief review of the literature. [Section 3](#) discusses the theory and empirical models that explain the possibility of a bleak outcome from adopting a common currency. The empirical results are discussed in [Section 4](#), and [Section 5](#) offers conclusion.

## 2. LITERATURE REVIEW

### 2.1. On Common Currencies and International Trade

Many studies on common currency focus on the type of exchange-rate regime suitable for international trade. For instance, [Mundell \(1961\)](#), in his pioneering thesis on optimum currency areas, argued that countries that are integrated through international trade and allow the free flow of factors of production should consider fixed exchange rates for cross-border transactions. The theory of an Optimum Currency Area (OCA) dates back to the classic works of [Mundell \(1961\)](#), [McKinnon \(1963\)](#), and [Kenen \(1969\)](#). Optimum currency area theory provides fundamental criteria for the establishment of a currency area. An OCA can be seen as a currency union within a geographical area in which member states either share a common currency or maintain separate national currencies pegged to each other's currency at a fixed rate, with full convertibility of the respective currencies, or when countries in that union share a common currency ([Mundell, 1961](#)).

Regarding whether the CFA franc zone is an example of an OCA, [Couharde et al. \(2013\)](#) argued that it is not clear where the CFA countries stand with respect to OCA analysis. Despite the fact that the region has successfully maintained a currency union to date, the region has failed to meet a number of important OCA criteria. The OCA criteria are too restrictive for monetary unions that were formed on a political rather than an economic basis.

[Rose \(2000\)](#) estimated the effects that a common currency has on bilateral trade flow. His findings revealed that regional trade agreements that adopt a single currency tend to trade three times more than those with multiple currencies. Although Rose's estimates have been the subject of criticism in the literature, they laid the foundation for studies on the relationship between a common currency and intra-regional trade. Trade blocs that adopt a common currency tend to eliminate volatility caused by fluctuations in exchange rates, and this, in turn, is likely to reduce trade costs and enhance intra-regional trade ([Cieřlik et al., 2012](#)). [Frankel and Rose \(2002\)](#) suggested that countries that are heavily involved in trade with neighbouring countries should consider the possibility of a common currency. However, the benefits of trade in a currency union ultimately depend on the country with which one enters a currency union.

[Carrère \(2004\)](#) used the [Hausman–Taylor \(1981\)](#) method of estimation and found no evidence of improved intra-regional trade in CEMAC, even though increased trade flows did occur among member states. [Gbetnkom \(2008\)](#), on the other hand, posited that the growth rate of the Gross Domestic Product (GDP) of member states, as opposed to the monetary union, played a significant role in promoting bilateral trade among CEMAC member states between 1995 and 2000.

[Chen and Novy \(2018\)](#) challenged the idea of a homogeneous one-size-fits-all approach by using a gravity equation to evaluate the trade effect of currency unions. Their analysis on currency unions, trade, and heterogeneity showed that conventional homogeneous currency-union estimates do not provide enough helpful guidance for countries that are considering joining a currency union.

Furthermore, studies on sectoral trade flows offer contrasting views on the effects of a common currency on exports. Some authors ([Rodgers 2009](#); [Bergin and Lin, 2012](#); [Rose and van Wincoop, 2001](#)) have found that a common currency has a positive and significant effect on trade. By contrast, [Fosu \(1992\)](#) and [Akinniran and Olatunji \(2018\)](#) found that a common currency negatively influences agricultural exports. Furthermore, [Frankel \(2009\)](#) found that the adoption of a single currency has positive short- and long-term effects on intra-regional trade. However, [Butkus et al. \(2018\)](#) argued that any positive effects on trade flow resulting from trade integration are only noticeable in the short term.

Furthermore, [Rose and Glick \(2015\)](#) revisited their earlier studies from 2002, which had used pre-1998 data to estimate the effects of currency unions on trade by using conventional gravity models. Taking advantage of the availability of a large panel of data, including observations

from more than 200 countries over 66 years, their results regarding the European EMU revealed a significantly negative effect on exports, whereas other currency unions revealed a much larger positive effect. They concluded that such an analysis depends on a precise econometric methodology, and that it was beyond their ability to estimate the aggregate trade effect of currency unions on trade with any degree of confidence, particularly for the EMU. This means that as more data on currency unions become available over time, the analysis of the net effects of a common currency on bilateral trade flow will likely differ from earlier studies, when insufficient data were available (Glick and Rose, 2016).

## 2.2. On Common Currencies, Exchange Rates, and Competitiveness

Since the euro was launched on 1 January 1999, it has become an important reference currency for the two CFA franc zones in West and Central Africa, where member states maintain a fixed peg to the euro. Although CEMAC and WAEMU use two separate currencies, they maintain the same exchange-rate parity to the euro. As the euro has appreciated over time, its role as a financial currency in Africa has increased. For example, in 2007, for the first time, the stock of outstanding international debt securities in Africa, totalling USD \$32 billion, was denominated in euro, as opposed to the US dollar (Djoulfelkit, 2007). As the euro appreciates, the CFA franc, in particular, tends to appreciate nominally against the currencies of countries outside of the union, potentially hampering the competitiveness of member countries. The study of Colliac and Blé (2019) showed an overvaluation in many of the CEMAC countries, as compared to the case of WAEMU.

When the real appreciation of a currency is not accompanied by an improved economic situation, it is likely to result in a loss of competitiveness (Coulibaly, 2014). Despite the advantage of a pegged exchange rate in mitigating the volatility of the exchange rate, it can damage the prospect of any growth in cases of overvaluation (Fosu, 2012). This was the case with the CFA franc and its impact on the growth rate in the region before the major devaluation in 1994. Prior to the devaluation of the CFA franc in 1994, the appreciation of the French currency between the mid-1980s and 1993, combined with inadequate internal economic policies, had dramatic effects on the CFA franc. According to Klau (1998), the overvaluation of the CFA franc contributed to the poor economic performance of the CFA zone.

The period between 2000 and 2006 saw the real effective exchange rate of the CFA franc zone appreciate by approximately 14%. The appreciation of the euro against the US dollar and increasing trade with Asian countries, the currencies of which are pegged to the US dollar, might have accounted for the appreciation in the exchange rate (Djoulfelkit, 2007). Concerns were also expressed that the strong appreciation of the euro would reduce the competitiveness and growth perspectives of the CFA franc zone. This was after the persistent appreciation of the euro in January 2013, where its nominal effective exchange rate appreciated by approximately 5.0% (CaixaBank, 2014).

The real exchange rate can be considered an important determinant of the export competitiveness of the CFA zone. An overvalued real exchange rate signals resource movement from the export sector to the production of domestic goods. International competitiveness is negatively affected, as exporters find it difficult to compete. Since the real exchange rate is a strategic variable for determining the competitiveness of the CFA zone, Marumbok's (2007) analysis of the effects of an overvalued exchange rate shows that the real exchange-rate effects of the CFA parity's switch to the euro in 1999 did not favour the CFA zone. Rather, it has contributed to the appreciation of the real exchange rate.

## 3. THEORETICAL AND EMPIRICAL FRAMEWORK

### 3.1. Theoretical Model: The Gravity Model and Common Currency

The gravity model of trade stipulates that the volume of trade between two countries is proportional to the size of and distance between the countries in question. The model has been used to analyse other areas of interest, including the flow of migration and foreign direct investment (Martinez-Zarzoso and Nowak-Lehmann, 2003; p. 295). According to Vanderkamp (1977), the gravity model helps explain anomalies in trade and has achieved both empirical and theoretical success at explaining various types of regional and international trade flow, including international capital flow and exchange rate policies. In deriving a theoretical gravity equation and assuming the presence of border effects, such as transport costs and tariffs, Feenstra (2004) adopted the constant elasticity of substitution utility function, stated as follows:

$$U^j = \sum_{i=1}^C \sum_{k=1}^{N^i} (c_k^{ij})^{(\sigma-1)/\sigma} \quad (1)$$

where  $c_k^{ij}$  is the value of exports from country  $i$  to country  $j$  of goods  $k$ .

In this model, each country produces a variety of unique products. Total exports from countries  $i$  to  $j$  are similar to the total consumption of goods  $k$  to country  $j$ . In this model, all products exported by country  $i$  sell for the same price ( $p^{ij}$ ) in country  $j$ . With prices  $p^{ij}$  equal across a variety of goods, the total consumption in country  $j$  is also equal across products  $k = 1, \dots, N^i$  sold by country  $i$ , and then  $c_k^{ij} = c^{ij}$ . Given this assumption, the utility function can be modified as follows:

$$U^j = \sum_{i=1}^C N^i (c^{ij})^{(\sigma-1)/\sigma} \quad (2)$$

where  $c^{ij}$  is the consumption of any product by country  $j$  from country  $i$ .

Feenstra (2004) showed that the representative consumer maximises Equation (2) subject to budget constraints, as given by Equation (3):

$$Y^j = \sum_{i=1}^C N^i p^{ij} c^{ij} \quad (3)$$

where  $Y^j$  denotes the aggregate expenditure (income) in country  $j$ .

To derive the demand for each product  $c^{ij}$ , we can maximise Equation (2) subject to Equation (3), as follows:

$$c^{ij} = (p^{ij} / P^j)^{-\sigma} (Y^j / P^j) \quad (4)$$

where  $P^j$  is country  $j$ 's overall price index, as defined in Equation (5):

$$P^j = \left( \sum_{i=1}^C N^i (p^{ij})^{(1/(1-\sigma))} \right) \quad (5)$$

From Equations (4) and (5), the total value of exports from country  $i$  to  $j$  can be derived as follows:

$$X^{ij} = N^i Y^j \left( \frac{p^{ij}}{P^j} \right)^{1-\sigma} \quad (6)$$

Equation (6) gives a simple derivation of the gravity model, where bilateral trade in exports from country  $i$  to country  $j$  is proportional to the products of the two countries' GDPs (Feenstra, 2004). The size of both countries is measured in terms of GDP. Trade between two countries tends to diminish with the distance between the countries in question.

Krugman and Obstfeld (2006) showed that the gravity model can be used to assess the impact of the formation of regional integration on international trade flow. However, recent studies have shown that the gravity model suffers from two fundamental flaws. These problems stem from the usage of a logarithm in linear form to solve the problems of bias estimates due to misspecification and the presence of missing data (Gómez-Herrera, 2013). The presence of missing data or zero flows were usually dealt with in the gravity equation by ignoring the zeroes. However, Linders and De Groot (2006) showed that ignoring the zero flows is at odds with proper econometric modelling; they should not be ignored. They suggested using a sample selection model, as it allows potential trade between trading partners and zero flows to be explained jointly. Applying the fixed-effects model of the gravity equation also helps in correcting the misspecification bias (Linders and De Groot, 2006).

Given these challenges with the theoretical gravity model, we adopted alternative estimation techniques that allow us to compare the difference in outcomes before and after the intervention in the CEMAC customs union in 1994. We also adopted techniques that have the potential to minimise biases in the analysis of intra-regional trade flow that may result from assuming linearity and stationarity.

## 3.2. Empirical Model

Two different but somewhat related empirical models were adopted for the analyses in this paper: (i) the Threshold Autoregressive (TAR) model, which is used to test whether the institution of a common currency has indeed had any positive effects on CEMAC intra-regional trade flow; and (ii) the diff-in-diff estimation technique, which serves as a sensitivity test, or a test of the fitness of the variables in the model. Finally, we checked whether the results from the diff-in-diff model complement those of the TAR model.

### 3.2.1. Threshold autoregressive model

The TAR model has been used extensively in applied economics. Common areas include agricultural economics, where variables tend to be non-stationary (Zapata and Gauthier, 2003), and finance and investment (Hansen, 1999). It is also applicable to spatial market integration, where it is believed that for spatially separated markets to be in equilibrium, transaction costs play an important role. The model provides a better estimation, especially in situations where the data have non-stationary and cointegration properties (Zapata and Gauthier, 2003). The choice of the non-linearity effect of a common currency suffices for our study, as a common currency can alter the slope of the relationship between bilateral trade and member-state GDP (Katayama and Melatos, 2011).

In the TAR model, a variable  $q_t$  determines the regime of the threshold value. A regime is determined by a set of observable variables at time  $t$ . Each regime is estimated using the linear autoregressive model. Hansen (1999) suggested the following model for a non-dynamic balanced panel:

$$\text{For a given balanced panel } \{y_{it}, q_{it}, x_{it}; 1 \leq i \leq n, 1 \leq t \leq T\}, \quad (7)$$

where  $i$  represents an individual countries,  $t$  is time,  $y_{it}$  is the dependent variable and also a scalar,  $q_{it}$  is the threshold variable and also a scalar, and  $x_{it}$  is the regressor, which is a  $k$  vector.

According to Zapata and Gauthier (2003), the model can be specified as

$$y_i = \begin{cases} \mu_i + \beta'_1 x_{it} + e_{it} & \text{if } q_{it} \leq \gamma \\ \mu_i + \beta'_2 x_{it} + e_{it} & \text{if } q_{it} > \gamma \end{cases} \quad (8)$$

where  $q_{it}$  is the state-determining variable dividing the equation into two regimes, and  $\gamma$  is an unknown threshold parameter estimated by the least squares approach.

Given  $\beta = \beta'_1 \beta'_2$ , which denotes the coefficients to be estimated, Equation (8) can take the form:

$$y_{it} = \mu_i + \beta' x_{it}(\gamma) + e_{it} \quad (9)$$

Equation (9) is divided into two regimes. The regimes depend on whether the determining variable  $q_{it}$  is larger or smaller than  $\gamma$ .  $x_{it}$  represents regressors, which include GDP, GDP per capita, Foreign Direct Investment (FDI), the population, the labour force, and trade openness.

$\beta_1$  and  $\beta_2$  identify the different regression slopes, and the elements of  $x_{it}$  must be time invariant to identify  $\beta_1$  and  $\beta_2$ . Also,  $e_{it}$  is assumed to have a mean of zero with finite variance  $\sigma^2$ , which is independent and identically distributed.

One advantage of using the TAR model is that it can accommodate different links among variables in distinct regions (Hansen, 1999). This applies to member states in the CEMAC region that have distinct national characteristics. The least squares estimation technique is usually used to estimate the threshold model. The estimation technique follows that of Hansen (1999).

From Equation (7), the average is taken over the given time period to derive Equation (10):

$$\bar{y}_{it} = \mu_i + \beta' \bar{x}_{it}(\gamma) + \bar{e}_{it} \quad (10)$$

Taking the difference between Equations (9) and (10), Equation (11) is obtained:

$$y_{it}^* = \beta' x_{it}^*(\gamma) + e_{it}^* \quad (11)$$

Equation (11) implies that the fixed-effect transformation has been made, where

$$y_{it}^* = y_{it} - \bar{y}_i, x_{it}^*(\gamma) = x_{it}(\gamma) - \bar{x}_i(\gamma), \text{ and } e_{it}^* = e_{it} - \bar{e}_i \quad (12)$$

According to Wang (2015), to estimate  $\gamma$  least squares estimation techniques can be used to restrict the interval range  $(\gamma, \bar{\gamma})$ . The estimated threshold value  $\gamma$  is the value that minimises the residual sum of squares.

We carried out a test to determine the number of thresholds in the regression. The estimation was done using the least squares method, allowing one, two, or three thresholds. A bootstrap was used to compute the  $p$ -value. Using 300-bootstrap replication, since the sample size is small, the  $p$ -value for the threshold model using intra-regional exports and our sample split indicated the presence of a single threshold.<sup>1</sup> We then used a single threshold regression model, derived from Equation (12), as given by Equation (13):

$$y_{it} = \mu_i + \beta'_1 x_{it} I(q_{it} \leq \gamma) + \beta'_2 x_{it} I(q_{it} > \gamma) + e_{it} \quad (13)$$

where  $I(\bullet)$  is the indicator function, and the parameter  $\mu_i$  is the individual fixed effect, while the disturbance term  $e_{it} \approx (0, \sigma^2)$ .

Equation (13) can then be expanded by including the independent variables:

$$Y_{it} = \mu_i + \beta_1 x_{it} I(q_{it} \leq \gamma) + \beta_2 x_{it} I(q_{it} > \gamma) + \beta_3 \text{GDP} + \beta_4 \text{gdppc} + \beta_5 \text{fdi} + \beta_6 \text{pop} + \beta_7 \text{trade}_{\text{open}} + e_{it} \quad (14)$$

<sup>1</sup>Threshold variable: Exports value.

### 3.2.2. Difference-in-differences estimator

Following [Giavazzi and Tabellini's \(2005\)](#) methods of estimation, the diff-in-diff method estimates the average change in output for the treatment group, which, in our case, involved the CEMAC member states that adopted the common currency in 1994. To do this, [Zuccardi Huertas \(2013\)](#) proposed two main steps:

- Step 1: The average output value is calculated before and after the treatment. This removes biases that might have resulted from unobserved time phenomena and permanent time trends affecting both groups.
- Step 2: The difference between the treated and the control groups is calculated. The control group, in our case, comprised countries in Central Africa that are members of a larger trade bloc, the Economic Community of Central African States (ECCAS), that did not adopt the common currency. The countries in the control group are therefore not part of CEMAC. This step is vital, as it removes biases caused by unobserved individual phenomena that are not related to the treatment of and permanent differences between the groups.

The idea is to match trade flow data from 1994 for the control group that did not institute the common currency with that of CEMAC, to examine how intra-regional trade flows changed in the treated and control groups. The difference between intra-regional trade flow before and after 1994 in CEMAC and the difference between intra-regional trade flow before and after 1994 in the ECCAS area are then calculated.

In the analysis of the impact of the adoption of the common currency on CEMAC intra-regional trade, the intra-trade flow in country  $i$  in region  $S$  at time  $t$  is denoted by  $\exp_{ist}$ . Assuming a fixed-effects model for  $\exp_{it}$ , an estimated typical regression model is given as follows:

$$\ln \exp_{ist} = \alpha_0 \text{cemdummy}_{it} + X' \delta + a_i + a_t + \mu_{it} \quad (15)$$

where  $\ln \exp$  is the log of exports, and  $\text{cemdummy}$  is a dummy variable that equals 1 after the region has adopted the common currency, and 0 otherwise.  $X$  is a vector of control variables, and these variables include the labour force, GDP, trade openness, and FDI.  $a_i$  is a set of country fixed effects that accounts for factors that are persistent in the region, such as social norms and political and economic factors that affect intra-regional trade flow ([Conti, 2014](#)).  $a_t$  is a set of time dummies that captures and takes into consideration common macroeconomic shocks, and  $\mu_{it}$  is the error term.

As mentioned above, the control group is ECCAS (viz., Angola, Burundi, Democratic Republic of Congo, and Sao Tome and Principe). The inclusion of country-specific temporal trends in a diff-in-diff model is important, as this accounts for the different levels of growth between member states of the control and treatment groups.

### 3.3. Data Sources

Data for a panel of the 10 countries of CEMAC/ECASS—Cameroon, Chad, Central African Republic, Republic of the Congo, Equatorial Guinea, Gabon, Angola, Burundi, Democratic Republic of Congo, and Sao Tome and Principe—were pooled over the period from 1980 to 2013. The control variables used in our trade analysis included the following:

- Total merchandise trade ( $X_{ij}$ ): The merchandise trade is composed of imports and exports over the sample period. We used the growth rate of exports, as it is a common indicator used to assess economic progress in terms of the value of goods consumed by foreigners. According to [Federici and Marconi \(2002\)](#), the growth rate of exports determines the rate of output growth.
- Gross domestic product ( $Y_i$ ): The real GDP or GDP per capita ( $\text{gdppc}_c$ ) of both the exporter and importer are used as a proxy to determine the level of economic growth. The growth rate in GDP and GDP per capita was used to analyse data from the United Nations Conference on Trade and Development (UNCTAD) and World Trade Organisation (WTO) statistics databases.
- Population ( $\text{pop}_i$ ) and labour force ( $\text{lf}$ ): According to [Frankel \(1997; p. 57\)](#), the size of a country can be measured in two main ways—the total output of a country Gross National Product (GNP) and the size of the population. Population and labour force data were derived from the UNCTAD statistics database.
- Foreign direct investment ( $\text{fdi}$ ): This is considered as the net flow of the transfer of skilled personnel, marketing skills, financial and intangible assets such as technologies, and the net inflow of fixed assets. The data were derived from World Bank Development Indicators.
- Trade openness ( $\text{trade\_open}$ ): This corresponds to the ratio of the share of trade to total GDP. We expected a positive relationship between trade openness and net exports.
- Dummy variables for a common currency ( $\text{cem\_CFA}$ ): This takes a value of 1 if trading partners adopt a common currency, and 0 otherwise.

## 4. RESULTS

The test statistics for single, double, and triple thresholds, as well as their bootstrap  $p$ -values, are shown in Table 1. Only the test for a single threshold is statistically significant, with a  $p$ -value of 0.073. As such, there is strong evidence of a single threshold in the regression relationship. Focusing on this, the growth rate of exports ( $\text{exp\_gr}$ ) was trimmed at 5% on both sides of the threshold to search for the threshold estimator. In accordance with Wang (2015), a grid of 400 was used to mitigate computational errors.

Table 2 shows the regression coefficients and the ordinary least squares standard errors. Column 1 shows a fixed-effects panel regression. Most of the variables are statistically significant, except for the labour force ( $\text{lf}$ ) and population ( $\text{pop}$ ). The second and third columns show the regression estimates of a single threshold model. In column 2, we use the OLS standard error, and in column 3, we apply the White-corrected standard error.

The coefficient of interest is the common currency variable ( $\text{cem\_CFA}$ ). Table 2 shows that the effect of the common currency is negative and statistically significant, regardless of the estimating method. However, the magnitude of the coefficient for the single threshold is much larger, suggesting possible non-linearity.

The CEMAC GDP has a slightly positive relationship with exports, while trade openness ( $\text{trade\_open}$ ) is positive and highly significant, consistent with previous studies. The CEMAC population and labour force are both statistically insignificant, suggesting that the member states' population and labour force do not affect CEMAC's intra-regional trade flow. Also, the results show that the level of net inward FDI ( $\text{fdi}$ ) is positive and significant, implying that the net inflow of FDI into the CEMAC region played a significant role in promoting the region's trade.

To accommodate different links and characteristics among member states using the threshold model,<sup>2</sup> it is important to identify the impact of the introduction of the common currency on intra-regional trade using the variation within countries. This is undertaken to check if our results are robust with regard to unobserved country-specific heterogeneity; the results are shown in Table 3, including temporal trends. The inclusion of country-specific temporal trends allows for the possibility of different growth paths by member states.

**Table 1** | Threshold effect test (bootstrap = 0 300 300)

| Threshold | RSS  | MSE  | $F_{\text{stat}}$ | Prob   | Crit10  | Crit5   | Crit1   |
|-----------|------|------|-------------------|--------|---------|---------|---------|
| Single    | 1.40 | 7.10 | 7.44              | 0.0733 | 6.3952  | 7.9671  | 10.3223 |
| Double    | 1.34 | 6.77 | 9.48              | 0.1333 | 10.6064 | 13.1333 | 17.4077 |
| Triple    | 1.32 | 6.69 | 2.36              | 0.9033 | 12.5498 | 15.0560 | 25.2339 |

Notes: The bootstrap was used to test the threshold effect for each simulation. We set the bootstrap number to 300 for the double- and triple-threshold models. However, we set 0 for the single-threshold model because there was no need to use the bootstrap method for it again. Source: Author's computation using `xthreg` in Stata. RSS, residual sum of squares.

**Table 2** | Fixed-effects panel data and threshold regression estimates (1980–2013)<sup>a</sup>

|                               | (1)                              | (2)                                   | (3)  |
|-------------------------------|----------------------------------|---------------------------------------|--|
|                               | (Fixed-effects panel regression) | Single threshold: Fixed-effects panel | Single threshold: Fixed-effects panel, with White-corrected SE |
| Variables <sup>b</sup>        | $\text{exp}$                     | $\text{exp}$                          | $\text{exp}$   |
| GDP                           | 0.363*** (0.0492)                | 0.370*** (0.0484)                     | 0.370*** (0.0710)  |
| $\text{gdppc\_c}$             | −0.0968*** (0.0332)              | −0.120*** (0.0334)                    | −0.120*** (0.0272)   |
| $\text{fdi}$                  | 1.370*** (0.129)                 | 1.293*** (0.129)                      | 1.293** (0.379)  |
| $\text{pop}$                  | −0.285 (0.266)                   | −0.371 (0.262)                        | −0.371 (0.498)   |
| $\text{lf}$                   | 0.633 (0.641)                    | 0.792 (0.629)                         | 0.792 (1.283)  |
| $\text{trade\_open}$          | 1.076*** (0.0344)                | 1.089*** (0.0346)                     | 1.089*** (0.0763)  |
| $\text{cem\_CFA}$             | −333.0** (141.0)                 | −677.1*** (213.5)                     | −677.1* (285.0)  |
| Constant                      | −1601*** (245.6)                 | −56,690** (25,082)                    | −56,69 (39,619)  |
| No. of observations           | 231                              | 231                                   | 231  |
| $R$ -squared                  | 0.981                            | 0.982                                 | 0.982  |
| No. of countries              | 6                                | 6                                     | 6  |
| Number of $\text{ctry\_pair}$ | 7                                | 7                                     | 7  |

Notes: Column 1 shows a fixed-effects panel regression, without taking the threshold into account. Columns 2 and 3 show the estimates for a single-threshold model. In column 2 we use the conventional standard error, and in column 3 we apply the White-corrected standard error. <sup>a</sup>We used the `xthreg` STATA command to implement the method by Hansen (1999), in which the bootstrap method is used to test the null hypothesis of no threshold and to fit the fixed-effects panel threshold model. <sup>b</sup>See Section 3.3 for definitions of the variables. Standard Errors (SE) in parentheses. \* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ .

<sup>2</sup>Shown from the results in Table 2.

Table 3 reports the panel regression estimates when year and country fixed effects are taken into account. The results in column 1 show that the adoption of the common currency (cem\_CFA) in 1994 is significantly negative at the 1% level. When the clustered Standard Error (SE) is considered in column 2 of Table 3, the coefficients are still significant, but at the 10% level. The clustered SE is expected to increase the confidence intervals because it allows for correlation between observations (Sarzos, 2012). To check the fit of the model, we apply the natural logarithm of export in column 3. There is a decrease in the standard-error coefficients. The coefficients are still statistically significant at the 1% level with a  $p$ -value of  $-0.528$ . Applying a natural logarithmic transformation of the dependent variable allows for a non-linear relationship between the dependent and independent variables while remaining within the regression framework.

To perform a robustness check, one lag and two leads of the common currency dummies are introduced. Introducing one lag and two leads takes into consideration the possibility of pre-trends in the data (Conti, 2014). This includes any anticipatory effects before the introduction of the common currency, or economic shocks when the currency was instituted, such as the devaluation of the CFA franc in 1994. This is shown in column 4 of Table 3, where the effects are negligible although statistically significant. The lagged value is statistically significant at the 1% level with negligible positive effects.

In column 5, we add other regressors, as in Equation (14), such as GDP, regional and member states' labour force (lf), the net inflow of FDI (fdi), and trade openness (trade\_open). The coefficients are positive and statistically significant at the 1% level.

As an alternative specification, the diff-in-diff method of analysis was applied, where countries in the CEMAC customs union were considered the treatment group and the control group comprised countries that are not members of CEMAC but that are members of ECCAS. The diff-in-diff results in Table 4 show the empirical estimations of Equation (15). Column 1 of Table 4 shows that the coefficient of the 'diff-in-diff' variable is negative and significant at the 1% level, indicating an adverse effect on CEMAC intra-regional trade flow.

**Table 3** | Panel regression results with year and country fixed effects (1980–2013)

|                     | 1                 | 2               | 3                 | 4                    | 5                  |
|---------------------|-------------------|-----------------|-------------------|----------------------|--------------------|
| Variables           | exp               | exp             | ln exp            | ln exp               | exp                |
| cem_CFA             | −8.424*** (2.244) | −8.424* (3.885) | −0.528*** (0.123) | −0.484*** (0.119)    | −360.5*** (138.4)  |
| GDP                 |                   |                 |                   |                      | 0.386*** (0.0195)  |
| gdppc_c             |                   |                 |                   |                      | −0.0783** (0.0359) |
| lf                  |                   |                 |                   |                      | 0.0869*** (0.0307) |
| fdi                 |                   |                 |                   |                      | 0.622*** (0.0787)  |
| trade_open          |                   |                 |                   |                      | 1.129*** (0.0236)  |
| $t$                 | 994.8*** (119.4)  | 994.8* (453.0)  | 0.103*** (0.0221) | 0.0926*** (0.0204)   |                    |
| cem_lag1            |                   |                 |                   | 0.0139*** (0.00340)  |                    |
| cem_lead1           |                   |                 |                   | 0.00268** (0.00102)  |                    |
| cem_lead2           |                   |                 |                   | −0.00881** (0.00289) |                    |
| Constant            | −5.119*** (1.234) | −5.119 (5.170)  | 5.393*** (0.364)  | −9.961 (11.31)       | −4.046*** (285.0)  |
| Observations        | 384               | 384             | 384               | 381                  | 384                |
| R-squared           | 0.229             | 0.229           | 0.477             | 0.478                | 0.992              |
| Number of ctry_pair | 12                | 12              | 12                | 12                   | 12                 |

Notes: Column 1 shows a parsimonious specification, as we only take into account country and year fixed effects. Column 2 shows the estimates with robust clustered standard errors. In column 3, we use the logarithmic, non-linear functional form of exports, and in column 4, we introduce a lag and two leads to take into consideration the possibility of pre-trends in the data. In column 5, the model is re-estimated with other covariates. Standard errors in parentheses. \* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ .

**Table 4** | Difference-in-differences regression results (1980–2013)

|                     | 1                 | 2                  | 3                |
|---------------------|-------------------|--------------------|------------------|
| Variables           | exp               | exp                | exp              |
| .treated            | −                 | 60.06 (285.2)      | 9.837*** (1,745) |
| Time                | 26.919*** (4.709) | 414.4 (272.2)      | −14.73 (1.892)   |
| diff-in-diff        | −7.775*** (2.328) | −49.43 (354.0)     | −5.584** (2,461) |
| GDP                 |                   | 0.0973*** (0.0122) |                  |
| gdppc_c             |                   | −0.121*** (0.0314) |                  |
| lf                  |                   | −0.0285 (0.0200)   |                  |
| fdi                 |                   | 1.222*** (0.0871)  |                  |
| trade_open          |                   | 1.457***           |                  |
| Constant            | 1.675 (3,188)     | 4.254*** (0.210)   | 5.241*** (0.289) |
| Observations        | 384               | 384                | 384              |
| R-squared           | 0.328             | 0.650              | 0.124            |
| Number of ctry_pair | 12                |                    |                  |

Notes: Country and year fixed effects are included in column 1; covariates—GDP, GDP per capita (gdppc\_c), labour force (lf), FDI (fdi), and trade openness—are introduced in column 2. In column 3, we apply kernel propensity score matching to the difference-in-differences method. Standard errors in parentheses. \* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ .

When other covariates are introduced, as shown in column 2 of [Table 4](#), the diff-in-diff coefficient is still negative but insignificant. This suggests that the negative effect appears to vanish when the model is more fully specified.<sup>3</sup> The results in [Table 4](#) are therefore less supportive than those in [Table 3](#).

A typical concern with the diff-in-diff model is that the compositions of the program and intervention groups may change over time and may differ in ways that would affect their trends over time, due to confounding effects. One way to overcome this concern is to apply propensity score matching. According to [Stuart et al. \(2014\)](#), propensity score matching is commonly used to take into account confounding effects due to observed covariates that differ either across groups in the pre-period, or over time due to changes in group composition. Column 3 in [Table 4](#) shows the results from applying kernel propensity score matching to the diff-in-diff model. The results do not change as compared to those of column 1. The effect is still negative and significant at the 5% level.

## 5. CONCLUSION

In this paper, we used the TAR and the diff-in-diff methods to analyse the effects of a common currency on intra-regional trade in the CEMAC regional bloc, taking into account individual fixed effects. We found evidence that the model with a single regime adequately separated policy changes before and after 1994, based on the impact of the CFA franc on the flow of intra-regional trade. In particular, our results suggested that under the fixed-effects model, regional GDP, FDI, and trade openness positively affected intra-regional trade. The effect of the common currency variable was negative and significant in the fixed-effects model, but not significant in the diff-in-diff model when other covariates were added.

We uncovered a turning point after 1994, between the common currency and the flow of CEMAC intra-regional trade, with the likelihood that the post-1994 effect attributable to adopting the single currency was negative or, at best, non-positive. This result is evidence against the claim that common currencies lead to increased intra-regional trade.

Since the CFA franc is pegged to the euro, there is a tendency for it to appreciate nominally against other currencies outside of the CEMAC customs union. This has the potential to hamper the competitiveness of CEMAC-member countries. This currency appreciation effect would thus negate the expected positive impact of the common currency.

## CONFLICTS OF INTEREST

The authors declare they have no conflicts of interest.

## AUTHORS' CONTRIBUTION

The authors contributed equally to the article.

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<sup>3</sup>According to [Schechter \(2017\)](#), adding covariates to a difference-in-differences model reduces confounding bias and sometimes reduces residual variance in the equation.

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