Three Essays on Monetary Union in West Africa

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Thesis submitted to the University of Ottawa
in partial Fulfillment of the requirements for the degree of

Doctor of Philosophy

in

Economics

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Abstract

Chapter 1- *How well-off or worse-off a country can be by joining a currency union in the presence of structural heterogeneity and idiosyncratic shocks? In light of the proposed creation of a currency union for the Economic Community of the West African States (ECOWAS), we develop a three-region DSGE model to explore the question. We divide the ECOWAS into three regions-Nigeria, the existing WAEMU (West-African Economic Monetary Union), and the rest. Considering two monetary regimes (monetary union and monetary independence), we assess the heterogeneity in the responses to country-specific productivity and terms-of-trade shocks in these two regimes, as well as the costs related to the loss of monetary independence. Our results indicate that shocks hitting a given region generate cross-border spillover effects, whose sign and magnitude depend not only on the nature of the disturbance but also on its origin and on the monetary policy regime considered. Moreover, the propagation of shocks across regions is magnified under the monetary union regime. Shocks hitting Nigeria's economy tend to have a more destabilizing effect on the other regions, especially when they are inside the union. Our results also suggest that the proposed monetary union for the ECOWAS region can potentially lead to welfare improvement for all the members, but the magnitude of the welfare gain is relatively small.*

Chapter 2- *In this chapter, we develop a multi-region New-Keynesian Dynamic Stochastic General Equilibrium (DSGE) of the West-African countries to provide a quantitative analysis of intergovernmental fiscal transfers in the context of the proposed creation of a monetary union. We assess the potential role of fiscal transfers in the stabilization of business cycle fluctuations in the projected monetary union in the presence of idiosyncratic shocks. Starting from a baseline scenario with no fiscal transfers among the regions, we analyze the dynamic and welfare impacts of full and partial fiscal equalization schemes with nominal tax revenue sharing within the union. We consider adverse productivity and term-of-trade shocks. Our simulation results suggest that the transfer mechanism is an efficient stabilizing tool. However, the stabilization property of the fiscal transfer system hinges upon the full or partial nature of the compensation system. Moreover, the ability of the transfer system to absorb the negative effects of idiosyncratic shocks depends not only on the type of shock but also on the size of the region directly affected.*

Chapter 3- *We analyze in this chapter the macroeconomics effects of fiscal policy shocks in the Economic Community of West African States (ECOWAS). To that end, we use a Global Vector Autoregression (GVAR) model, which allows us to assess both the within coun-*

try and the cross borders spillover effects of the fiscal shocks. For the dynamic analysis, we consider negative country-specific public spending and revenue shocks affecting Nigeria as well as regional public spending and revenue shocks affecting two groups of countries in the area, namely the West African Economic and Monetary Union (WAEMU) and the Rest of ECOWAS (RECOWAS). We provide evidence of considerable cross-country heterogeneity in fiscal spillovers; for instance, spillovers are high for fiscal shocks affecting Nigeria while the cross-border spillover effects on Nigeria are weak for shocks affecting WAEMU and RECOWAS. Our results also suggest that fiscal policy is very relevant in stimulating real output in each of the ECOWAS countries but limited for the cross-country output stimulation.

Acknowledgment

This Ph.D. process has been a long journey full of up and down moments but guided by God. Without his blessing and grace, this accomplishment would not have been possible, and I am so grateful.

I am also grateful to my professors, colleagues, friends, and family members, whose guidance, encouragement, and support of all kinds have made this dissertation possible.

First and foremost, I would like to express my most profound appreciation and gratitude to my supervisor Yazid Dissou, who has been an incredible mentor to me. I want to appreciate all your intellectual contributions, time, encouragement, funding, and support of all kinds that contributed to making my Ph.D. experience so productive and exciting. I could not have sought a better advisor, as you have been more than a supervisor, a father figure, and a mentor. Thank you for your continuous support; I am sincerely grateful to you.

I would also like to extend my gratitude to my dissertation committee members, Lilia Karnizova, Hashmat Khan, and Nasser Ary Tanimoune, for your time, constructive comments, and feedback throughout my dissertation writing process. Your contributions have significantly contributed to improving the quality of the dissertation. Thank you so much.

My sincere thanks to all my friends and colleagues at the University of Ottawa, who contributed to make this journey full of good memories and excitement. A special thanks to Michela Planatscher for always being available to support or just chatting about life. My wholehearted thank you to my friends Constant and Chimène Adounsa for your encouragement and calls to check on my progress. It is now done!

Finally, to my family, I would never find the right word to thank you for all you have done, your prayers, encouragement, and all kinds of support. To my father - René Adjalala and mother - Madja Hortense, I am forever grateful for all the sacrifices you have made, which made this accomplishment possible. I can only imagine how happy you are now that my dissertation has been completed. I am also grateful to my brother - Pericles, sisters - Lucrece, Dores, Phines, Sophie, and my brother in law - Jean Aguegue, for always being there for me. You have been supportive in many ways, and I am thankful. Lastly, and most of all, I would like to express my warm gratitude to my loving, supportive, encouraging, and patient husband - Gedeon Djissa, whose support during this Ph.D. is so much appreciated. This work is the fruit of your unwavering support, and I am genuinely grateful to you.

Table of content

Abstract ii
Acknowledgment iv
General Introduction x

1 Idiosyncratic Shocks in a Currency Union: Perspectives from the West African Monetary Union with a New-Keynesian Model 1
1.1 Introduction 2
1.2 Related Literature 5
1.3 Stylized facts about ECOWAS countries 7
1.4 Structure of the model 8
1.4.1 Households 9
1.4.2 Firms 15
1.4.3 Price setting 17
1.4.4 Monetary and fiscal policy 18
1.4.5 International price 20
1.4.6 Market clearing conditions and model dynamics 21
1.5 Data, calibration, and simulations 22
1.5.1 Data and calibration 22
1.5.2 Variance decomposition 23
1.5.3 Impulse responses analysis 24
1.6 Welfare analysis 28
1.7 Conclusion 29
Appendix Chapter 1 31

2 Fiscal Transfers in a Currency Union: An analysis of the upcoming West African Monetary Union with a New-Keynesian Model 38
2.1 Introduction 39
2.2 Literature review 43
2.3 Model description 45
2.3.1 Firms 46

2.3.2 Households . . . 48
2.3.3 Common monetary authority . . . 55
2.3.4 Regional fiscal authorities . . . 56
2.3.5 Fiscal equalization . . . 57
2.3.6 International price . . . 58
2.3.7 Market clearing conditions and model dynamics . . . 59
2.4 Data, calibration, and results . . . 60
2.4.1 Data and calibration . . . 60
2.4.2 Business cycle analysis and variance decomposition . . . 61
2.4.3 Impulse response analysis . . . 62
2.5 Welfare analysis . . . 64
2.6 Conclusion . . . 65
Appendix . . . 67

3 Fiscal Policy in the Transition to Monetary Union: A Global VAR Analysis for the West African Countries 75
3.1 Introduction . . . 76
3.2 Literature review . . . 78
3.2.1 Existing literature . . . 79
3.2.2 Fiscal policy in ECOWAS countries . . . 81
3.3 Model description . . . 82
3.3.1 Data . . . 85
3.3.2 Specification and Estimation of the Country-Specific Models . . . 85
3.3.3 Dynamic analysis . . . 88
3.4 Conclusion . . . 92
Appendix . . . 94
General Conclusion . . . 104

List of Tables

1.1 Stylized facts 31
1.2 Correlation of cyclical components 31
1.3 Export shares 32
1.4 Import shares 32
1.5 Weights in regional aggregate data 32
1.6 Calibration of the model parameters 33
1.7 Variance decomposition: Monetary independence (in percentage) 34
1.8 Variance decomposition: Monetary union (in percentage) 34
1.9 Measures of welfare change (% of steady state consumption) 35

2.1 Calibration of model parameters 67
2.2 Standard deviations (Productivity shock from NIGERIA) 67
2.3 Standard deviations (Productivity shock from WAEMU) 68
2.4 Standard deviations (Productivity shock from RECOWAS) 68
2.5 Correlation of selected variables with GDP 68
2.6 Regional cross-correlation of selected aggregate variables 69
2.7 Variance decomposition: Monetary union without federal fiscal arrangement (in percentage) 69
2.8 Variance decomposition: Monetary union with federal fiscal arrangement (in percentage) 70
2.9 Measures of welfare change for productivity shocks (% of steady state consumption) 71
2.10 Measures of welfare change for terms-of-trade shocks (% of steady state consumption) 71

3.1 Public spending and tax revenue (average 2010-2018, % GDP) 94
3.2 Descriptive statistics of selected domestic variables (Average 1980-2018) . . 94
3.3 Contemporaneous effects of foreign variables on their domestic counterparts 95
3.4 VARX* order and number of cointegration relationships in the country-specific models 95

3.5 Unit root test for domestic variables 96
3.6 Unit root test for foreign variables 96
3.7 Weak exogeneity tests of the country-specific foreign variables 97
3.8 Average pair-wise cross-section correlation 97
3.9 Trade weight matrix 98
3.10 Generalized Forecast Error Variance Decomposition: Revenue and spending Nigeria 98
3.11 Generalized Forecast Error Variance Decomposition: Revenue and spending WAEMU 99
3.12 Generalized Forecast Error Variance Decomposition: Revenue and spending RECOWAS 100

List of Figures

1.1 **Comparison of business cycle** 35
1.2 **Effect of tradable productivity shock originating from Nigeria** . . . 35
1.3 **Effect of tradable productivity shock originating from Nigeria (cont.)** 36
1.4 **Effect of tradable productivity shock originating from WAEMU** . . 36
1.5 **Effect of tradable productivity shock originating from WAEMU (cont.)** 36
1.6 **Effect of tradable productivity shock originating from RECOWAS** 36
1.7 **Effect of tradable productivity shock originating from RECOWAS (cont.)** 36
1.8 **Effect of terms of trade shock originating from Nigeria** 36
1.9 **Effect of terms of trade shock originating from Nigeria (cont.)** . . 36
1.10 **Effect of terms of trade shock originating from WAEMU** 36
1.11 **Effect of terms of trade shock originating from WAEMU (cont.)** . 37
1.12 **Effect of terms of trade shock originating from RECOWAS** 37
1.13 **Effect of terms of trade shock originating from RECOWAS (cont.)** 37

2.1 **Effects of a tradable productivity shock originating from Nigeria (part 1)** 72
2.2 **Effects of a tradable productivity shock originating from Nigeria (part 2)** 72
2.3 **Effects of a tradable productivity shock originating from WAEMU (part 1)** 72
2.4 **Effects of a tradable productivity shock originating from WAEMU (part 2)** 73
2.5 **Effects of a tradable productivity shock originating from RECOWAS (part 1)** 73
2.6 **Effects of a tradable productivity shock originating from RECOWAS (part 2)** 73
2.7 **Effects of a terms-of-trade shock originating from Nigeria (part 1)** . . . 73
2.8 **Effects of a terms-of-trade shock originating from Nigeria (part 2)** . . . 73

2.9 **Effects of a terms-of-trade shock originating from WAEMU (part 1)** . . 73
2.10 **Effects of a terms-of-trade shock originating from WAEMU (part 2)** . . 73
2.11 **Effects of a terms-of-trade shock originating from RECOWAS (part 1)** 74
2.12 **Effects of a terms-of-trade shock originating from RECOWAS (part 2)** 74

3.1 **Primary balance and public debt (% GDP)** 101
3.2 **Impulse responses of country-specific negative spending shock affecting Nigeria** 101
3.3 **Impulse responses of country-specific negative spending shock affecting Nigeria (cont.)** 101
3.4 **Impulse responses of country-specific negative spending shock affecting Nigeria (cont.)** 102
3.5 **Impulse responses of country-specific negative tax revenue shock affecting Nigeria** 102
3.6 **Impulse responses of country-specific negative tax revenue shock affecting Nigeria (cont.)** 102
3.7 **Impulse responses of country-specific negative tax revenue shock affecting Nigeria (cont.)** 102
3.8 **Impulse responses of regional negative spending shock affecting WAEMU** 102
3.9 **Impulse responses of regional negative spending shock affecting WAEMU (cont.)** 102
3.10 **Impulse responses of regional negative spending shock affecting WAEMU (cont.)** 102
3.11 **Impulse responses of regional negative tax revenue shock affecting RECOWAS** 103
3.12 **Impulse responses of regional negative tax revenue shock affecting RECOWAS (cont.)** 103
3.13 **Impulse responses of regional negative tax revenue shock affecting RECOWAS (cont.)** 103
3.14 **Impulse responses of regional negative spending shock affecting RECOWAS** 103
3.15 **Impulse responses of regional negative spending shock affecting RECOWAS (cont.)** 103
3.16 **Impulse responses of regional negative spending shock affecting RECOWAS (cont.)** 103

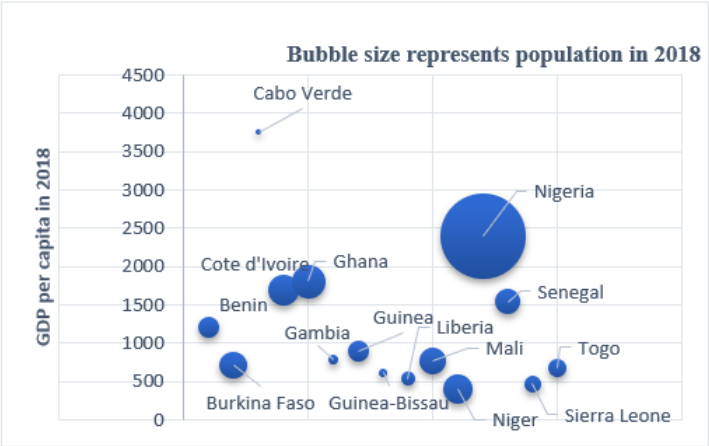
General Introduction

This thesis explores the macroeconomic implications of the project of forming a monetary union in the Economic Community of West African Countries (ECOWAS). The Economic Community of West African Countries (ECOWAS) is a regional institution founded in 1975 to promote cooperation and economic integration in 15 West African countries. The region can broadly be divided into two groups: Eight countries (Benin, Burkina Faso, Cote d'Ivoire, Guinea Bissau, Mali, Niger, Senegal, and Togo) forming the West African Economic and Monetary Union (WAEMU)- the existing monetary union in West Africa that has the CFA franc as a common currency, and the non-WAEMU countries, namely Cape Verde, Ghana, Guinea, The Gambia, Nigeria, Liberia, and Sierra Leone. Since its creation, the main objective of the ECOWAS is to enhance economic and monetary integration in the region. As part of this goal, these countries launched in 2000 a project of creating a region-wide monetary union with a common currency, which will be called "Eco". The deadline for the creation of the union has been missed several times due to the lack of political commitment and the lack of preparation. Still, the project is to be implemented by the end of 2020.

Joining a monetary union can be beneficial for the participating countries since it eliminates transaction costs and exchange rate risks and promotes competition among members because of price comparison and transparency. However, there are also several costs associated with a monetary union, especially the loss of monetary sovereignty, which can be welfare reducing if member countries face asymmetric shocks. The creation of a successful monetary union requires then a thorough assessment of its net benefits, which are traditionally based on the Optimum Currency Area (OCA) theory pioneered by Mundell [1961], [McKinnon, 1963] and [Kenen, 1969]. Their theory suggests that an Optimum Currency Area (OCA) must satisfy four main conditions. Firstly, the existence of an integrated labor market that allows workers to move throughout the union to fill employment gaps. Secondly, the price and wage flexibility and capital mobility are necessary to eliminate regional trade imbalances. Thirdly, the existence of a centralized mechanism for fiscal transfers to countries that are negatively affected by asymmetric shocks. Lastly, participating countries should have similar business cycles to respond efficiently to asymmetric shocks. None of these conditions seems to be verified in the ECOWAS countries, and more, one salient fact about the region is that the member countries are very heterogeneous in size, population, economic structure, political influence, etc. This situation raises relevant concerns among policymakers and researchers about the ability of the ECOWAS countries to form a successful monetary union.

As an example, the Figure below illustrates the fact that ECOWAS is a heterogeneous group

of countries both in terms of population size and economic wealth. Per capita GDP in the region in 2018 ranges from USD 473 (Liberia) to USD 3 760 (Cape Verde) with Nigeria, which is the largest country in the area in terms of population. Mindful of this heterogeneity, they set some convergence criteria as the first step toward the creation of a successful currency union. Those criteria, which include a budget deficit below 3% of GDP, the public debt of no more than 70% of GDP, inflation of 5%, have never been met by all the countries, making the creation of this monetary union more challenging. Thus, creating a successful currency union will require the ECOWAS countries to overcome some critical challenges.



This dissertation, which is presented in the form of three papers, aimed at advancing understanding about these challenges while assessing the effectiveness of this monetary union project. The main objective of the dissertation is to respond to two broad research questions. The first is the propagation mechanism of idiosyncratic shocks in the context of this upcoming monetary union, and the second is the central role fiscal policy should play in the smooth transition and the stabilization of shocks in the union. Regarding the methodology used, two types of macroeconomic models are considered: The Dynamic Stochastic General Equilibrium model (DSGE), which is used in the first two chapters, and the Global Vector Autoregressive model (GVAR), which is used in the last chapter. DSGE models, on the one hand, are built on the microeconomic theoretical foundation of optimizing agents (households and firms). The government and the central bank affect the economy through the implementation of fiscal and monetary policies, and historical data are introduced to fit the model as much as possible to the investigated economies. The GVAR model, on the other hand, provides a global macroeconomic modeling framework that allows the analysis of different shocks and transmission channels across countries. It consists of several individual country Vector Autoregressive model (VAR) models that are stacked together and simultaneously solved into a single multi-country model using weights related to the international linkages between the different countries. For the different analyses, the ECOWAS area is divided

into three blocks, namely NIGERIA-the largest country in the region, the existing West-African Economic Monetary Union (WAEMU) formed by eight French-speaking countries in the area, and the remaining-six English speaking countries which we will refer to as RE-COWAS.

The first chapter of the thesis sheds light on the effectiveness of creating a full ECOWAS currency union in the presence of structural heterogeneity and idiosyncratic shocks. We use a multi-region Dynamic Stochastic General Equilibrium (DSGE) model that features multiple economic agents, multiple sectors with monopolistic competition, nominal and real rigidities, to assess the propagation mechanism of idiosyncratic shocks in the ECOWAS region. The analysis is motivated by the fact that adjustment costs to asymmetric shocks can be high for countries in a monetary union because of the loss of domestic interest rate as an instrument of monetary policy and the loss of nominal exchange rate as a shock absorber. In the model, the ECOWAS area is divided into three blocks, as mentioned previously, and we consider two monetary regimes: a monetary union where the monetary policy is conducted by a common central bank and monetary independence where each country has control over its monetary policy. In this framework, we assess the heterogeneity in the responses to idiosyncratic productivity and terms-of-trade shocks in the two regimes, as well as the costs related to the loss of monetary independence. It follows from the analysis that it is not straightforward to say whether macroeconomic stability would increase or decrease if the ECOWAS countries were to form their monetary union. However, the effects of the shocks affecting the different regions are magnified in the monetary union regime compared to the monetary independence regime. Also, shocks hitting Nigeria's economy tend to have a more destabilizing effect on the other regions, especially when they are inside the union. Our results also suggest that the monetary union for the ECOWAS region will potentially lead to welfare improvement for all the members. The results of this study indicate that additional adjustment mechanisms are needed to compensate, to some extent, the costs endured by the ECOWAS countries in the presence of shocks in order to sustain the monetary union.

The second chapter is built on the conclusion of the first that found that additional adjustment tools to cope with idiosyncratic shocks are needed for success in the proposed monetary union in West Africa. In this chapter, a fiscal transfer mechanism is explored as an adjustment tool to deal with the effects of idiosyncratic shocks in the ECOWAS region. Researchers and policymakers have largely debated over the requirement to complement a monetary union by a fiscal transfer scheme that acts as automatic insurance against asymmetric shocks. Given the stabilizing ability of such transfer in existing federations like the United States, Canada, Switzerland, and Germany, there is a rising interest in implementing

this adjustment mechanism in other monetary unions, especially the European Monetary Union (EMU). Our analysis in this chapter is motivated by the fact that a monetary union subject to asymmetric fluctuations requires a risk-sharing mechanism to stabilize output. Our objective is to describe some characteristics of the transfer system as a shock stabilizer in the upcoming ECOWAS monetary union in the presence of idiosyncratic shocks. We use a multi-region New-Keynesian model, in which we assume that the West African countries are already in a monetary union and share risks through fiscal transfers. The model includes heterogeneous agents; to take into account the occurrence of liquidity constraints among the households and to reflect some realistic economic features of the countries under study. Starting from a baseline scenario with no fiscal transfers among the regions, we analyze the dynamic and welfare impacts of full and partial fiscal equalization schemes with nominal tax revenue sharing within the union in the presence of idiosyncratic productivity and terms-of-trade shocks. The results suggest that the transfer system possesses some relevant stabilization potential—however, its stabilization property hinges upon the full or partial nature of the compensation system. Moreover, the ability of the transfer system to absorb the adverse effects of idiosyncratic shocks depends not only on the type of shock but also on the size of the region directly affected. The optimal design of the transfer, which is a critical aspect to consider, was not taken into account in this analysis.

Finally, in the third chapter, we investigate with a GVAR model the role played by fiscal policy in the dynamics of the main macroeconomic indicators in the ECOWAS countries. This investigation is of high interest since, with the loss of monetary sovereignty in a monetary union, a strong emphasis should be placed on fiscal policy, especially for the adjustment to macroeconomic shocks. The model allows us to assess the international interdependencies and the transmission channels of fiscal shocks across the ECOWAS countries. The estimated fiscal shocks are country-specific negative shocks affecting tax revenue and public spending in Nigeria, WAEMU, and the RECOWAS. It follows from our results that there is little fiscal interlinkage between the ECOWAS countries; this suggests that a centralized fiscal tool would be necessary to absorb shocks in the region if they were to form their monetary union. Also, we provide evidence of considerable heterogeneity in fiscal spillovers across the region. For instance, the spillovers are high for fiscal shocks affecting Nigeria, while the cross-border spillover effects of shocks affecting WAEMU and RECOWAS in Nigeria are small. Trade is the main channel through which the shock is transmitted to the other countries.

Overall, this dissertation provides strong technical evidence that the ECOWAS monetary union project, though relevant and potentially feasible, presents some critical challenges related to the management of shocks and the necessity to implement appropriate adjustment mechanisms for the success of this union.

Chapter 1

Idiosyncratic Shocks in a Currency Union: Perspectives from the West African Monetary Union with a New-Keynesian Model

1.1 Introduction

This paper develops a multi-region dynamic stochastic general equilibrium (DSGE) model to analyze the transmission mechanisms and the welfare implications of asymmetric shocks in the proposed monetary union of West Africa. The creation of the European Monetary Union in 1999 has rekindled the debates over the opportunity to create currency unions in several regions around the world. A currency union is an agreement between two or more countries to share a common currency or peg their cross borders exchange rates. As broadly discussed in the literature, they are several benefits for a country to join a currency union (see Zika and UK [2005], Madhur [2004], Emerson [1992], etc., for an extensive review). The adoption of a single currency eliminates or reduces all the costs associated with the exchange rates (transaction costs, exchange-rate volatility, etc.), and as a consequence, it facilitates price comparison and harmonization (Rogoff [1996]). While the potential benefits can make a currency union attractive, several costs are also associated with joining a monetary union. The main ones are the loss of national monetary sovereignty, the loss of control over the monetary policy, and the loss of the central bank as a lender of last resort. These losses can have several macroeconomic implications, especially when countries face asymmetric shocks that can destabilize their national economies. That issue refers to the theory on optimal currency area pioneered by Mundell [1961], McKinnon [1963], and Kenen [1969].

Given the relative success of the European Monetary Union, there has been a renewed and growing interest in creating a monetary union in other regions of the world, including the Economic Community of West African States (ECOWAS [1]). The ECOWAS was established in 1975 to promote cooperation and economic integration in fifteen West African countries. These countries have already formed a customs union and are planning to move their economic integration a step forward by adopting a single currency. They have indicated their intention to speed up the monetary component of the integration by adopting a single currency by the year 2020.

The idea to impose a single currency for the whole region has raised legitimate questions about the ability of these countries to create a currency union. In light of the theory of optimal currency area, the synchronicity of their business cycles has been scrutinized. Several papers have assessed the characteristics of the shocks that affect the different economies within the West-African region. In line with Bayoumi, Eichengreen and Eichengreen [1994], several studies have focused their analyses on the prevalence of asymmetric shocks in the region to assess the suitability of forming a currency area. For example, using different econometric models, several papers like (Fielding and Shields [2001], Masson and Pattillo

[1] ECOWAS comprises 15 countries which are Benin, Burkina, Cap-Verde, Ivory Coast, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo

[2002], Bénassy-Quéré and Coupet [2005], Buigut and Valev [2005], van den Boogaerde and Tsangarides [2005], Qureshi and Tsangarides [2006]) have analyzed, the shocks that affected several African countries. They concluded that ECOWAS members are not only highly heterogeneous in their production structure, but they also face asymmetric shocks. The latter could exacerbate the challenges of forming a monetary union. Houssa [2008] examined output growth shocks in West Africa using a dynamic factor model. He concluded that most of the countries in the region are mainly affected by negatively correlated supply shocks that will make adjustment difficult if they were to form a monetary union.

In reality, few studies on the viability of the formation of a monetary union in West Africa have examined the propagation mechanisms of those asymmetric shocks within the region. They have mostly focused on analyzing the characteristics of the shocks faced by the different economies within the region when monetary policy instrument is the only stabilizing tool available for the region. They have not assessed the extent to which these shocks are transmitted within the ECOWAS region and the reactions to them, both in the originating countries and in the rest of the region. From a policy perspective, the outcomes of these shocks are more important than their characteristics alone.

One notable exception is Carton et al. [2010], who developed a two-region DSGE model of the West African economy to analyze the optimal exchange rate regime in the presence of terms-of-trade shocks. The two regions consist of, on the one hand, Nigeria, and on the other hand, the eight Francophone countries that already share a common currency in the context of the existing West-African Monetary Union (WAEMU). The other seven countries of West Africa have been ignored in their analysis. In their model, each region produces a tradable good, which is exclusively exported to the rest of the world, and nontradable goods, which are consumed locally or traded within the region. In addition, their model accounts for oil production, which is modeled as an endowment. In the presence of an oil price shock in Nigeria, the authors find among several results that a fixed exchange rate regime is the best regime for WAEMU, while Nigeria would be better off with a flexible exchange rate regime with fixed money supply.

In this paper, we contribute to the debate on the viability of the monetary union in West Africa by filling the above-mentioned gap and offering a richer model of the region. We analyze how asymmetric shocks are propagated within these ECOWAS economies, and how well-off or worse-off are these economies in the face of these shocks when they are outside or inside a currency union. In general, asymmetric shocks are perturbations that affect a set of regions differently: they can be grouped into two categories. The first category comprises country-specific shocks, i.e., idiosyncratic shocks that affect just one country and hence, are

asymmetric in their impacts. The second category consists of shocks that are common to several regions but have different impacts, i.e., symmetric in origin but asymmetric in impact (see Emerson [1992]). In this study, we consider the first type of asymmetric shocks. We will, therefore, use interchangeably the terms asymmetric shocks and idiosyncratic shocks in the rest of the paper.

We build upon the recent literature on the New Open Economy Macroeconomics (NOEM) literature, pioneered by Obstfeld and Rogoff [2000], and recent contributions in the literature on New-Keynesian DSGE models in the context of closed and open economies, like Smets and Wouters [2003], Benigno [2004], Beetsma and Jensen [2005] and Gali and Monacelli [2005]. In contrast to some multi-country DSGE models found in the literature that consists of only two regions (Home and Foreign), which are usually of the same size, the present model features the disaggregation of the ECOWAS into three regions. The three economies considered are Nigeria, the WAEMU [2] countries, and the Rest of ECOWAS countries (henceforth RECOWAS [3]). These economies share not only economic links among themselves, but also have individual relations with the rest of the world. Hence, we do account for all economies of the region, and account for the reality, which suggests that these economies differ in size and have individual links with the rest of the world. In addition to differentiating the economies, we also consider two productive sectors, which are the tradable and nontradable sectors. Due to data limitation, the informal sector is not explicitly taken into consideration in this analysis. We consider both nominal and real frictions in the model by introducing nominal price rigidity à-la Calvo [1983] and investment adjustment costs in line with Gertler, Sala and Trigari [2008].

We used the model to examine two types of country-specific shocks affecting each of the three economies of the region: total factor productivity shocks and terms-of-trade shocks. Mendoza [1995] has shown that international price shocks account for nearly half of the volatility of production in African countries. In the same vein, a more recent paper by Fernández, Schmitt-Grohé and Uribe [2017] suggests that world shocks to commodity prices explain a significant proportion of business cycles in individual economies in the developing world.

We assume that monetary policy is the only stabilization tool available in the proposed union. Hence, we ignore alternative potential stabilization instruments that can be used in a currency union, such as fiscal transfers. We analyze the propagation mechanisms and adjustments to the shocks in two regimes: monetary independence and monetary union.

[2]WAEMU is a monetary union formed by eight french speaking countries in West Africa that are member of the CFA zone: Benin, Burkina-Faso, Cote d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, Togo

[3]We call RECOWAS the group of countries represented by Ghana, Liberia, Guinea, Sierra Leone, Gambia

The following insights emerge from our results :

(i) First, in both monetary union and monetary independence, the adverse productivity shock causes a decline in real variables such as output, consumption, investment in the domestic economies, and cause an increase in the price level. In the monetary independence regime, the central bank responds to the inflationary pressure by tightening the nominal interest rate. Moreover, the magnitude of the effect of the shock on the main variables in each region is higher in monetary union compared to monetary independence.

(ii) Second, regardless of their origins, productivity shock has a negative spillover effect on the other regions in both regimes. Exceptions are observed in WAEMU and RECOWAS where productivity shocks affecting them are positively transmitted to the other two regions. In both regimes, terms-of-trade shocks are also negatively transmitted across the three regions.

(iii) Third, in the monetary union regime, the shocks originating from WAEMU and RECOWAS produce a lower response in the union-wide interest rate compared to shocks originating from Nigeria.

(iv) Fourth, shocks originating from Nigeria tend to have a more significant effect on WAEMU and RECOWAS, while the effects are relatively mitigated for shocks coming from WAEMU and RECOWAS.

(vi) Finally, the ECOWAS currency union will lead to welfare improvement for all the three regions, but the magnitude of the welfare gain is relatively small.

The remainder of the paper is organized as follows. In the next section, we review the related literature; the third section presents some relevant stylized facts about the ECOWAS countries. Section 4 describes the basic structure of the model. In section 5, we first discuss the data along with the model calibration, and we analyze the simulation results in the sixth section. The last section concludes.

1.2 Related Literature

Following the seminal paper of Mundell [1961] on the theory of optimal currency area (OCA), a vast and expanding literature on the feasibility of a monetary union in the presence of asymmetric shock has emerged. They mostly used the European monetary union or the United States as reference cases (Bayoumi, Eichengreen and Eichengreen [1994], Eichengreen

et al. [1996], Krugman [1993] Dehesa and Krugman [1993] and Feldstein [1997]). Still, another strand of literature has started to analyze the feasibility of monetary unions in other parts of the world, and mostly in Africa. Asongu, Nwachukwu and Tchamyou [2017] provide an excellent review of the studies on various proposed monetary unions in Africa, including the ECOWAS monetary union project.

Regarding the ECOWAS region, the key insights from their review are the mixed conclusions reached by the various studies on the viability of a monetary union in the region. Some authors offered a very pessimistic view about the project, while others provided a more nuanced assessment of the creation of this monetary union. The pessimists raised concerns over the viability of the formation of a monetary union among the West African countries in light of the heterogeneity of the shocks in the absence of the exchange rate as a policy instrument. In what follows, we provide a brief review of the main findings in key papers related to the topic.

Batté et al. [2009] used a two-region DSGE model to discuss the type of monetary regime that could be adopted by the ECOWAS monetary union. They found that in the presence of commodity price shocks, the most stabilizing regime for Nigeria is fixed money supply, while WAEMU will be better off with a fixed exchange rate regime. Coulibaly and Gnimassoun [2013] used panel cointegration techniques to analyze the optimality of the ECOWAS monetary union. They focus on the similarities and dissimilarities of ECOWAS member states in terms of economic competitiveness. Their results suggest that the WAEMU area is the most homogeneous group of countries in the Central and Western parts of Africa. They concluded that Ghana, Gambia, and, to a lesser extent, Sierra Leone, could join the WAEMU countries to form a larger union.

Debrun, Masson and Pattillo [2005] analyzed the incentives to join a monetary union in West Africa and found that asymmetric shocks are less important than government spending propensities in the evaluation of the net gains and losses from potential monetary unions. They developed a theoretical model with monetary and fiscal policy interactions to analyze the net gains or losses of the proposed ECOWAS monetary union. They found that the union is not compatible with most WAEMU countries because of the high fiscal distortions in Nigeria and because of its terms-of-trade that are negatively correlated with those of the other ECOWAS countries. However, according to their numerical results, the ECOWAS monetary union would be profitable for all members if Nigeria's financing needs were equal to the average of the other countries. Moreover, if the union was created gradually, i.e., the nonWAEMU members were added individually to the existing monetary union (WAEMU), there would also be a welfare improvement for all member countries.

Tsangarides and Qureshi [2008] used cluster analysis to assess the suitability and the sus-

tainability of the monetary unification project in West Africa. Their results suggested that the ECOWAS monetary union was not relevant because of the dissimilarities in the economic characteristics of the candidate countries. Masson and Pattillo [2002] assessed the viability of a monetary union in West Africa and discussed the various institutional options for implementing monetary cooperation. They concluded that instead of trying to meet a very short deadline for the creation of a monetary union, the countries of the region should invest their energies into reinforcing convergence on low inflation, sustainable fiscal policies and structural policies necessary for strong growth.

Fielding and Shields [2001] developed a VAR model to assess the impact of output and inflation shocks on the members of two existing monetary unions of the CFA Franc Zone. They found a significant and positive correlation of inflation shocks in all countries of the Franc CFA zone and concluded that as long as inflation mattered for policy and the policy response to inflation shocks was immediate, appurtenance to the zone was not a cost. In contrast, they found that output shocks were not correlated among all members of the area. They partitioned the zone into two subsets of high and low correlations of output shocks. The two subsets did not coincide with the existing boundaries of the two monetary unions of the Franc CFA Zone. Accordingly, they suggested a redefinition of the boundaries of the two monetary unions.

1.3 Stylized facts about ECOWAS countries

Reducing the divergence among economic indicators such as GDP growth, inflation, or public debt is a key factor in the success of a currency union. We explore in this section the characteristic of the economies under study in order to have a broad view of their structure. Tables 1.1-1.4 present some stylized business cycles facts for the three blocks of regions. The variables presented cover the period 1981-2012. The figures in table 1.1 do not seem to suggest any convergence in economic growth rates among the ECOWAS countries. The tables also show that Nigeria, Cote d'Ivoire, Ghana, and Senegal are the dominant countries of the region with the largest GDP per capita.

In order to deepen the analysis, we compute three measures of business cycles in order to see how they are synchronized between the regions. These measures are the fluctuation in the annual growth rate of real GDP, five years rolling correlation coefficient for the GDP growth rate (Figure 1.1), and the correlation coefficient of the cyclical component of GDP [4] (Table 1.2). It appears from Panels (a) and (b) of Figure 1.1 that significant business cycle divergences emerge between Nigeria, WAEMU, and RECOWAS. We can also observe in

[4]We extract the cyclical components using the Hodrick-Prescott (HP) filter

Panel (b) that, on average, Nigeria is more correlated with WAEMU than with RECOWAS. A more detailed analysis (Table 1.2) shows that the growth cycles of the ECOWAS countries are not significantly synchronized. We can distinguish on one side a group of countries formed by Mali, Niger, Senegal, Cote d'Ivoire, and Senegal, which have a positive and significant correlation. The synchronization of those countries can be explained by the fact that they are members of a currency union (WAEMU). On the other side, Nigeria is not synchronized with any other countries in the area. While this result is not significant, it shows the particularity of Nigeria, which is an oil exporter, while all the other countries are mainly specialized in the agricultural sector. Moreover, in the RECOWAS region, we have some countries such as Guinea, Liberia, and Ghana that have positive and non-significant growth cycle while the economic cycles are negative and non-significant for Gambia and Ghana. Overall, the analysis suggests that business cycles are generally not synchronized among the countries except for the WAEMU block, countries, where a positive correlation has been observed among their cyclical components.

Moreover, in terms of production structure, the export diversification indices of the ECOWAS countries (second column of Table 1.1) are very low. In reality, some countries in the region depend mainly on a small number of raw agricultural products (cocoa, coffee, cotton, etc.) and minerals (oil, cobalt, etc.). Finally, intra-regional trade is low in West African countries (see Table 1.3 and 1.4) with about 7.5% (3.5%) of Nigeria's total exports (imports) that are traded with the ECOWAS region while WAEMU and RECOWAS trade respectively 16.3% and 10.8%, of their total exports with the rest of the region.

1.4 Structure of the model

The structure of the model inherits many characteristics of a large class of New-Keynesian small open economy Dynamic Stochastic General Equilibrium model like the one developed by Smets and Wouters [2003], Christiano, Eichenbaum and Evans [2005], Gali and Monacelli [2005]. The main difference of the present model from those in the above-mentioned references is its a multi-region, multi-sector model characteristics. In our model, the world is composed of three regions, namely Nigeria (N), WAEMU (W), the rest of ECOWAS countries (RE), and the rest of the world. In each region, there are four types of agents (households, firms, the government, and the monetary authority). Households provide labor and rent capital to firms. They derive utility from the consumption of goods and from leisure. The productive sector in each region is disaggregated into two sectors that produce the tradable and the nontradable goods. The nontradable goods of a given region are consumed only locally. They are not traded within the union. The tradable good produced in a given region is consumed locally or exported to the other regions of the union, or to the rest of the world.

We assume that the traded goods produced within the union are regionally differentiated, in the sense that they are imperfect substitutes. Production takes place in two steps in each sector. In the first step, a continuum of intermediate goods producers combines labor and capital to produce intermediate goods. The latter are combined by the final good producers to generate outputs that are used for consumption, investment, or exports. Labor and physical capital are mobile between sectors in a given region and are immobile across regions.
In the spirit of the New-Keynesian models, we introduce product price rigidity in the model to account for the non-neutrality of money. As in Smets and Wouters [2003], we assume intermediate goods producers are monopolistic competitors that set nominal prices using Calvo (1983) style staggered contracts. The reliance on monopolistic competition is required to justify the existence of price stickiness. Final good producers operate under perfect competition. We also introduce real frictions in the model in the form of adjustment cost to investment. The government of each region exerts fiscal authority over its region only.

The monetary authority conducts the monetary policy by setting the nominal interest rate in response to changes in inflation, output, and the exchange rate. We consider two monetary regimes, a monetary independence regime in which the independent monetary authority in each region determines its monetary policy, and a monetary union regime in which a common central bank manages the monetary policy for the entire union.

1.4.1 Households

Intertemporal optimization

The representative infinitely living household has preference for consumption $C_{i,t}$, receives disutility from labor $N_{i,t}$, and has access to the financial market where he can buy and sell domestic and foreign bonds. His lifetime utility function is weakly separable in the index of consumption and hours of labor supply. In particular, it is increasing and concave in consumption and decreasing in labor; it is given by:

$$U(C_{i,t}, N_{i,t}) = E_0 \sum_{t=0}^{\infty} \beta_i^t \left(\frac{C_{it}^{1-\sigma}}{1-\sigma_i} - \psi \frac{N_{i,t}^{1+\phi_i}}{1+\phi_i} \right) \tag{1.1}$$

Where $i = \{N, W, RE\}$ is the index used for regions $\beta \in (0,1)$ is the discount factor, σ is the risk aversion parameter, $N_{i,t}$ is the total number of hours worked, ϕ is the inverse of elasticity of labor supply, and ψ is the marginal dis-utility of participating in the labor market. E_0 is the conditional expectation based on the information set available in period 0.
The household supplies labor services $N_{i,t}$ to the firms with the nominal wage $W_{i,t}$ as compensation and rents capital $K_{i,t}$, and receives the rental rate $R_{k_{i,t}}$. He also receives the

profits, $\Pi_{i,t}$ distributed by the monopolistic firms, and pays a lump-sum tax $T_{i,t}$ to the government. We assume that foreign bonds are denominated in the foreign currency so that $e_{i,t}$ denotes the bilateral exchange rate between the region i and the rest of the world. The budget constraint is then given by:

$$\begin{aligned} &P_{C_{i,t}}C_{i,t} + B_{i,t+1} + e_{i,t}B^*_{i,t+1} + P_{I_{i,t}}I_{i,t} = W_{i,t}N_{i,t} + R^k_{i,t}K_{i,t} + \\ &B_{i,t}(1+r_{i,t}) + e_{i,t}B^*_{i,t}(1+r^*_{i,t}) + \Pi_{i,t} - T_{i,t} \end{aligned} \tag{1.2}$$

where $P_{C_{i,t}}$ and $P_{I_{i,t}}$ are respectively the aggregate prices index for region i's private consumption and investment. $B_{i,t}$ and $B^*_{i,t}$ are respectively the households holding of domestic and foreign bonds that provide, respectively, the real returns $r_{i,t}$ and $r^*_{i,t}$.
The prospect that the agent plays a Ponzi game and accumulate an infinite amount of assets is ruled out by imposing the following transversality condition:

$$\lim_{t\to\infty} E_0 \left(\frac{B_{i,t}}{1+r_{i,t}} \right) = 0 \tag{1.3}$$

$$\lim_{t\to\infty} E_0 \left(\frac{B^*_{i,t}}{1+r^*_{i,t}} \right) = 0 \tag{1.4}$$

The physical capital stock is owned by the representative household; it evolves according to the following motion law:

$$K_{i,t+1} = (1-\delta_i)K_{i,t} + I_{i,t}\left[1 - S\left(\frac{I_{i,t}}{I_{i,t-1}}\right)\right] \tag{1.5}$$

where δ_i denotes the physical rate of depreciation and $S\left(\frac{I_{i,t}}{I_{i,t-1}}\right) = \frac{\kappa_i}{2}\left(\frac{I_{i,t}}{I_{i,t-1}} - 1\right)^2$ is the investment adjustment costs.
We derive the optimality conditions for the representative household with respect to consumption, labor supply, capital, domestic and foreign bond holdings:

$$C_{i,t}^{-\sigma_i} = \lambda_{i,t} P_{C_{i,t}} \tag{1.6}$$

$$\psi_i N_{i,t}^{\phi_i} = \lambda_{i,t} W_{i,t} \tag{1.7}$$

$$\lambda_{i,t} = \beta E_t \lambda_{i,t+1}(1 + r_{i,t+1}) \tag{1.8}$$

$$\lambda_{i,t} = \beta E_t \lambda_{i,t+1} \frac{e_{i,t+1}}{e_{i,t}}(1 + r^*_{i,t+1}) \tag{1.9}$$

$$Q_{i,t} = \frac{\mu_{i,t}}{\lambda_{i,t}} \tag{1.10}$$

$$Q_{i,t} = \beta E_t \left[\left(\frac{\lambda_{i,t+1}}{\lambda_{i,t}} \right) (1 - \delta_i) Q_{i,t+1)} + R^k_{i,t+1} \right] \tag{1.11}$$

$$P_{I_{i,t}} = Q_{i,t} - Q_{i,t} S\left(\frac{I_{i,t}}{I_{i,t-1}} \right) - Q_{i,t} S'\left(\frac{I_{i,t}}{I_{i,t-1}} \right) \frac{I_{i,t}}{I_{i,t-1}} + \beta E_t \frac{\lambda_{i,t+1}}{\lambda_{i,t}} Q_{t+1} S'\left(\frac{I_{i,t+1}}{I_{i,t}} \right) \left(\frac{I_{i,t}}{I_{i,t-1}} \right)^2 \tag{1.12}$$

$\lambda_{i,t}$ and $\mu_{i,t}$ are the Lagrange multipliers related to, respectively, the budget constraint and the capital accumulation equation. Equations (2.23)-(2.28) summarize the inter-temporal decisions of households in the goods and assets markets. $\lambda_{i,t}$ represents the shadow price i.e., the maximum price that the consumer is willing to pay to have an extra unit of consumption in the future. This shadow price is equal to the marginal utility of aggregate consumption in Equation (2.23). $\mu_{i,t}$ is the marginal benefit in terms of the utility of one unit of investment. Equation (2.24) describes the labor supply resulting from the optimal choice of the agent between consumption and leisure. Equations (2.25) and (2.26) suggest that the marginal utility of consuming one more unit today is equal to the expected present value of the additional future consumption, obtained by investing in domestic and foreign bonds. Equation (2.27) represents the marginal Tobin's Q and states that the marginal cost of investment is equal to the marginal benefit and finally (2.28) indicates that the value of currently installed capital depends on its future expected value, taking into account the depreciation rate and the expected rate of return.

Intratemporal optimization

Consumption $C_{i,t}$ is a composite good consisting of tradable $C^T_{i,t}$), and nontradable goods $C^N_{i,t}$ that can be given by the following CES aggregator.

$$C_{i,t} = \left((1 - \omega_i) C_{i,t}^{T\,\frac{\eta_i - 1}{\eta_i}} + \omega_i C_{i,t}^{N\,\frac{\eta_i - 1}{\eta}} \right)^{\frac{\eta_i}{\eta_i - 1}} \tag{1.13}$$

where the parameter η is the intra-temporal elasticity of substitution in consumption between tradable and nontradable goods. The higher is this latter, and the more substitutable the goods are. The parameter ω is the weight of the nontradable bundle in aggregate consumption. The objective of the representative household is to minimize the expenditures on the tradable and nontradable goods while maintaining a certain target level of the consumption good. This optimization problem yields the following demand functions for the tradable and nontradable goods:

$$C_{i,t}^{T} = (1-\omega_i)\left(\frac{P_{C_{i,t}}^{T}}{P_{C_{i,t}}}\right)^{-\eta_i} C_{i,t} \tag{1.14}$$

$$C_{i,t}^{N} = \omega_i\left(\frac{P_{i,t}^{N}}{P_{C_{i,t}}}\right)^{-\eta_i} C_{i,t} \tag{1.15}$$

where $P_{C_{i,t}}$, $P_{C_{i,t}}^{T}$, $P_{i,t}^{N}$ are respectively the consumer price index and the price index of tradable and nontradable goods. The overall consumer price index is given by:

$$P_{C_{i,t}} = \left((1-\omega_i)P_{C_{i,t}}^{T^{1-\eta_i}} + \omega_i P_{i,t}^{N^{1-\eta_i}}\right)^{\frac{1}{1-\eta_i}} \tag{1.16}$$

The tradable goods are either domestically produced or imported from abroad. The consumption of tradable is a combination of domestically produced tradable good ($C_{i,t}^{TH}$), and of the aggregate of imported goods ($C_{i,t}^{TF}$)

$$C_{i,t}^{T} = \left((1-\alpha_i)C_{i,t}^{TH^{\frac{\epsilon_i-1}{\epsilon_i}}} + \alpha_i C_{i,t}^{TF^{\frac{\epsilon_i-1}{\epsilon_i}}}\right)^{\frac{\epsilon_i}{\epsilon_i-1}} \tag{1.17}$$

α_i is the trade share parameter and i the elasticity of substitution between domestically produced goods and the composite of foreign goods. Like in the previous case for total consumption, the intratemporal optimization problem leads to the following demand functions for locally produced and the composite of imported tradable goods:

$$C_{i,t}^{TH} = (1-\alpha_i)\left(\frac{P_{i,t}^{TH}}{P_{C_{i,t}}^{T}}\right)^{-\epsilon_i} C_{i,t}^{T} \tag{1.18}$$

$$C_{i,t}^{TF} = \alpha_i\left(\frac{P_{C_{i,t}}^{TF}}{P_{C_{i,t}}^{T}}\right)^{-\epsilon_i} C_{i,t}^{T} \tag{1.19}$$

where $P_{i,t}^{TH}$;and $P_{i,t}^{TF}$ are, respectively, the prices of domestically produced tradable and imported goods. The tradable goods price index is given by:

$$P_{C_{i,t}}^{T} = \left((1-\alpha_i)P_{C_{i,t}}^{TF^{1-\epsilon_i}} + \alpha_i P_{i,t}^{TH^{1-\epsilon_i}}\right)^{\frac{1}{1-\epsilon_i}} \tag{1.20}$$

The composite of imported tradable goods from abroad is made of goods produced in the union or imported from the rest of the world. It is a CES aggregate of imported good from the rest of the world $C_{i,t}^{TROW}$, and the index of consumption goods produced by the other members of the union:

$$C_{i,t}^{TF} = \left((1-\tau_i)C_{i,t}^{TROW^{\frac{\upsilon_i-1}{\upsilon_i}}} + \tau_i C_{i,t}^{TU^{\frac{\upsilon_i-1}{\upsilon_i}}}\right)^{\frac{\upsilon_i}{\upsilon_i-1}} \tag{1.21}$$

The parameter υ_i is the elasticity of substitution between goods produced in the union, and those produced in the rest of the world. The parameter τ_i measures the weight of the tradable bundle produced by the other members of the union.
The solution to the problem of finding the optimal allocation of expenditures on goods imported from the rest of the world and the index of goods produced by the other members of the union gives the following demand functions:

$$C_{i,t}^{TROW} = (1-\tau_i)\left(e_{i,t}\frac{PM_{i,t}^{ROW}}{P_{C_{i,t}}^{TF}}\right)^{-\upsilon_i} C_{i,t}^{TF} \tag{1.22}$$

$$C_{i,t}^{TU} = \tau_i\left(\frac{P_{C_{i,t}}^{TU}}{P_{C_{i,t}}^{TF}}\right)^{-\upsilon_i} C_{i,t}^{TF} \tag{1.23}$$

where $P_{C_{i,t}}^{TU}$ and $PM_{i,t}^{ROW}$, $P_{C_{i,t}}^{TF}$ are the price indices of tradable from the union, the rest of the world, and the overall foreign tradable price. The index price of the foreign tradable goods is given by:

$$P_{C_{i,t}}^{TF} = \left(\tau_i P_{C_{i,t}}^{TU^{1-\upsilon_i}} + (1-\tau_i)PM_{i,t}^{ROW^{1-\upsilon_i}}\right)^{\frac{1}{1-\upsilon_i}} \tag{1.24}$$

Finally, the index of goods produced by the other members of the union ($C_{i,t}^{TU}$) is a CES composite of goods imported from other countries l ($l \neq i$).

$$C_{i,t}^{TU} = \left[\sum_l (\Omega_{il})C_{i,t}^{Tl^{\frac{\Gamma_i-1}{\Gamma_i}}}\right]^{\frac{\Gamma_i}{\Gamma_i-1}} \tag{1.25}$$

Γ_i is the elasticity of substitution between goods produced in the foreign countries, and Ω_{il} measures the share of the tradable imported bundle produced in the region l. The household allocates expenditure according to the demand functions for goods imported from each l :

$$C_{i,t}^{Tl} = \Omega_i \left(\frac{P_{C_{i,t}}^{Tl}}{P_{C_{i,t}}^{TU}} \right)^{-\Gamma_i} C_{i,t}^{TU} \tag{1.26}$$

The price index for the goods produced in the union is given by:

$$P_{C_{i,t}}^{TU} = \left[\sum_j \Omega_{il} e_{i,t} (P_{C_{l,t}}^{Tl})^{1-\Gamma_i} \right]^{\frac{1}{1-\Gamma_i}} \tag{1.27}$$

We use the same procedure for the investment good. We assume that the demand for investment $I_{i,t}$ is a CES of a basket of nontradable and tradable investment goods. This latter is a composite of home and foreign tradable investment goods, which in turn is a composite of imported investment goods from the union and from the rest of the world:

$$I_{i,t} = \left((1-\iota_i) I_{i,t}^{T \frac{\zeta_i - 1}{\zeta_i}} + \iota_i I_{i,t}^{N \frac{\zeta_i - 1}{\zeta_i}} \right)^{\frac{\zeta_i}{\zeta_i - 1}} \tag{1.28}$$

$$I_{i,t}^{T} = \left((1-\nu_i) I_{i,t}^{TF \frac{\chi_i - 1}{\chi_i}} + \nu_i I_{i,t}^{TH \frac{\chi_i - 1}{\chi_i}} \right)^{\frac{\chi_i}{\chi_i - 1}} \tag{1.29}$$

$$I_{i,t}^{TF} = \left((1-\psi_i) I_{i,t}^{TU \frac{\mu_i - 1}{\mu_i}} + \psi_i I_{i,t}^{TROW \frac{\mu_i - 1}{\mu_i}} \right)^{\frac{\mu_i}{\mu_i - 1}} \tag{1.30}$$

$$I_{i,t}^{TU} = \left[\sum_j (\kappa_{ij}) I_{i,t}^{Tj \frac{\xi_i - 1}{\xi_i}} \right]^{\frac{\xi_i}{\xi_i - 1}} \tag{1.31}$$

The optimal demand function of investment goods and the associated prices indexes are defined by:

$$I_{i,t}^{T} = (1-\iota_i)\left(\frac{P_{I_{i,t}}^{T}}{P_{I_{i,t}}}\right)^{-\zeta_i} I_{it} \tag{1.32}$$

$$I_{i,t}^{N} = \iota_i\left(\frac{P_{i,t}^{N}}{P_{I_{i,t}}}\right)^{-\zeta_i} I_{it} \tag{1.33}$$

$$I_{i,t}^{TF} = (1-\nu_i)\left(\frac{P_{I_{i,t}}^{TF}}{P_{I_{i,t}}^{T}}\right)^{-\chi_i} I_{i,t}^{T} \tag{1.34}$$

$$I_{i,t}^{TH} = \nu_i\left(\frac{P_{i,t}^{TH}}{P_{I_{i,t}}^{T}}\right)^{-\chi_i} I_{i,t}^{T} \tag{1.35}$$

$$I_{i,t}^{TU} = (1-\psi_i)\left(\frac{P_{I_{i,t}}^{TU}}{P_{I_{i,t}}^{TF}}\right)^{-\mu_i} I_{i,t}^{TF} \tag{1.36}$$

$$I_{i,t}^{TROW} = \psi_i\left(\frac{e_{i,t}PM_{i,t}^{ROW}}{P_{I_{i,t}}^{TF}}\right)^{-\mu_i} I_{i,t}^{TF} \tag{1.37}$$

$$I_{i,t}^{Tj} = \kappa_i\left(\frac{P_{I_{i,t}}^{Tj}}{P_{I_{i,t}}^{TU}}\right)^{-\xi_i} I_{i,t}^{TU} \tag{1.38}$$

$$P_{I_{i,t}} = \left((1-\iota_i)P_{I_{i,t}}^{T^{1-\zeta_i}} + \iota_i P_{i,t}^{N^{1-\zeta_i}}\right)^{\frac{1}{1-\zeta_i}} \tag{1.39}$$

$$P_{I_{i,t}}^{T} = \left((1-\nu_i)P_{I_{i,t}}^{TF^{1-\chi_i}} + \nu_i P_{i,t}^{TH^{1-\chi}}\right)^{\frac{1}{1-\epsilon_i}} \tag{1.40}$$

$$P_{I_{i,t}}^{TF} = \left((1-\psi_i)P_{I_{i,t}}^{TU^{1-\upsilon_i}} + \psi_i e_{i,t}PM_{i,t}^{ROW^{1-\upsilon_i}}\right)^{\frac{1}{1-\upsilon_i}} \tag{1.41}$$

$$P_{I_{i,t}}^{TU} = \left[\sum_j \kappa_{ij} e_{i,t}(P_{I_{j,t}}^{Tj})^{1-\xi_i}\right]^{\frac{1}{1-\xi_i}} \tag{1.42}$$

1.4.2 Firms

On the production side, we assume that there are two types of firms so that the production takes place in two steps. In the first steps, a continuum of intermediate goods producers (wholesale firm) indexed by $j \in [0,1]$ produces a differentiated good by combining capital and labor, taking the rental rate of capital and the wage rate as given. They operate in a monopolistically competitive environment where they set prices in a staggered manner following Calvo [1983]. Second, the final goods producers (retailers) combine the varieties produced by the intermediate firms to produce a homogeneous final good and sell it to buyers in a perfectly competitive market. For the sake of simplicity, we assume that capital and

labor are homogeneous; they are freely mobile between the two sectors in a given region.

Domestic intermediate goods producers

In each economy $i \in (N, W, RE)$, there is a continuum of intermediate goods-producing firms j, which produces a differentiated good $Y_t(j)$. They use the following Cobb-Douglas production function that exhibits a constant-returns-to-scale technology in both inputs:

$$Y^s_{i,t}(j) = A^s_{i,t} K^s_{i,t}(j)^{\alpha^s_i} N^s_{i,t}(j)^{1-\alpha^s_i} \tag{1.43}$$

with $s = \{\text{Domestic Tradable (TH)}, \text{Nontradable (N)}\}$, $A_{i,t}$ is a region-specific factor productivity shock that follow an exogenous AR(1) process.

$$log(A^s_{i,t}) = log(A^s_{i,ss}) + z^s_{a_{i,t}} \tag{1.44}$$

$$z^s_{a_{i,t}} = \rho^s_{a_i} z^s_{a_{i,t-1}} + \epsilon^s_{a_{i,t}} \tag{1.45}$$

where $\epsilon^s_{a_{i,t}}$ is a serially uncorrelated shock with zero mean and standard deviation σ_{a_i}.
The intermediate goods firms take the price level $W_{i,t}$, and $R^k_{i,t}$ as given, and minimize their production cost under the technology constraints to find the optimal demand for factor uses. The cost minimization problem is then giving by:

$$\underset{K^s_{i,t}, N^s_{i,t}}{\text{Min}} \quad W_{i,t} N^s_{i,t} + R^k_{i,t} K^s_{i,t} \tag{1.46}$$

$$\text{subject to} \quad Y^s_{i,t} = A^s_{i,t} K^{s\alpha^s_i}_{i,t} N^{s1-\alpha^s_i}_{i,t} \tag{1.47}$$

From the first-order conditions, we get the expression for the marginal cost of firms producing domestic tradable and nontradable goods:

$$mc^s_{i,t} = \frac{W_{i,t}}{1-\alpha^s_i}^{1-\alpha^s_i} \frac{R^k_{i,t}}{\alpha^s_i}^{\alpha^s_i} \frac{1}{A^s_{i,t}} \tag{1.48}$$

The equation (2.6) states that at the optimum, the marginal cost depends negatively on technology and positively on the nominal wage and the rental rate of capital.

Final good producers

The final goods producers use all varieties $j \in (0, 1)$ of intermediate goods as inputs to produce the final good $Y_{i,t}$ using a Dixit-Stiglitz production function (Dixit and Stiglitz

[1977]). They operate in a perfectly competitive market and face the following problem:

$$\underset{y^s_{i,t}(j)}{\text{Max}} \quad p^s_{i,t}y^s_{i,t} - \int_0^1 p^s_{i,t}(j)y^s_{i,t}(j)dj \tag{1.49}$$

$$\text{subject to} \quad y^s_{i,t} = \left[\int_0^1 y^s_{i,t}(j)^{\frac{\epsilon^p_i - 1}{\epsilon^p_i}} dj\right]^{\frac{\epsilon^p_i}{\epsilon^p_i - 1}} \tag{1.50}$$

The input demand function associated to this problem can be written as follow:

$$y^s_{i,t}(j) = \left(\frac{P^s_{i,t}(j)}{P^s_{i,t}}\right)^{-\epsilon^p_i} Y^s_{i,t} \tag{1.51}$$

The price of the final good is:

$$P^s_{i,t} = \left(\int_0^1 {P^s_{i,t}}^{1-\epsilon^p_i}(j)dj\right)^{\frac{1}{1-\epsilon^p_i}} \tag{1.52}$$

1.4.3 Price setting

Final goods prices are perfectly flexible, whereas those of the intermediate goods are sticky. Following Gali and Monacelli [2005], we assume that the prices of the differentiated goods are set in a staggered style à la Calvo [1983]. This suggests the presence of nominal rigidity in the model. According to Calvo, firms receive in each period a signal indicating whether they can review their prices. Hence, at a given time, a random fraction of firms that are called the forward-looking firms can adjust their prices optimally while the remaining backward-looking firms set their prices based on rules of thumb using historical information about the price level.

Let's suppose that in every period t, firms producing tradable and nontradable goods are allowed to reset their price with probability $1 - \theta^s_i$ in a forward-looking manner. The proportion of firms that do not receive any price updating signal index their price to the past observed inflation rate while the remaining proportion can adjust their price level and choose the optimal prices $p^*_{i,t}$. The average price level in the economy is then giving by:

$$P^s_{i,t} = \left[(1-\theta_i){P^s_{i,t}}^{*(1-\epsilon^p_i)} + \theta_i {P^s_{i,t-1}}^{1-\epsilon^p_i}\right]^{\frac{1}{1-\epsilon^p_i}} \tag{1.53}$$

Firms that are allowed to re-optimize their price in period t choose the optimal price by maximizing the present discounted value of their future profits subject to the demand

function.

$$\underset{p^{s*}_{i,t}(j)}{\text{Max}} \qquad \Pi = E_t \sum_{k=0}^{\infty} \theta_i^k \Delta_{k,t+k} \left[\frac{p^{s*}_{i,t}(j)}{P^s_{i,t+k}} y^s_{i,t+k}(j) - \frac{mc^s_{i,t+k}}{P^s_{i,t+k}} y^s_{i,t+k}(j) \right] \tag{1.54}$$

$$\text{subject to} \qquad Y^s_{i,t+k}(j) = \left[\frac{p^{s*}_{i,t}(j)}{P^s_{i,t+k}} \right]^{-\epsilon} y^s_{i,t+k} \tag{1.55}$$

where $\Delta_{k,t+k}$ is the stochastic discount factor.
From the first-order condition of the profit maximization problem and by assuming that all firms choose the same price level, we obtain the following expression for the optimal price level:

$$P^{s*}_{i,t} = \frac{\epsilon^p_i}{\epsilon^p_i - 1} E_t \frac{\sum_{k=0}^{\infty} \theta_i^k \Delta_{k,t+s} \frac{mc^s_{i,t+k}}{1-\epsilon^p_i} y_{i,t+k}}{\sum_{k=0}^{\infty} \theta_i^k \Delta_{k,t+s} \frac{y^s_{i,t+k}}{p^{s(1-\epsilon)}_{i,t+k}}} \tag{1.56}$$

The equation (2.14) shows that firms maximize their expected future profits by choosing an optimal price that is equal to a constant markup over a discounted stream of expected future nominal marginal cost. Finally, after some manipulation, the expression of the New-Keynesian Phillips curve can be derived:

$$\pi^s_{i,t} = \beta E_{i,t} \pi^s_{i,t+1} + \lambda^s_i mc^s_{i,t} \tag{1.57}$$

$$\lambda^s_i = \frac{(1-\beta\theta^s_i)(1-\theta^s_i)}{\theta^s_i} \tag{1.58}$$

The equation (2.17) suggests that current inflation rates for the domestic tradable and non-tradable goods are individually determined by that the expected value of future inflation rates and their marginal cost.

1.4.4 Monetary and fiscal policy

We consider two types of monetary regimes in the model: monetary union and monetary independence. By following existing papers in the DSGE literature (Justiniano and Preston [2010]; Smets and Wouters [2007]), we approximate the monetary policy using the Taylor-type rule.

Policy under monetary independence and monetary union

To reflect the monetary policy framework under an independent monetary regime, we assume that the central Bank in each block of countries conducts monetary policy by managing the short-term nominal interest rate $R_{i,t}$ using the Taylor rule. They adjust their interest rate in response to the deviation of inflation, output, and exchange rate from their respective targets.

$$\frac{R_{i,t}}{R_{ss,i}} = \left(\frac{R_{i,t-1}}{R_{ss,i}}\right)^{\gamma_i^r} \left[\left(\frac{Y_{i,t}}{Y_{ss,i}}\right)^{\gamma_i^y} \left(\frac{\Pi_{i,t}}{\Pi_{ss,i}}\right)^{\gamma_i^\pi} \left(\frac{e_{i,t}}{e_{ss,i}}\right)^{\gamma_i^e}\right]^{1-\gamma_i^r} \epsilon_{i,t}^m \tag{1.59}$$

where γ_i^r is the degree of interest rate smoothing, γ^π, γ^y, and γ^e are respectively, the relative weights on inflation, output, and exchange rate. The error term $\epsilon_{i,t}^m$ is a monetary policy shock. $R_{ss,i}$ is the steady-state nominal interest rate. Total output $Y_{i,t}$ in the region i is defined such that :

$$P_{i,t}Y_{i,t} = P_{i,t}^{TH}Y_{i,t}^{TH} + P_{i,t}^{N}Y_{i,t}^{N} \tag{1.60}$$

$$P_{i,t} = P_{i,t}^{TH^{w_i}}P_{i,t}^{N^{1-w_i}} \tag{1.61}$$

Where w_i the relative weight of the tradable sector in the aggregate output of region i.
For the monetary union regime, we assume that monetary authorities care equally about the members of the union. Moreover, they are not concerned with the dispersion of inflation and output across the union. They rather seek to stabilize aggregate inflation and aggregate output. In particular, we consider an interest rate rule where the common central bank responds to deviations of output, inflation, and changes in the exchange rate for the whole union:

$$\frac{R_t^U}{R_{ss}^U} = \left(\frac{R_{t-1}^U}{R_{ss}^U}\right)^{\gamma^r} \left(\left(\frac{Y_t^U}{Y_{ss}^U}\right)^{\gamma^y} \left(\frac{\Pi_t^U}{\Pi_{ss}^U}\right)^{\gamma^\pi} \left(\frac{e_t^U}{e_{ss}^U}\right)^{\gamma^e} \epsilon_t^m\right)^{1-\gamma^r} \tag{1.62}$$

$$P_t^U Y_t^U = \sum_i P_{i,t}Y_{i,t} \tag{1.63}$$

$$P_t^U = \prod_i P_{i,t}^{w_i^p} \tag{1.64}$$

$$\Pi_t^U = \frac{P_t^U}{P_{t-1}^U} \tag{1.65}$$

where P_t^U is the aggregate GDP deflator in the union and is represented by the geometric mean of the regional level GDP deflators , Π_t^U is the union-wide inflation. Y_t^U is the aggregate

GDP of the union and is the sum of the goods produced in each region. The relative weight w_i^p, and $w_i^\pi \in [0,1]$ are calculated on the basis of the participation of the region i in, respectively the aggregate output and consumption of the union:

$$w_i^p = \frac{Y_{i,t}}{\sum_i Y_{i,t}} \tag{1.66}$$

$$w_i^\pi = \frac{c_{i,t}}{\sum_i c_{i,t}} \tag{1.67}$$

Government budget constraint and current account balance

Regarding fiscal policy, in each region, the government consumes goods and levies a lump-sum tax on the income of the representative household. It finances any shortfall between its revenue and its spending by issuing new bonds. We assume that government spending is only on nontradable goods and is governed by an exogenous stochastic process. The government faces a period-by-period budget constraint that suggests that the sum of its spending on goods, the repayments of maturing bonds, and of their interest payments must be equal to the sum of the lump-sum tax and the newly issued bonds. The government period budget constraint is defined by:

$$P_{i,t}^N G_{i,t} + R_{i,t} B_{i,t} = T_{i,t} + B_{i,t+1} \tag{1.68}$$

The government expenditures $G_{i,t}$ are fixed:

$$log(G_{i,t}) = log(G_{i,ss}) \tag{1.69}$$

where $G_{i,ss}$ is the government spending at steady state.
Finally, by combining the household's budget constraint, the government budget constraint, and the expression of the pure profit of the firms, we obtain the following current account balance that describes the evolution of the economy's net foreign assets:

$$e_t B_{i,t+1}^* = e_{i,t} B_{i,t}^* R_{i,t}^* + P_{i,t}^{TH} EX_{i,t} - P_{i,t}^{TF} C_{i,t}^{TF} \tag{1.70}$$

1.4.5 International price

The ECOWAS regions considered in this model are small compared to the rest of the world. Each of them considers the world interest rate as given. We assume the rest of the

world interest rate $r^*_{i,t}$ is a constant:

$$log(r^*_{i,t}) = log(r^*_{i,ss}) \tag{1.71}$$

where $r^*_{i,ss}$ is the world interest rate at steady state.
We define the bilateral terms-of-trade between each region and the rest of the world by:

$$TOT_{i,t} = \frac{PX^{ROW}_{i,t}}{PM^{ROW}_{i,t}} \tag{1.72}$$

Each region is a price-taker vis-a-vis the rest of the world markets, and hence, the export and import prices from the rest of the world are exogenous.

$$log(PX^{ROW}_{i,t}) = log(PX^{ROW}_{i,ss}) + z^{px}_{i,t} \tag{1.73}$$
$$z^{px}_{i,t} = \rho^{px}_i z^{px}_{i,t-1} + \epsilon^{px}_{i,t} \tag{1.74}$$
$$log(PM^{ROW}_{i,t}) = log(PM^{ROW}_{i,ss}) + z^{pm}_{i,t} \tag{1.75}$$
$$z^{pm}_{i,t} = \rho^{pm}_i z^{pm}_{i,t-1} + \epsilon^{pm}_{i,t} \tag{1.76}$$

1.4.6 Market clearing conditions and model dynamics

We end the model description with the specification of the market-clearing conditions. In equilibrium, all markets must clear in each region. The goods market equilibrium conditions require production to be equal to aggregate demand in each region. In the domestic tradable sector, goods produced are consumed by households, invested or sold abroad:

$$Y^{TH}_{i,t} = C^{TH}_{i,t} + I^{TH}_{i,t} + EX^{ROW}_{i,t} + \sum_j EX^j_{i,t} \tag{1.77}$$

where $EX^{ROW}_{i,t}$, and $EX^j_{i,t}$ represent respectively the exports of the region i to the rest of the world and to the other countries of the model.

$$EX^{ROW}_{i,t} = \tau \left(\frac{PX^{ROW}_{i,t}}{P^{TH}_{i,t}} \right)^{-\upsilon} Y^{ROW}_{i,t} \tag{1.78}$$
$$EX^j_{i,t} = C^{Ti}_{j,t} + I^{Ti}_{j,t} \tag{1.79}$$

where the output level for the rest of the world is assumed to be fixed:

$$log(y^{ROW}_{i,t}) = log(y^{ROW}_{i,ss}) \tag{1.80}$$

where $y_{i,ss}^{ROW}$ is the output of the rest of the world at steady state.
Similarly, the market-clearing condition in the nontradable sector imply that, in each region, the nontradable good is either consumed, invested, or purchased by the government:

$$Y_{i,t}^{N} = C_{i,t}^{N} + I_{i,t}^{N} + G_{i,t} \tag{1.81}$$

In the factor markets (labor and capital), the wage rate and the rental rate of capital must adjust to clear the markets.

$$K_{i,t} = \int_0^1 K_{i,t}^{TH} + \int_0^1 K_{i,t}^{N} \tag{1.82}$$

$$N_{i,t} = \int_0^1 N_{i,t}^{TH} + \int_0^1 N_{i,t}^{N} \tag{1.83}$$

The dynamics of the model is represented by the intertemporal decision in the goods and asset market (2.23)-(2.28), the intratemporal consumption decision (2.37)-(2.42) and investment decision (2.55)-(2.60), the sectoral production function (2.1), the real marginal cost (2.6), the sectoral Phillips curves (2.17), the equations for the monetary policy (1.59)-(2.69), the government budget constraint and the current account balance (2.76) and(1.70), and the equilibrium conditions (2.88)-(2.92).

1.5 Data, calibration, and simulations

This section discusses the data used in the model, the calibration of the parameters, and the numerical strategy used to find the solutions. As in many studies, the calibration exercise consists to either borrow the parameters from the literature on the economies of similar structure and/or estimate them from time-series data for the economies studied. In this study, we calibrate the parameters using both the existing literature and time-series estimation. We choose the parameters to be consistent with the assumptions of previous work in similar countries. For simplicity, the elasticity parameters in the three regions are assumed to be identical. Still, the weights in the utility, production functions, and trade relationships are not identical. The latter have been calibrated to match the moments observed in the data. The model dynamics is analyzed by focusing on the variance decomposition and impulse responses. We analyze the impact of idiosyncratic disturbances on the real side of the economy in each of the three regions.

1.5.1 Data and calibration

We obtain national accounts data on GDP, consumption investment, and labour supply from the World Bank (World Development Indicators, WDI), while trade data come from UN COMTRADE and CEPII database. Output in the tradable sector is measured by total real production in manufacturing sectors and primary industries (agriculture, fishing, forestry, and mining). The output of nontradable includes output from the construction, transportation, storage, public service, finance, and real estate industries. The tradable sectors account for 61%, 51%, and 55% of GDP in Nigeria, respectively, WAEMU and the rest of ECOWAS. This is consistent with the standard value used in the literature for low-income countries (Lombardo and Ravenna [2012] and Kose and Riezman [2001], etc.). The average shares of consumption in output are 68%, 73%, and 77% for, respectively, Nigeria, WAEMU, and RECOWAS, while the average shares of investment in output are 13%, 16%, and 21% for respectively the same regions. We assume the steady-state value of the world interest rate is 0.04, which is consistent with the rate faced by African countries in international markets. This suggests a calibrated value of discount factor β, which is equal to 0.96. Following Ostry and Reinhart [1992], we set the risk aversion parameter σ_i to 2.61. This value is computed using a panel of developing countries. We assume that the elasticity of substitution between tradable and non-tradable consumption and investment is 0.9, while the elasticity of substitution of tradable goods between regions is 1.5. The values of the latter two parameters are identical to the ones used by Dagher, Gottschalk and Portillo [2012] in their study on Ghana. Regarding the capital depreciation rate, δ, we assigned a value of 0.07, which is commonly used in the literature. We set the value of the Calvo parameter, θ, to 0.8. The coefficient of output and inflation in the Taylor rule are respectively set to 0.8, 1.5, Which means that the central bank gives higher weight to inflation targeting compared to output targeting. As Nigeria and the RECOWAS do not follow a fixed-exchange rate policy, we set the value of their parameter describing the reaction of the nominal interest rate to the exchange rate in the Taylor rule to 0.8. In contrast, the value of that parameter has to be larger in the case of the WAEMU region, which follows a fixed-exchange-rate regime. We used 1.7 for that parameter for the WAEMU region. Finally, we set the persistence and standard deviation of the region-specific technology and terms-of-trade shocks to 0.75 and 0.01, respectively (Babilla [2015]). All the calibrated parameters are in Table 2.1

1.5.2 Variance decomposition

We evaluate the dynamic properties of the model by discussing the variance decomposition i.e., the shocks that drive the behavior of the main variables. Tables 1.7 and 1.8 present the contribution of each shock, namely the tradable productivity shock and the terms-of-

trade shock, to the variability of the selected variables for each block of countries. We can observe that in the monetary independence regime, a large share of real output fluctuations in all three regions is attributed to domestic productivity, and terms-of-trade shocks, which explain more than 90 percent of the volatility of output, while the fraction of variance for each variable explained by shocks affecting the other regions is always negligible: shocks from the partner regions explain less than 1% percent of the variability in output. Similar results are observed for consumption, investment, inflation and, labour supply with a large contribution of domestic shocks to their variability. In contrast, in the monetary union regime, we can observe a more significant cross-country contribution of the shocks to the variability of the different variables considered. For example, productivity and terms-of-trade shocks originating from WAEMU and RECOWAS explain respectively about 2% and 21% of fluctuations of output in Nigeria. Furthermore, in the monetary union regime, productivity shock originating from Nigeria is the main driver of variations in output, consumption, investment, inflation, and labor supply in the three regions. Finally, it is worth mentioning that in both regimes, each of the variables is primarily driven by productivity shocks. These results suggest that the international transmission of shocks in the ECOWAS region is relatively small in the monetary independence regime compared to the monetary union regime.

1.5.3 Impulse responses analysis

In this section, we analyze the impact of country-specific productivity and terms-of-trade shocks on the three regions. For both shocks, we implemented a 1% standard deviation fall in their steady-state values. We considered orthogonalized innovations to shocks in the sense that we implemented each shock in a single region at the time; we did not assume any regional correlation among the shocks. Despite their idiosyncratic nature, those shocks have spillover and heterogeneous effects within the union. In our discussions, we highlight the transmissions of these shocks across regions. For the sake of simplicity, in our discussions, we denote "home region", the region where the shock originates and the "partner regions", the two other regions in the model. For example, if the source of the shock is Nigeria (home region), WAEMU and RECOWAS will be referred to as partner regions. For each shock, we report in Figures 2.2-2.12 the impulse-response functions [5] in both monetary union (red line) and monetary independence (blue dashed line) regimes. All the IRFs represent a percentage deviation of the variables from their steady-state.

[5]The IRFs are displayed in a two Y-axis (the left axis is for the independent monetary policy regime and the right axis is for the monetary union)

Tradable productivity shock

Propagation mechanisms in the monetary independence regime

Let us start by considering the impact of a temporary one-standard negative deviation of productivity in the tradable sector in the home region (Nigeria, for instance). Figures 2.2-2.6 displays impulse responses of selected variables in the home region and the partner regions.

As expected, the negative productivity shock leads to a fall in the output of tradable goods in Nigeria in the regime with monetary independence. As a result of the fall in the returns to primary factors, households' income and wealth decrease, and consequently, there is a fall in aggregate consumption in Nigeria. Moreover, the negative impact of the shock on wealth combined with the decline in the marginal productivity of capital leads to a drop in total investment in the home region. Besides, as productivity falls, households have to increase their labor supply in this economy characterized by nominal price rigidity. It is worth noticing that the fall in productivity in Nigeria does not affect its tradable sector alone; it also has a negative impact on its nontradable sector because of the negative impact on consumption and investment induced by the fall in household wealth. Moreover, the fall in consumption and investment in Nigeria triggers a reduction in the demand for foreign goods, including imports from its partner regions. Total Nigerian imports, including its two components (imports from the union and imports from the rest of the world), decrease following the negative productivity shock.

The increase in the marginal cost of production in Nigeria induced by the decline in productivity in the tradable sector leads to an increase in inflation. In the monetary independence regime, the initial response of the Nigerian central bank to the inflationary pressure is to hike the nominal interest rate. Still, because of the temporary nature of the productivity shock, the inflation rate and the interest rate decreases accordingly. Given the adjustment of prices in the tradable sector in the home region, the real exchange rate depreciates in Nigeria to keep the competitiveness of the economy. It follows that total Nigerian exports are affected by two effects: the negative scale effects induced by the fall in output of the tradable sector, and the positive effect of the depreciation of the exchange rate. The impulse response functions suggest that the positive effect dominates the scale effect; total exports increase in the Nigerian region as a consequence of the negative productivity shock. Still, total Nigerian exports comprise its exports to the union and its exports to the rest of the world; the impulse response functions suggest that Nigerian exports to the union fall while its exports to the rest of the world increase. The latter result is consistent with the adjustments that occur in the partner regions, which experience a negative impact on their wealth

induced by the reduction in the demand for their goods by the home region.
Before elaborating on the transmission mechanisms of the shock in the home region to the rest of the union, it is important to note that we obtained the same qualitative results in each of the other two regions as in the case of Nigeria for negative productivity shocks to the tradable sector that occur in their regions. In what follows, we discuss in the regime of monetary independence the propagation mechanisms to the partners' regions of the negative productivity shock to the tradable sector in the home economy.
As discussed above, the productivity shock has some negative effects on demand and supply in the home region in addition to depreciating its nominal exchange rate. Recall that the shock led to a fall in household wealth in the home region, hence on their demand for foreign goods. The propagation mechanisms of the shock to the other regions occur mainly through trade links. The magnitudes of the impacts depend on the one hand on the extent of the trade links between Nigeria and each of its partners, and on the other hand, on the relative sizes of Nigeria and its partner regions in the union. The larger the share of home region's imports from a partner region in the latter's total exports, the more significant will be the impact of the reduction in home region's imports on the economy of the partner region. In the same vein, the larger the share of Nigeria's exports to a region in the latter's total imports, the more significant will be the impact of the productivity shock in Nigeria on that economy. Finally, the larger the size of the home region, the larger is the impact of the shock on the partner regions.
The impulse responses presented in Figure 2.2 suggest that the spillover effects of a shock in Nigeria on its partners are different from those of the shocks on their economies on Nigeria. While the shock in Nigeria has a negative impact on tradable output in both regions with a larger impact in WAEMU compared to RECOWAS, Nigeria benefits from a negative shock that affects the other regions with an expansion of its tradable sector. As an illustration, tradable output increases in Nigeria following a negative shock to productivity in the WAEMU since following the shock WAEMU economy becomes less productive than Nigeria for a given period, and its home varieties become relatively expensive compared to the partner region (the competitiveness channel). The trade impacts in both partner regions trigger an adjustment of the exchange rate in these economies. The latter depreciates in the WAEMU, while it appreciates in the RECOWAS.

Propagation mechanisms in the monetary union regime

Let's now consider the effect of the negative tradable productivity shock in the regime of monetary union. As in the monetary independence regime, this shock depresses both

demand and supply as it implies an increase in the marginal cost of firms that suffer a deterioration of their production capacity. By looking at Figures 2.2-2.6 (red lines), we can see that regardless of the origin of the shock, there is a negative co-movement of the main real variables: decline in output, consumption, investment, and labour supply. The decline in productivity also leads to an increase in the price level. We observe that all these negative effects are amplified under the monetary union regime compared to the monetary independence regime since adjustment costs are higher in monetary union because of the loss of exchange rate and interest rate as automatic shocks absorbers. Also, at the union level, the interest rate increases following the negative productivity shock and generate a higher reduction in consumption compared to the monetary independence regime. The decrease in investments and consumption generates a lower demand for imports, which explains the transmission of the shock across regions (aggregate demand channel).

The transmission of the shock shows that negative productivity shock in one region is always negatively transmitted to the other regions because of the increase in the union-wide interest rate, which hurts all the members of the union. As an illustration, a negative impact on productivity in Nigeria leads to an increase in the union-wide interest rate, which reduces wealth in the entire union. The tightening of the monetary policy results in a higher cost of borrowing, and consequently, households decrease their consumption, and firms decrease their production and labor demand. Also, the effect of the shock on the union-wide interest rate is higher for shocks originating from Nigeria compared to productivity shock originating from WAEMU and RECOWAS. The reason for this is that because of the relative size of Nigeria in the union, a negative shock on productivity in Nigeria has a more important impact on the common interest rate and the common exchange rate in comparison to the case the shock originates from the other regions. Moreover, regardless of the source of the productivity shock, the different variables are more sensitive to the shocks in the monetary union regime compared to the regime of monetary independence.

Terms of trade shock

Propagation mechanisms in monetary independence regime

We now assess the macroeconomic responses of West African economies to external price shocks, i.e., the impact of a one standard deviation decline in the export price of the rest of the world (ROW), which implies that the home economy is less competitive relative to the ROW. Figures 2.8- 2.12 display the response of the main variables.
Regardless of the source of the shock, we have identical responses on most variables in the

three home regions. The negative terms-of-trade shock results in lower exports to the rest of the world, higher imports and lower output of the index of tradable goods. As resources move from the tradable sector to the nontradable sector, output initially rises in the latter. This rise is short-lived because of the negative wealth effect of the terms-of-trade shock, which induces a fall in demand for nontradable goods. As a consequence, total output falls following the negative shock to the world export prices. The decrease in the demand for nontradable goods results in a fall in their prices that drives down the consumer price index. The central bank reacts to the fall in the inflation rate by decreasing nominal interest rates. As expected, the shock leads to a depreciation of the nominal exchange rate in each region. As in the previous experiment, a shock on the terms-of-trade originating from Nigeria has a significant effect on the other partner regions. As indicated in Figures 2.8, output, consumption, and investment fall in the partner regions when Nigeria experiences a negative terms-of-trade shock. This negative impact occurs mainly through the reduction in the demand for Nigerian imports coming from its partner regions. In addition, the depreciation of the nominal exchange rate in Nigeria induced by the shock improves the competitiveness of its exports to the other regions. In contrast, a negative shock to the terms-of-trade in the other regions has barely an effect on the Nigerian economy, because of the size effect, and also because of the low weights of the other regions in its total exports and total imports.

Propagation mechanisms in monetary union regime

Regarding the negative terms-of-trade shock in the monetary union setting, it causes a decline in output consumption and investment in all three regions and a hike in domestic inflation. The shock always leads to a negative effect on the economy of the partner regions since it causes an increase in the union-wide interest, which leads to a decline in consumption and investment in the three regions. Also, there is a drop in export within the union. The larger cross-border effect is associated with shock coming from Nigeria. Recall that Nigeria produces a large share of the union's output, and hence, when the shock originates from Nigeria, the negative effect on its economy has a larger spillover on the whole region. In contrast, terms-of-trade shock in WAEMU and RECOWAS have a negligible effect on Nigeria. Overall the results show that, in the context of monetary union, the decline in the price of export of the ROW in one region leads the other country to be worse off because of the increase in the union-wide interest rate and the drop in intra-regional trade.

1.6 Welfare analysis

We evaluate in this section the benefits/cost of joining the ECOWAS currency union through a welfare analysis. Following Schmitt-Grohé and Uribe [2004] and Kim et al. [2008]. We compute a utility base welfare by using the second-order approximation of the utility function. In particular, the welfare measure used is the unconditional expectation of the lifetime utility function of households.
The second-order Taylor approximation of the utility around the steady-state is:

$$EU(C_{i,t}, N_{i,t}) = U(C_i, N_i) + C_i^{1-\sigma_i} E(\tilde{C}_{i,t}) + \psi_i N_i^{1+\phi} E(\tilde{N}_{i,t}) - \frac{1}{2}\sigma_i C_i^{1-\sigma_i} var(\tilde{C}_{i,t}) - \frac{1}{2}\psi_i \phi N_i^{1+\phi} var(\tilde{N}_{i,t}) \tag{1.84}$$

Where $\tilde{X}_{i,t} = (\tilde{C}_{i,t}, \tilde{N}_{i,t})$ is the deviation of $X_{i,t}$ from its steady-state value. and $var(\tilde{X}_{i,t})$ is the variance of $X_{i,t}$

Considering the monetary independence regime as the benchmark scenario, the unconditional welfare gain or loss ϖ^{total} from changing regime is represented by the percentage deviation of consumption from its benchmark level considering each source of shock at a time.

$$U^{MU}((1 + \varpi_i^{total})C_i, N_i) = EU^{MI}(C_{i,t}, N_{i,t}) \tag{1.85}$$

If $\varpi^{total} > 0$, then the households are better off under monetary union compared to monetary independence. The unconditional welfare can be decomposed into two components: the change in consumption due to the effect of the shock on the mean of the variables ϖ^{mean} and the effect of the shock on the variance of the variables ϖ^{var} (see Kollmann [2002] and Bergin, Shin and Tchakarov [2007]). Hence the total welfare cost is given by:

$$\varpi_i^{total} = \varpi_i^{mean} + \varpi_i^{var} \tag{1.86}$$

Table 1.9 shows the welfare loss or gain when the three regions move from the state of monetary independence regime to monetary union. It reports the change in consumption relative to the steady-state level for the three regions that would be needed to have the same utility under both regimes. The result shows that the ECOWAS currency union will lead to welfare improvement for all the regions, but the magnitude of the welfare gain is relatively small and vary depending on the type and the origin of shocks. For instance, when the source of the productivity shock is Nigeria or WAEMU, Nigeria has the lowest welfare gain while RECOWAS has the highest welfare gain.

1.7 Conclusion

This paper contributes to the literature on currency union by examining the transmission mechanism of idiosyncratic shocks in countries sharing the same currency. More specifically, we investigate the mechanism of propagation of country-specific shocks in the projected monetary union for the Economic Community of West African States (ECOWAS) and their welfare implications. For that purpose, we develop a multi-region, multi-sector New-Keynesian model with nominal and real rigidity, which is calibrated using data from the ECOWAS area divided into three regions, namely Nigeria, the existing West African Economic Monetary Union (WAEMU), and the rest (RECOWAS). The dynamics of the model is assessed through country-specific productivity and terms-of-trade shocks considering two monetary regimes: monetary independence and monetary union.

Overall, the main take away from this analysis is that the patterns of the main macroeconomic variables in response to both productivity and terms-of-trade shock depend on the monetary regimes, and the response is also different in magnitude. In particular, the monetary union regime amplifies the negative effects induced by the productivity shock both within and across regions. In the regime where we have an independent monetary policy, productivity reduction in one region is not always negatively transmitted to the other regions, while in the case of a monetary union, regardless of the origin of the shock, it is negatively transmitted to the partners' regions. Also, the magnitude of the negative effect is higher in monetary union compared to monetary independence. For the terms-of-trade shock, the response of aggregate output is relatively similar in all monetary policy regimes with a decline in total output. Some differences are observed in the sectoral output responses. The shock is also negatively transmitted across regions. Moreover, there is a heterogeneity in response to shocks depending on their origin, and the shocks are transmitted across regions through two main channels: the aggregate demand channel and the competitiveness channel. We also find that the transmission of shocks originating from Nigeria is stronger under both monetary regimes showing that ECOWAS countries are more vulnerable to shocks affecting Nigeria.

From a welfare perspective, the creation of the ECOWAS monetary union will lead to welfare improvement for all the three regions. Still, the magnitude of the welfare gain is relatively small, and its magnitude varies across regions.

Appendix Chapter 1

Table 1.1: Stylized facts

	Export diversification index		GDP per capita (constant USD)		GDP growth (%)		Debt to GDP ratio		Inflation (%)		Export (% GDP)		Import(% GDP)	
	1981-1996	1997-2012	1981-1996	1997-2012	1981-1996	1997-2012	1981-1996	1997-2012	1981-1996	1997-2012	1981-1996	1997-2012	1981-1996	1997-2012
Nigeria	**6.02**	**5.83**	**1353.77**	**1774.33**	**0.81**	**7.07**	**108.07**	**38.76**	**30.01**	**11.51**	**27.21**	**35.98**	**17.81**	**25.62**
Benin	4.29	4.17	618.52	724.69	3.19	4.11	70.25	45.72	5.00	3.33	19.88	21.90	33.09	33.02
Burkina-Faso	4.69	4.41	347.80	503.89	4.09	5.92	34.84	39.91	4.82	2.58	10.28	12.83	26.72	26.65
Cote d'Ivoire	3.66	3.76	1536.17	1262.60	1.24	1.41	102.90	79.42	6.24	3.09	36.41	46.52	31.41	38.07
Guinea-Bisseau	4.29	5.19	595.59	542.64	3.97	0.30	275.76	240.20	52.07	5.92	9.90	19.77	40.33	31.73
Mali	4.89	4.56	472.29	640.23	3.11	4.89	99.81	50.45	4.89	2.35	16.33	24.17	33.16	32.16
Niger	5.49	4.74	392.96	337.60	0.36	4.50	59.31	60.30	4.91	2.34	18.70	17.95	25.35	32.04
Senegal	3.40	3.06	859.50	932.67	2.21	4.17	71.36	50.27	6.31	1.89	26.95	26.86	36.85	41.01
Togo	4.31	3.31	533.29	499.57	1.52	2.03	95.15	84.95	6.03	2.78	39.04	36.80	46.73	52.31
WAEMU	**4.38**	**4.15**	**669.52**	**680.49**	**2.46**	**3.42**	**101.17**	**81.40**	**11.28**	**3.04**	**22.19**	**25.85**	**34.21**	**35.87**
Cabo-verde	4.36	3.89	970.21	2640.85	7.23	6.68	59.25	76.75	9.77	2.89	18.92	32.47	66.66	63.59
The Gambia	4.43	3.53	519.95	526.26	3.03	3.65	104.79	108.13	13.36	5.56	40.64	27.38	51.22	37.83
Ghana	4.30	3.88	813.13	1126.24	3.41	6.23	36.36	59.43	40.71	16.08	16.04	35.14	22.48	51.96
Guinea	5.33	4.45	549.12	607.96	-0.87	3.50	95.03	105.59	23.71	13.72	26.96	25.27	28.41	27.76
Liberia	4.84	5.00	744.40	319.28	-14.25	6.90	85.14	286.22	9.34	9.32	59.42	36.60	55.68	104.45
Sierre-Leone	4.17	3.45	416.11	352.40	-1.32	6.08	128.83	125.41	61.96	13.23	22.45	15.58	24.73	31.69
RECOWAS	**4.57**	**4.03**	**668.82**	**928.83**	**-0.46**	**5.51**	**84.90**	**126.92**	**26.47**	**10.13**	**30.74**	**28.74**	**41.53**	**52.88**

Source: World Bank-WDI, Sample period 1981-2012.

Table 1.2: Correlation of cyclical components

Countries	**Nigeria**	**WAEMU**								**RECOWAS**					
	NGA	BEN	BFA	CIV	GNB	MLI	NIG	SEN	TGO	CPV	GMB	GHN	GIN	LIB	SLE
Nigeria	1														
Benin	0.18	1													
Burkina-Faso	-0.02	0.07	1												
Cote-d'Ivoire	0.02	0.18	0.46***	1											
Guinea-Bissau	0.07	0.32*	-0.02	-0.07	1										
Mali	0.03	0.11	0.49***	0.20	0.00	1									
Niger	-0.05	-0.03	0.67***	0.52***	-0.30*	0.46***	1								
Senegal	-0.05	0.16	0.33*	0.40**	0.00	-0.03	0.17	1							
Togo	0.11	0.04	0.11	0.27	0.33*	0.16	0.05	0.06	1						
Cabo-Verde	0.01	-0.05	-0.16	0.09	-0.03	-0.11	-0.01	-0.13	0.23	1					
Gambia	0.16	-0.21	-0.26	0.08	-0.13	-0.02	-0.11	-0.12	-0.11	-0.07	1				
Ghana	0.00	0.34*	0.01	-0.11	0.16	0.27	-0.18	0.14	0.23	-0.05	-0.26	1			
Guinea	-0.04	0.11	0.05	0.00	0.10	-0.14	0.21	-0.06	0.00	0.28	-0.21	0.04	1.00		
Liberia	-0.15	-0.01	0.18	0.21	0.01	0.09	0.09	0.05	0.38**	0.15	0.04	0.10	0.15	1	
Sierra-Leone	-0.07	0.03	-0.07	-0.05	-0.05	-0.25	0.02	0.01	-0.11	-0.21	-0.24	0.02	0.15	-0.13	1

Source: Author's calculation using World Bank data.
Significance at 1% (***), 5% (**), 10% (*)

Table 1.3: Export shares

	NIGERIA	**WAEMU**	**RECOWAS**
NIGERIA		3.92	3.58
WAEMU	9.79		6.58
RECOWAS	4.58	6.27	

Source: Author's calculation using UN COMTRADE data.
Sample period: 1981-2012.

Table 1.4: Import shares

	NIGERIA	**WAEMU**	**RECOWAS**
NIGERIA		2.94	1.52
WAEMU	8.30		5.04
RECOWAS	4.98	4.26	

Source: Author's calculation using UN COMTRADE data.
Sample period: 1981-2012.

Table 1.5: Weights in regional aggregate data

Variables	**NIGERIA**	**WAEMU**	**RECOWAS**
Output	69.93	20.33	9.75
Consumption	74.79	11.90	3.42
Export	82.58	14.31	3.11
Import	61.89	30.69	7.42

Source: Author's calculation using World bank data.

Table 1.6: Calibration of the model parameters

Parameter	Description	Nigeria	WAEMU	RECOWAS
σ	Risk aversion parameter	2.61	2.61	2.61
ϕ	Inverse labor supply elasticity	1	1	1
β	Discount factor	0.96	0.96	0.96
δ	Depreciation rate of capital	0.05	0.05	0.05
η, ζ	Elast. of subst. between T and NT consumption and investment goods	0.9	0.9	0.9
ϵ, χ, υ, μ, Γ, φ	Elast. of subst. between varieties of Tradable consumption and investment goods	1.5	1.5	1.5
ϱ	Elast. of subst. between the varieties of export goods	1.5	1.5	1.5
$\rho_a^{TH,NT}$	Persistence in domestic T and NT productivity	0.9	0.9	0.9
ρ_{pm}	persistence in world import price	0.75	0.75	0.75
$\sigma_a^{TH,NT}$	Standard deviation of productivity shock	0.01	0.01	0.01
σ_{pm}	Standard deviation of import price shock	0.01	0.01	0.01
$\theta^{TH,NT}$	Calvo parameter for domestic T and NT firms	0.8	0.8	0.8
γ^{π}	Inflation parameter in the Taylor rule	1.5	1.5	1.5
γ^{y}	Output parameter in the Taylor rule	0.8	0.8	0.8
γ^{r}	Interest rate smoothing parameter	0.6	0.6	0.6
γ^{e}	Exchange rate parameter in the Taylor rule	0.8	1.7	0.8
	Steady state value			
C/Y	Ratio of private consumption to GDP	0.68	0.73	0.77
I/Y	Ratio of Investment GDP	0.13	0.16	0.21
G/Y	Ratio of government spending to GDP	0.09	0.15	0.10
X/Y	Ratio of export to GDP	0.31	0.24	0.26
I/Y	Ratio of Import to GDP	0.21	0.34	0.38

Table 1.7: Variance decomposition: Monetary independence (in percentage)

	Monetary independence					
	ϵ_{ath} (NG)	ϵ_{tot}(NG)	ϵ_{ath} (W)	ϵ_{tot}(W)	ϵ_{ath}(RE)	ϵ_{tot}(RE)
	NIGERIA					
Output	70.58	29.39	0.02	0	0	0
Consumption	69.06	30.7	0.15	0.01	0.04	0.03
Investment	63.01	36.84	0.09	0.01	0.03	0.02
Inflation	42.54	57.41	0.04	0	0.01	0
Labour	29.71	70.2	0.06	0	0.01	0.01
	WAEMU					
Output	0.02	0.03	64.35	35.5	0	0.11
Consumption	0.06	0.23	57.71	41.65	0.04	0.31
Investment	0.04	0.07	57.24	42.37	0.03	0.24
Inflation	0.01	0.18	29.41	70.38	0.02	0.01
Labour	0.03	0.05	43.07	56.67	0	0.18
	RECOWAS					
Output	0.01	0.01	0.12	0.02	37.92	61.93
Consumption	0.02	0.06	0.48	0.06	34.4	64.98
Investment	0.01	0.02	0.29	0.05	32.61	67.02
Inflation	0	0.01	0.08	0.01	17.64	82.26
Labour	0.01	0.02	0.17	0.02	19.78	80

Table 1.8: Variance decomposition: Monetary union (in percentage)

	Monetary union					
	ϵ_{ath} (NG)	ϵ_{tot}(NG)	ϵ_{ath} (W)	ϵ_{tot}(W)	ϵ_{ath}(RE)	ϵ_{tot}(RE)
	NIGERIA					
Output	68.3	7.89	1.76	0.37	19.23	2.46
Consumption	65.28	13.29	1.85	0.57	16.21	2.79
Investment	62.29	13.5	1.96	0.47	19.09	2.68
Inflation	60.73	7.39	1.38	0.35	27.7	2.46
Labour	52.71	12.01	2.62	0.55	28.44	3.67
	WAEMU					
Output	62.59	1.99	9.08	3.36	20.79	2.2
Consumption	52.7	2.21	14.28	11.65	16.22	2.93
Investment	59.25	2.03	5.5	11.16	19.6	2.45
Inflation	62.32	2.05	0.34	11.95	21.49	1.85
Labour	68.08	2.22	0.25	4.28	22.69	2.48
	RECOWAS					
Output	51.82	1.93	1.88	0.17	25.72	18.49
Consumption	35.76	1.73	1.6	0.67	22.4	37.83
Investment	42.77	1.67	2.05	0.3	15.98	37.24
Inflation	63.68	2.18	0.93	0.22	19.1	13.89
Labour	62.15	2.35	2.34	0.23	9.14	23.78

Table 1.9: Measures of welfare change (% of steady state consumption)

Productivity shock			
	Nigeria	**WAEMU**	**RECOWAS**
Nigeria	2.02	1.62	0.44
WAEMU	3.89	3.20	0.89
RECOWAS	5.67	4.68	0.13
Terms of trade shock			
	Nigeria	**WAEMU**	**RECOWAS**
Nigeria	0.26	0.19	0.22
WAEMU	0.53	0.13	0.16
RECOWAS	0.79	0.10	0.13

Source: Author's calculation.

Figure 1.1: **Comparison of business cycle**

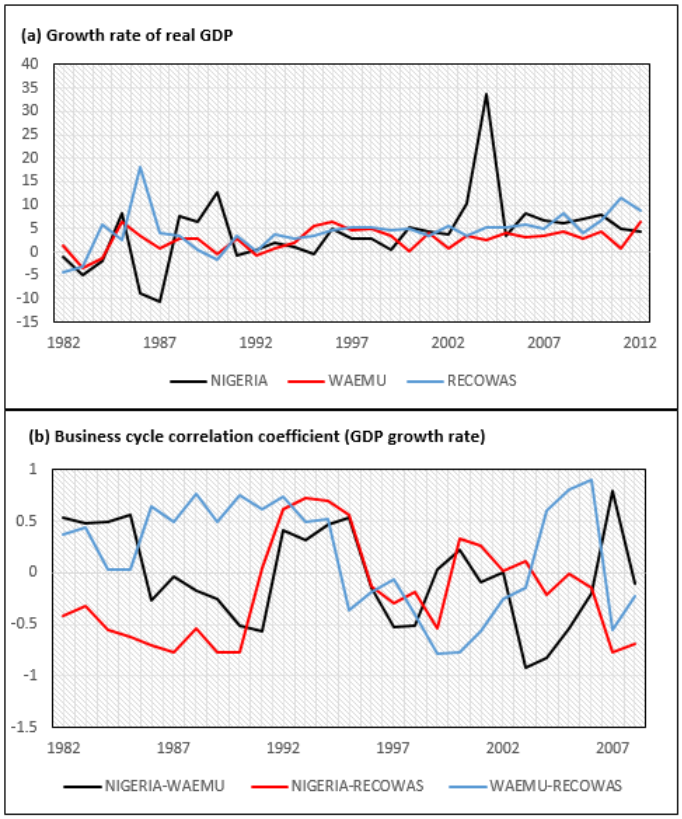
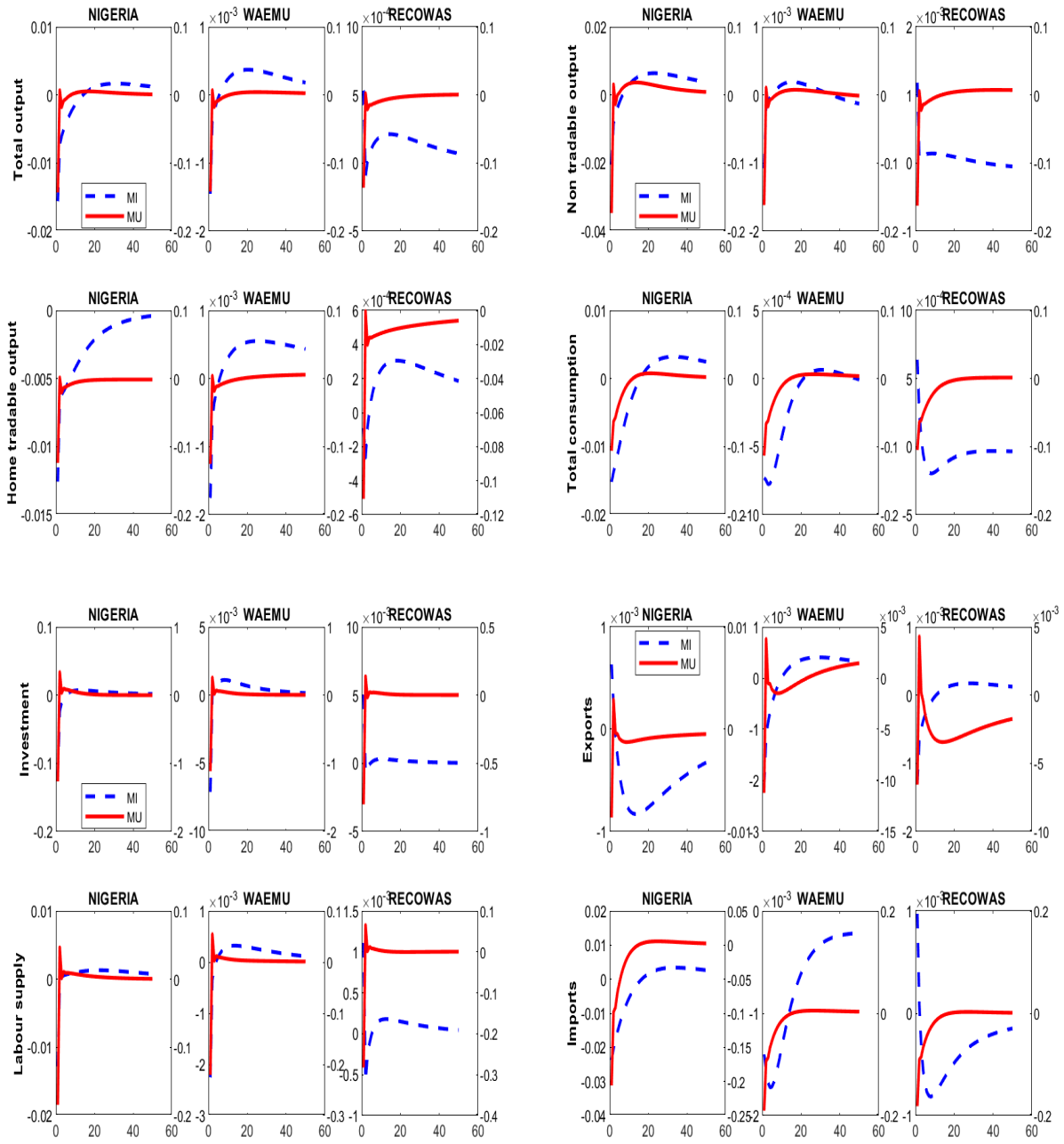
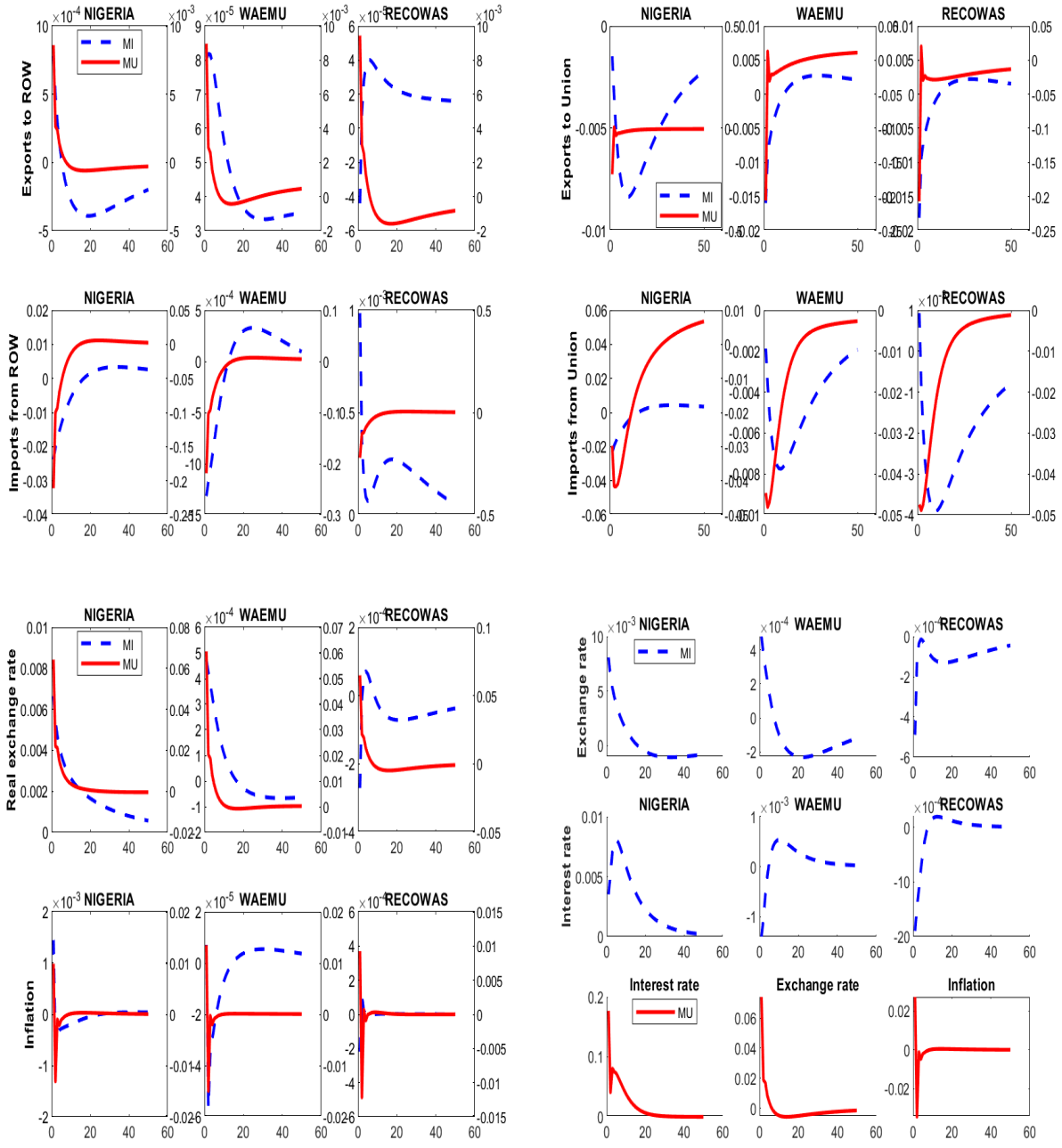


Figure 1.2: **Effect of tradable productivity shock originating from Nigeria**



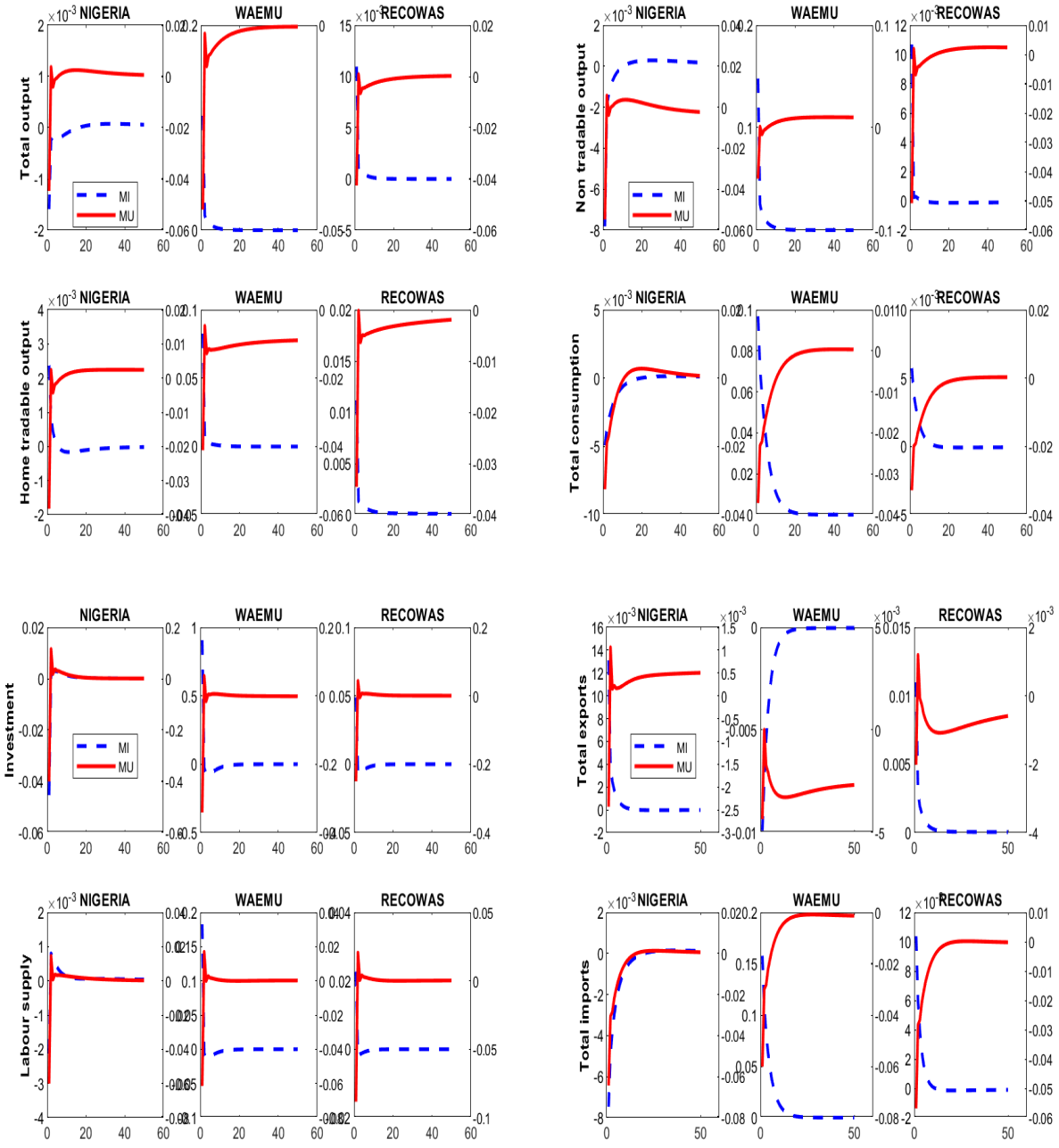
The IRFs are displayed in a two Y-axis (the left axis is for the independent monetary policy regime and the right axis is for the monetary union).

Figure 1.3: **Effect of tradable productivity shock originating from Nigeria (cont.)**



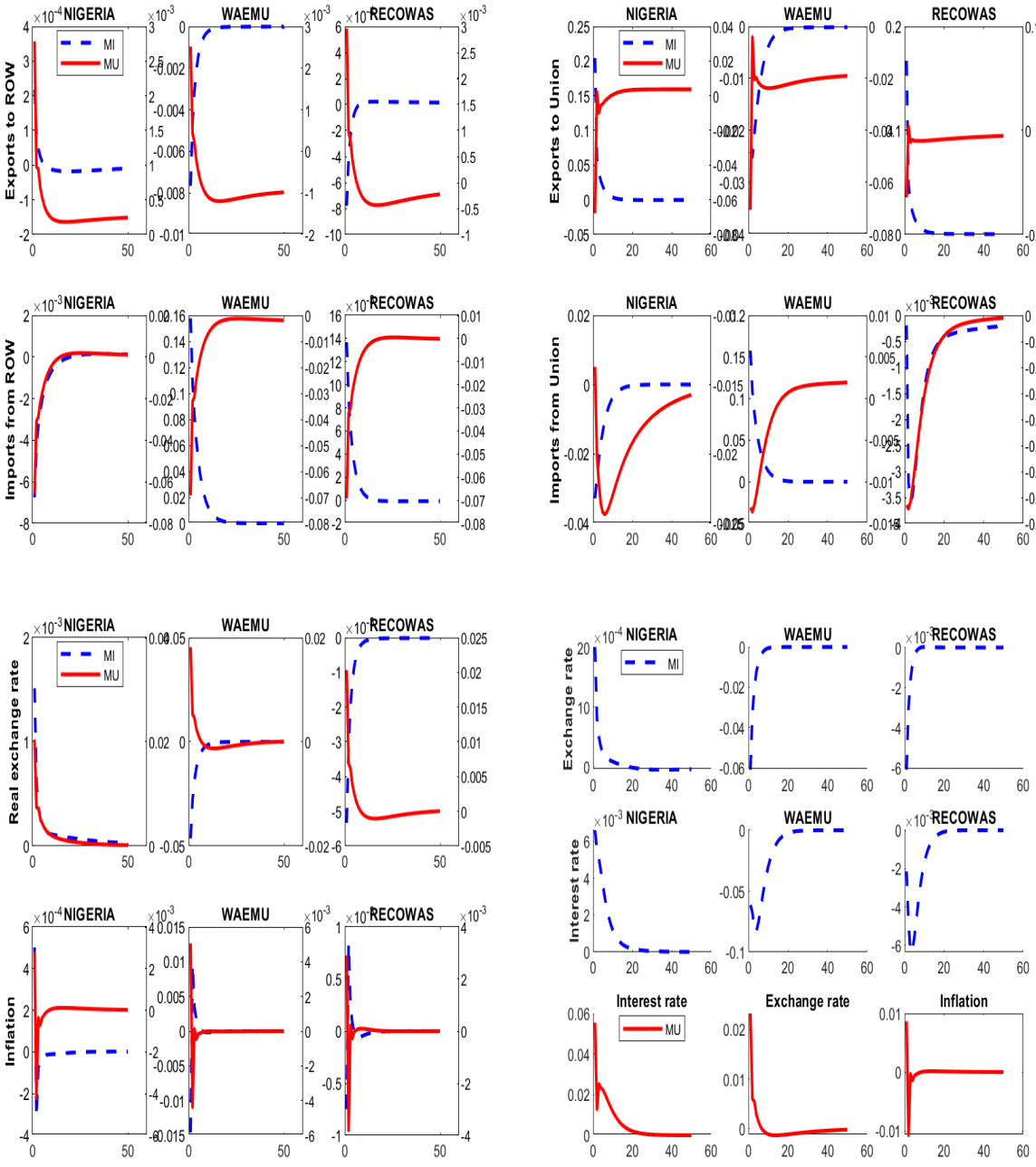
The IRFs are displayed in a two Y-axis (the left axis is for the independent monetary policy regime and the right axis is for the monetary union).

Figure 1.4: **Effect of tradable productivity shock originating from WAEMU**



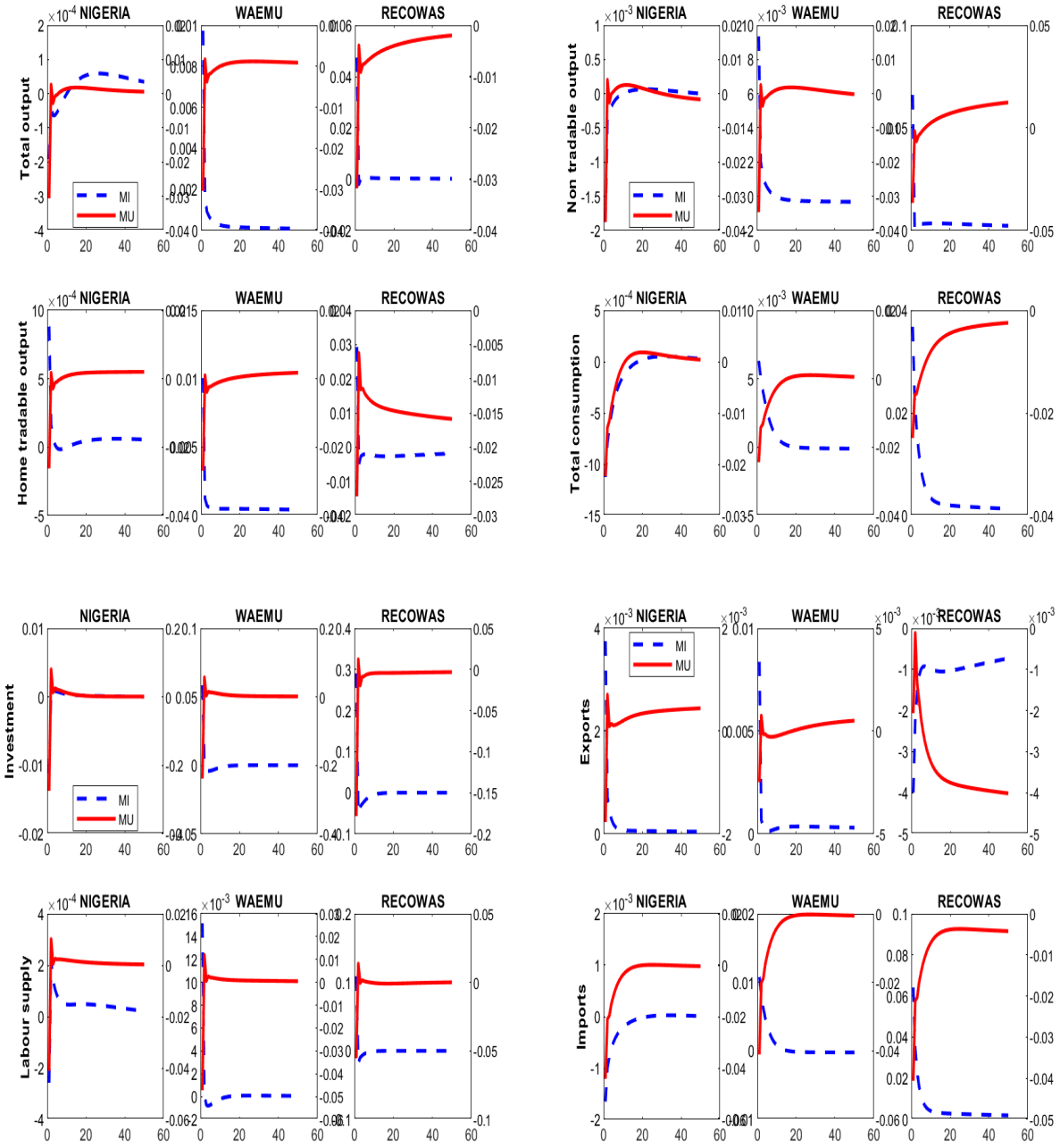
The IRFs are displayed in a two Y-axis (the left axis is for the independent monetary policy regime and the right axis is for the monetary union).

Figure 1.5: **Effect of tradable productivity shock originating from WAEMU (cont.)**



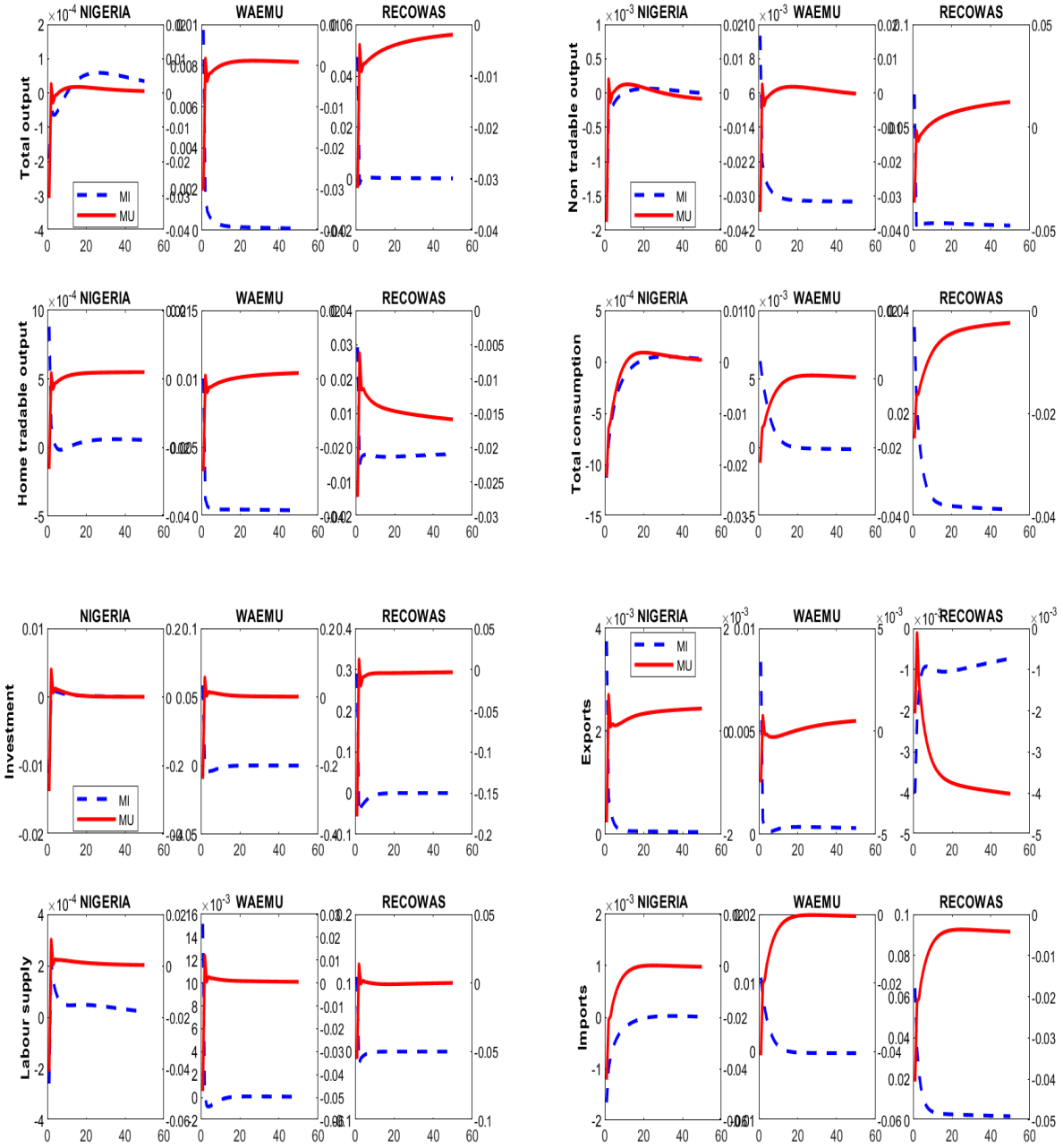
The IRFs are displayed in a two Y-axis (the left axis is for the independent monetary policy regime and the right axis is for the monetary union).

Figure 1.6: **Effect of tradable productivity shock originating from RECOWAS**



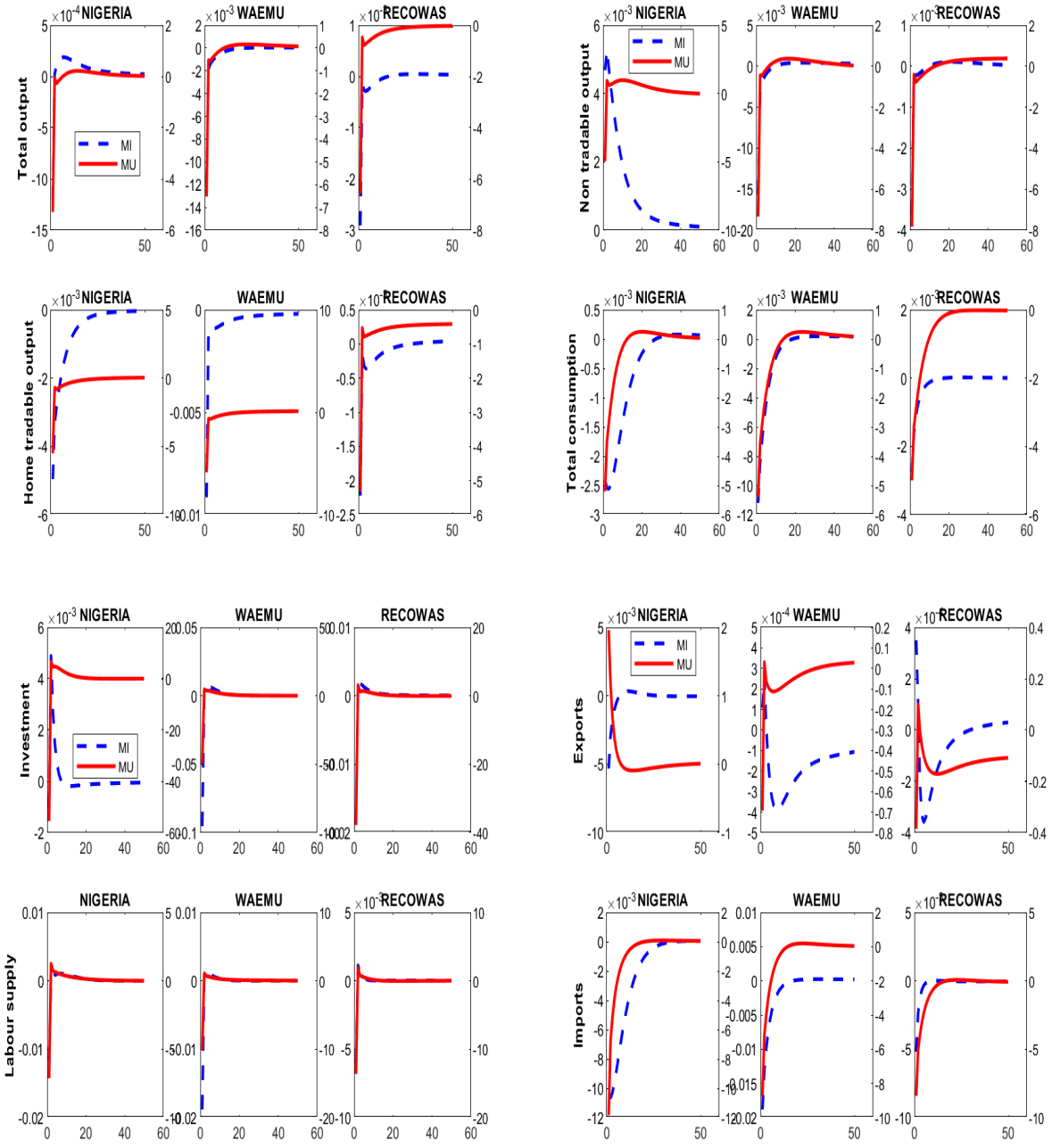
The IRFs are displayed in a two Y-axis (the left axis is for the independent monetary policy regime and the right axis is for the monetary union).

Figure 1.7: **Effect of tradable productivity shock originating from RECOWAS (cont.)**



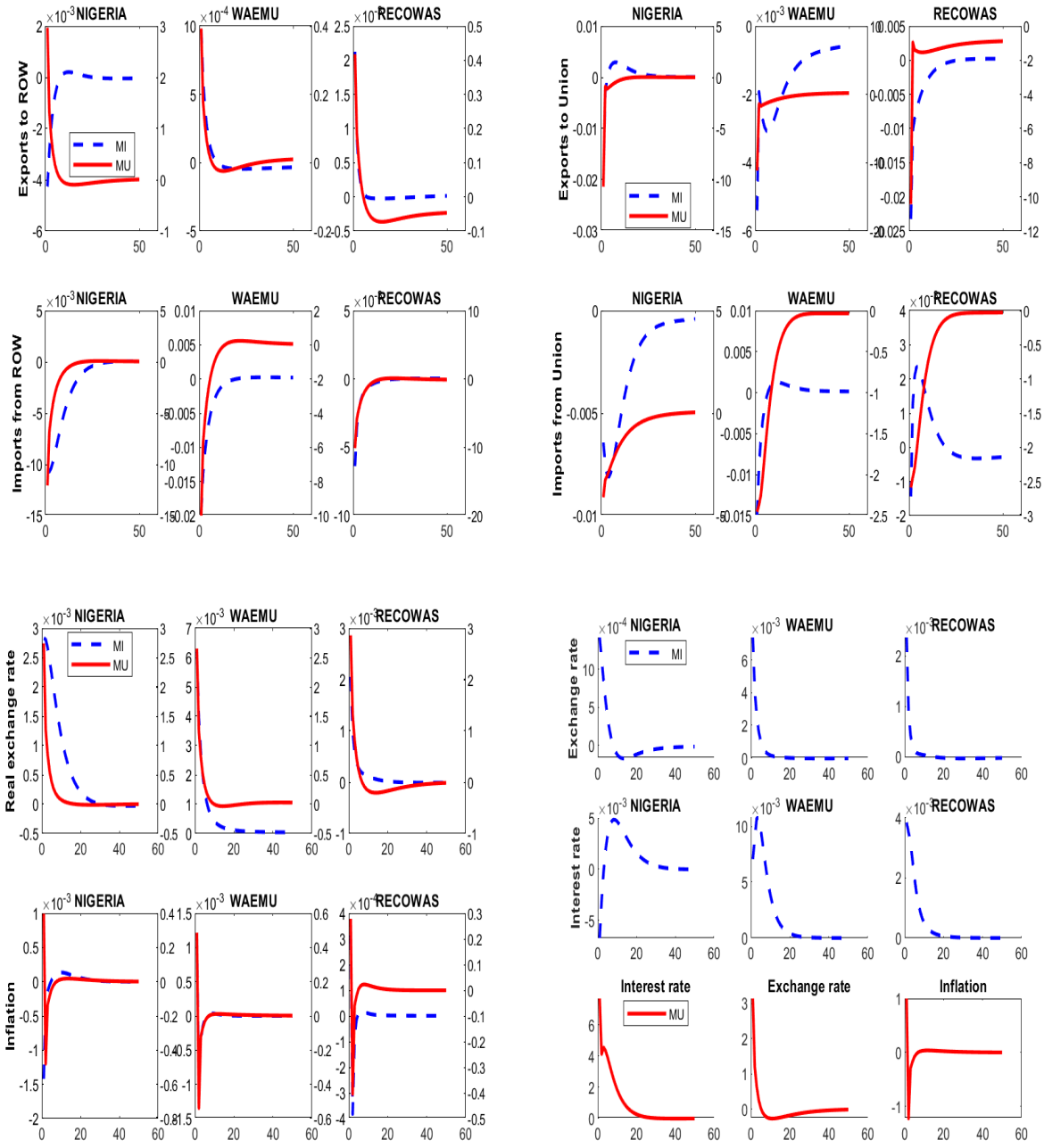
The IRFs are displayed in a two Y-axis (the left axis is for the independent monetary policy regime and the right axis is for the monetary union).

Figure 1.8: **Effect of terms of trade shock originating from Nigeria**



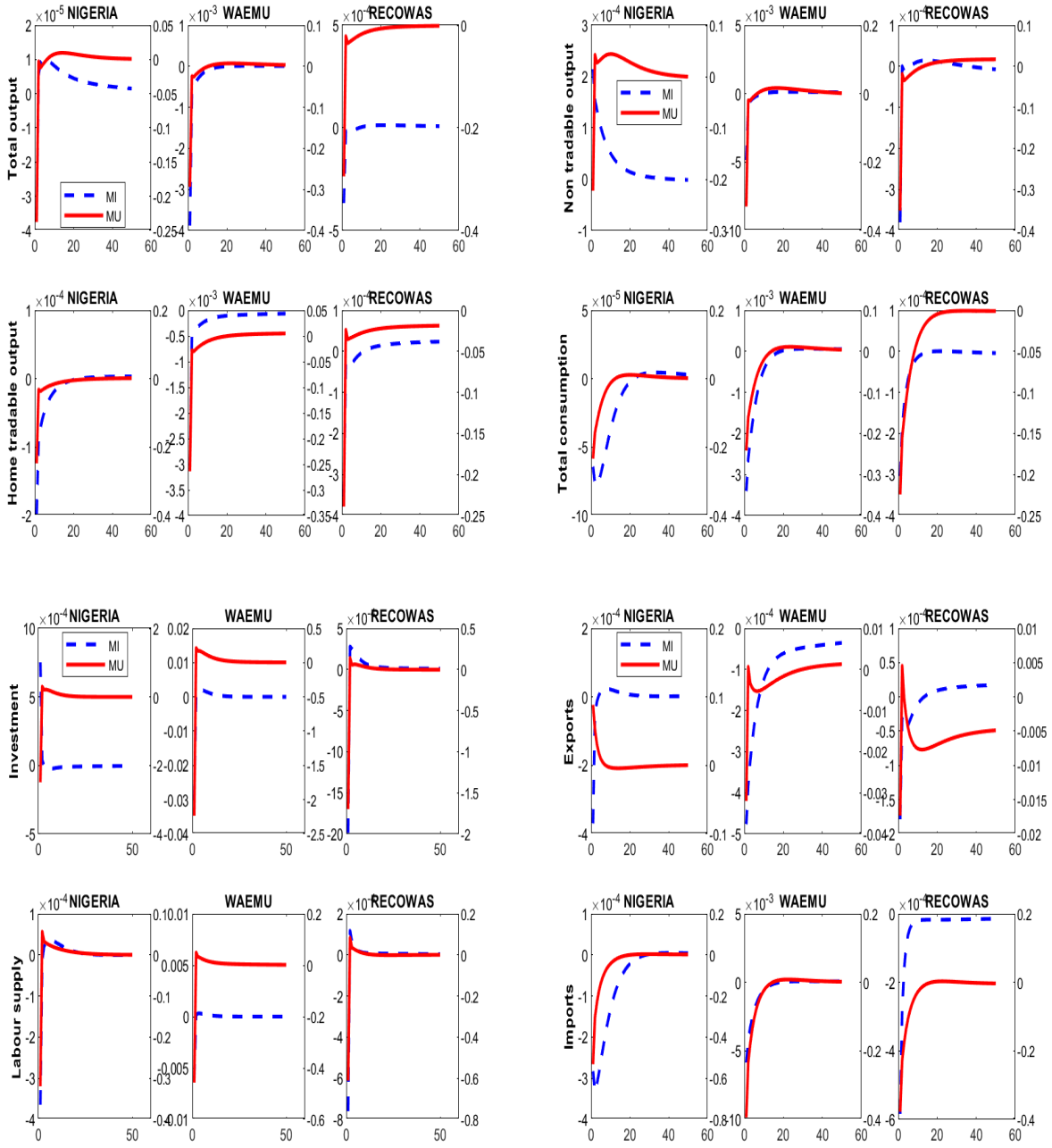
The IRFs are displayed in a two Y-axis (the left axis is for the independent monetary policy regime and the right axis is for the monetary union).

Figure 1.9: **Effect of terms of trade shock originating from Nigeria (cont.)**



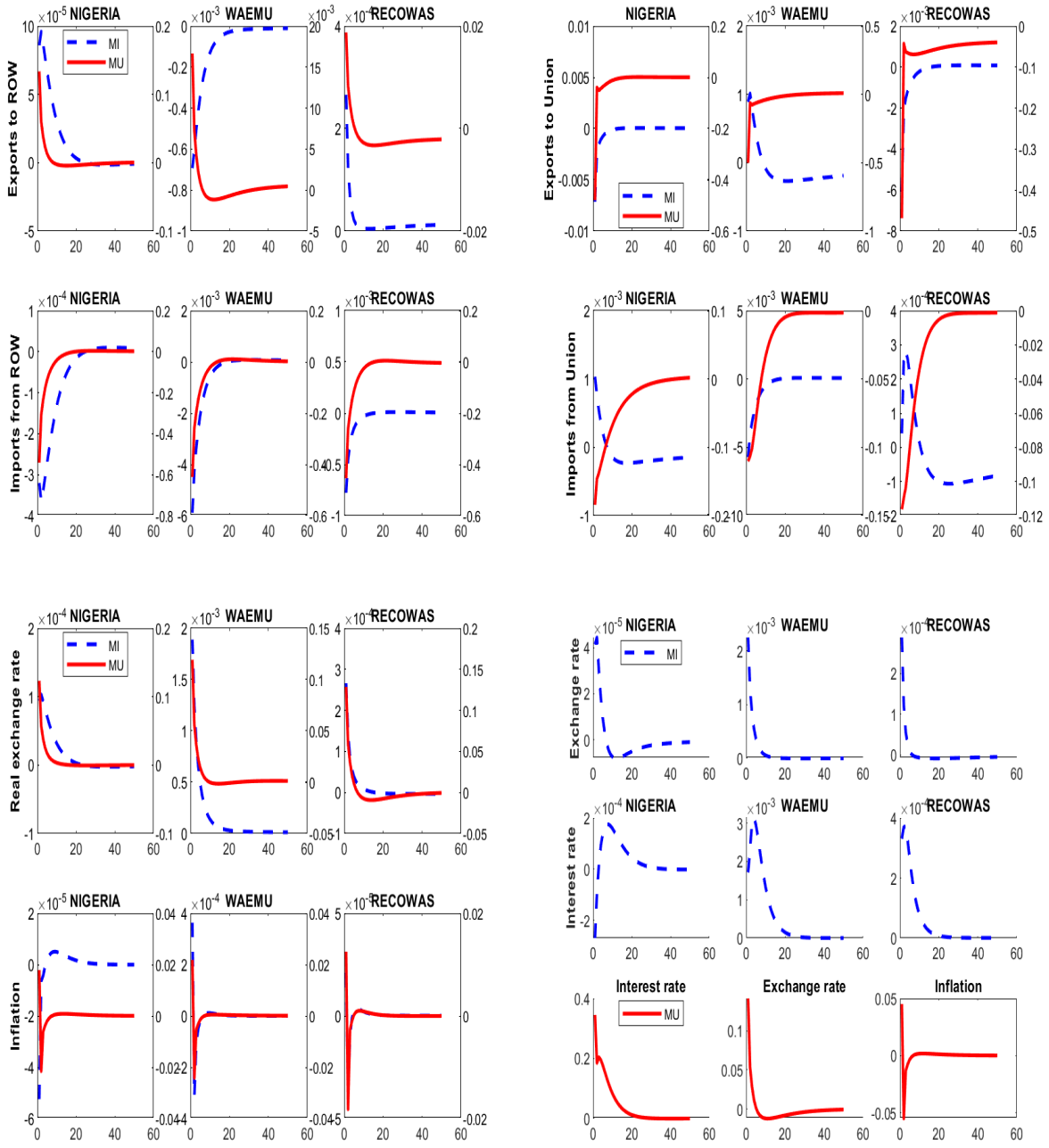
The IRFs are displayed in a two Y-axis (the left axis is for the independent monetary policy regime and the right axis is for the monetary union).

Figure 1.10: **Effect of terms of trade shock originating from WAEMU**



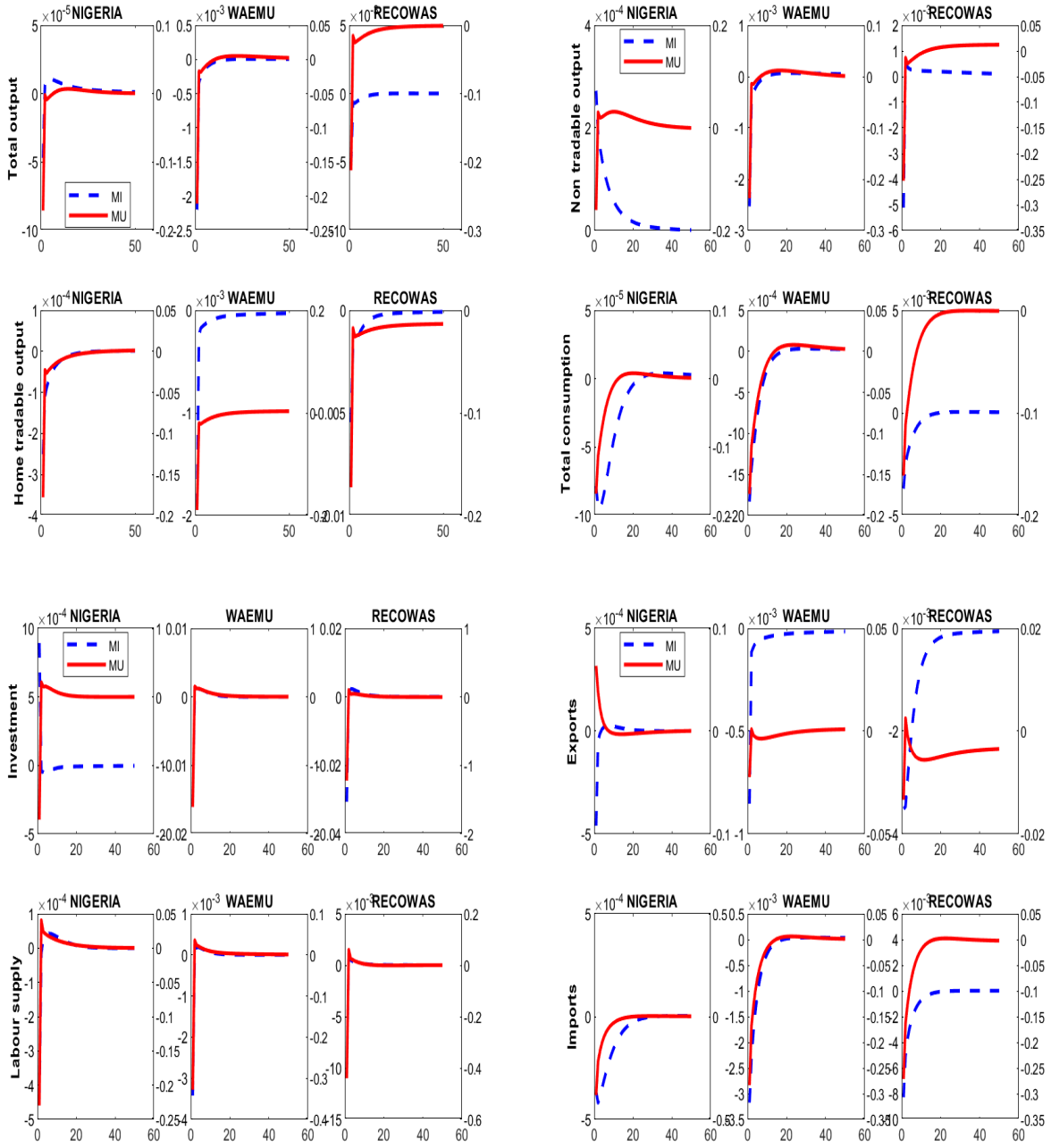
The IRFs are displayed in a two Y-axis (the left axis is for the independent monetary policy regime and the right axis is for the monetary union).

Figure 1.11: **Effect of terms of trade shock originating from WAEMU (cont.)**



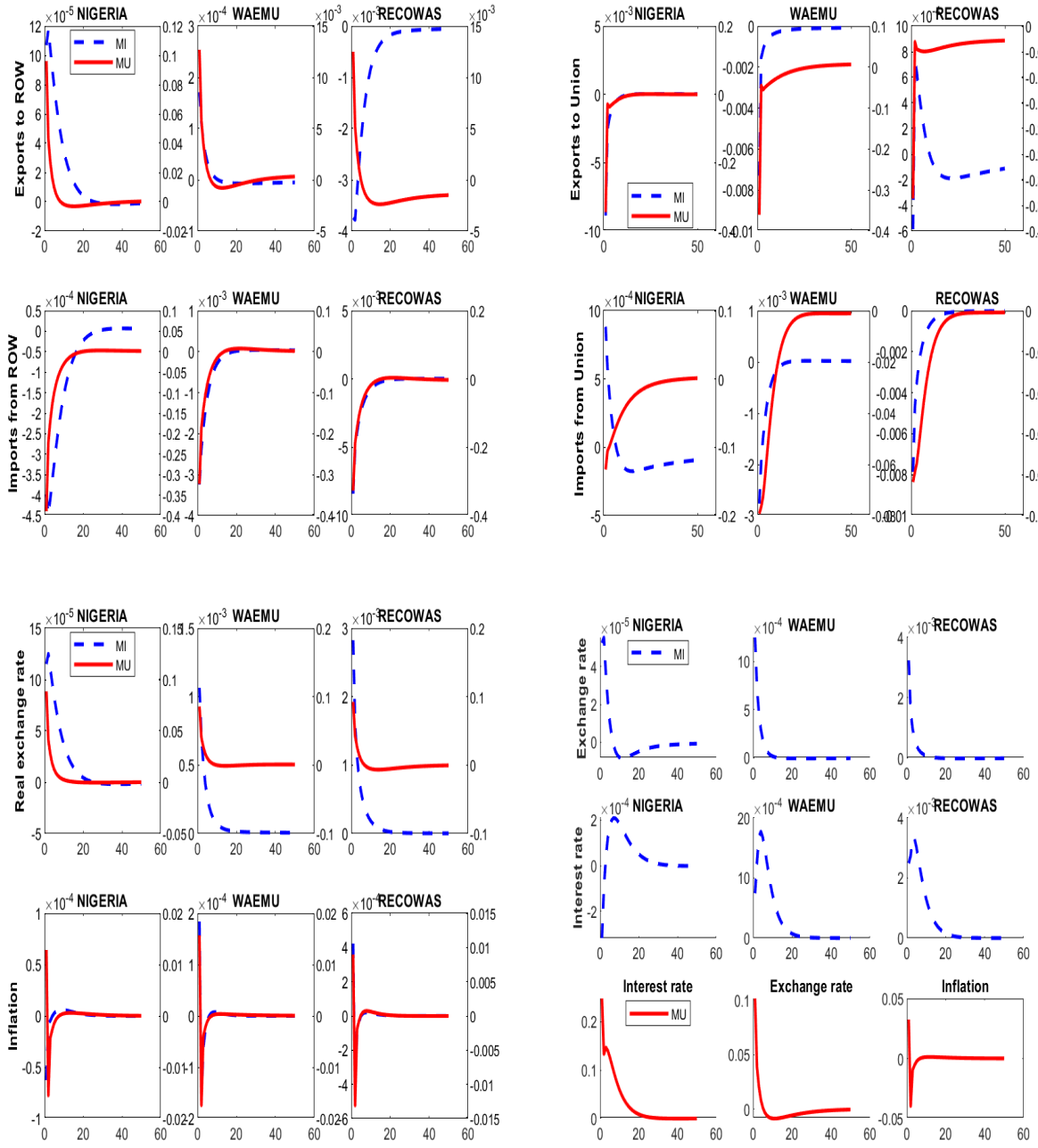
The IRFs are displayed in a two Y-axis (the left axis is for the independent monetary policy regime and the right axis is for the monetary union).

Figure 1.12: **Effect of terms of trade shock originating from RECOWAS**



The IRFs are displayed in a two Y-axis (the left axis is for the independent monetary policy regime and the right axis is for the monetary union).

Figure 1.13: **Effect of terms of trade shock originating from RECOWAS (cont.)**



The IRFs are displayed in a two Y-axis (the left axis is for the independent monetary policy regime and the right axis is for the monetary union).

Chapter 2

Fiscal Transfers in a Currency Union: An analysis of the upcoming West African Monetary Union with a New-Keynesian Model

2.1 Introduction

In a monetary union, member states are committed to a common monetary policy, while fiscal policy is the responsibility of each government. Asymmetric shocks across members of the union cannot be offset by the common central bank. The objective of the latter institution is to stabilize the union-wide inflation, leaving fiscal policy and financial markets to fulfill the stabilization role in the presence of idiosyncratic shocks. Due to the loss of the monetary policy autonomy by individual members, which is a crucial stabilization tool, macroeconomic fluctuations can represent a threat to stability in a monetary union, especially in the absence of alternative adjustment mechanisms. This cost associated with the creation of a monetary union represents one of the main concerns over the effectiveness of creating a monetary union in the Economic Community of Western African States (ECOWAS)[1]. The principal reason is the asymmetric nature of shocks faced by the member countries (Coulibaly and Gnimassoun [2013]; Debrun, Masson and Pattillo [2005]; Qureshi and Tsangarides [2006]; Masson and Pattillo [2002]). Recall that the ECOWAS region is a group of 15 West African Countries that have a customs union and are currently planning to increase their economic integration through the formation of a currency union, and the project is expected to be implemented by 2020.

In this paper, we investigate the role that fiscal transfers between countries could play in the stabilization of business cycle fluctuations in the projected monetary union in the ECOWAS region. In particular, we consider an international transfer system, which could serve as insurance against asymmetric cyclical income fluctuations in the union. The idea that fiscal transfer arrangements are needed for adjusting against idiosyncratic shocks in a monetary union has initially been introduced in the theory of optimum currency areas (OCA) pioneered by Mundell [1961], [McKinnon, 1963], and Kenen [2000]. These authors have argued that fiscal transfers should serve as an alternative adjustment mechanism in order to provide union's members insurance against asymmetric shocks. The reason is that during recessions, countries may have the incentive to leave the union in the absence of risk-sharing mechanisms (i.e., the ex-post instruments to smooth changes in consumption relative to output). Risk-sharing, which is defined as an efficient inter-spatial shock absorption mechanism through income and consumption smoothing (Ioannou and Schäfer [2017]), can be achieved via three main channels in a monetary union: the capital market channel, the credit market channel (henceforth market institutions channel) and central fiscal institutions (Asdrubali, Sørensen and Yosha [1996]). The capital market channel refers to the agent's ability to share risk

[1]The 15 members of the Economic Community of West African States (ECOWAS) are Benin, Burkina Faso, Cabo Verde, Cote d'Ivoire, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo

through a certain degree of cross-ownership of productive assets (portfolio diversification). In the second channel, agents can smooth their consumption through saving behavior, i.e., through lending and borrowing on the credit markets. The third channel refers to a centralized fiscal institution that provides cross-country income insurance via taxes, transfers, or grants in order to mitigate the impact of idiosyncratic shocks in a given country. These risk-sharing facilities have been useful in federations such as the United States and Canada, which are examples of relatively well-functioning monetary unions. These countries have a system of federal fiscal transfers acting as automatic insurance against asymmetric macroeconomic shocks. The literature on risk-sharing suggests that almost 80% of shocks in these federations (USA, Canada, or the UK) are smoothed through the three risk-sharing channels. In contrast, the euro area that has no centralized fiscal authority, insured less than half of the shocks affecting its members. Given the low level of financial and market integration in West Africa, this study focuses on the third channel and investigates the impact of a cross-country fiscal transfer arrangement within the proposed ECOWAS monetary union and its macroeconomic stabilization ability in response to idiosyncratic shocks. Two forms of fiscal risk-sharing schemes are mostly discussed in the literature: fiscal equalization with nominal tax revenue sharing and common central fiscal authority with real taxing powers.

Following Evers [2015], we consider a horizontal fiscal equalization where revenues are shared among the regions to insure against adverse shocks. In this fiscal equalization system, each region manages its fiscal policy independently, but tax revenues are redistributed across regions depending on their revenue-raising ability or fiscal capacity. The fiscal capacity of a member state is the difference between its net tax revenue and the average union-wide tax revenue. In the presence of a negative shock, regions whose fiscal capacity is below (above) the average union-wide tax revenue receive (contribute) an equalization payment from the other. In the practice of fiscal equalization, some countries use formulas to equalize fiscal capacity (Canada), expenditure needs (Spain, India, or Nigeria) or both fiscal capacity and expenditure needs (Germany, UK, or China). In this study, we equalize only the fiscal capacity since there is a substantive difference in the revenue-raising capacity of regions considered in the model.

As mentioned above, there is a substantial difference in the size and the economic needs of the region considered in our analysis. For instance, Nigeria GDP is approximately 2.5 times the GDP of the rest of ECOWAS countries (WAEMU[2] and the seven other English speaking countries), so the insurance of one percent of Nigeria's fiscal revenue drop would cost the

[2]The West African Economiv and Monetary Union (WAEMU) is a monetary union formed by the eight French speaking countries in West Africa (Benin, Burkina-Faso, Cote d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, Togo). Their common currency is FCFA

rest of ECOWAS, 2.5% of their total GDP, whereas Nigeria can compensate one percent of the rest of ECOWAS' fiscal loss by paying only 0.04% of its GDP. Because of this difference in economic needs, the establishment of intergovernmental risk sharing can potentially cause problems of moral hazard and equity. For instance, a small region like WAEMU might find it difficult to compensate for a more prominent region like Nigeria for the loss it encounters in the presence of negative shock. To address this issue, we introduce a transfer system that targets the difference in revenue relative to a reference situation without shock. Moreover, we follow Dolls et al. [2013] [3] and consider both a partial equalization system where only a fraction of the difference in fiscal capacity is equalized and a system with full compensation. Overall, the objective of this analysis is to respond to the following research questions:

- What is the effectiveness of intergovernmental fiscal transfer in mitigating the impact of idiosyncratic shocks within the ECOWAS monetary union?
- What are the implications of this intergovernmental fiscal transfer in terms of welfare?

Before moving forward, it is essential to highlight the concept of asymmetric shock considered in this paper. Asymmetric shocks are perturbations that do not affect a set of regions in the same way. They can be grouped into two categories, namely the country-specific shocks, i.e., shocks that affect just one country and hence are asymmetric in origin and impact, and shocks that are common to several regions but have different impacts, i.e., they are symmetric in origin but asymmetric in their impact (see Bajo-Rubio and Díaz-Roldán [2003] and Emerson [1992]). We consider in this study the first type of shock, i.e., country-specific shocks, which, as highlighted above, are asymmetric by nature.

To implement the analysis, we consider a multi-region New-Keynesian model in which the blocks of countries that form the ECOWAS monetary union share risks through fiscal transfer. The model is composed of three main regions (Nigeria, WAEMU, and the rest-RECOWAS [4]) that form a monetary union. The three regions have the same economic structure and are inhabited by the following agents: the households, the firms, the government, and the common central bank. One key feature of the model is the introduction of heterogeneous agents: the Ricardian and Non-Ricardian households. This choice is, on the one hand, motivated by the low development of the financial sector in the economies under study with a significant share of households that do not have access to the financial market.

[3] Dolls et al. [2013] considered in their analysis of the redistributive and stabilizing effects of fiscal integration in the EMU that only 10 percent of the differences in taxing capacities are equalized

[4] We denote RECOWAS the group of countries represented by Ghana, Liberia, Guinea, Sierra Leone, Gambia

On the other hand, it takes into consideration the problem of assessing fiscal stimulus in the standard DSGE model because of the failure of the consumption smoothing hypothesis (Baxter and King [1993], Mankiw [2000]). In reality, the standard DSGE model is based on Ricardian equivalence and predicts a decline in consumption in response to positive government spending shock since the tightening monetary policy that follows a fiscal expansion encourages households to save rather than to consume and thus, consumption declines. This result seems to be at odds with empirical findings in developing countries (Miyamoto, Nguyen and Sheremirov [2019]).

The model also includes several standard features of DSGE models, such as nominal and real rigidities (Smets and Wouters [2003], Christiano, Eichenbaum and Evans [2005], Gali and Monacelli [2005]).

The dynamic of the model is analyzed by examining two types of country-specific shocks affecting each region: terms-of-trade shock and tradable productivity shock. We analyze the propagation mechanisms and adjustments to the shocks considering two scenarios: a monetary union without fiscal transfer as a benchmark scenario and a monetary union with an intergovernmental fiscal transfer in the form of fiscal equalization. To the best of our knowledge, this is the first paper to investigate the question of inter-regional fiscal transfer in a currency union in the context of the African economic communities.

Our main findings can be summarized as follow:

(i) Overall, the stabilization property of the intergovernmental fiscal transfer in the ECOWAS region depends on whether they establish a full or partial compensation system. Also, the ability of the transfer system to absorb the negative effects of idiosyncratic shock depends not only on the type of shock but also on the region directly affected.

(ii) The transfer is countercyclical in the receiving region. However, its ability to stabilize the union-wide business cycle fluctuations depends on the region affected by the shocks. The higher the region's need and the less effective the transfer can be for stabilization purposes.

(iii) The stabilization property of the transfer is limited when the different regions are affected by a negative idiosyncratic terms-of-trade shock.

(iv) The fiscal transfer leads to welfare gain (loss) in the recipient (contributing) regions.

The rest of the paper is organized as follows. Section 2 describes the relevant literature related to this topic, and section 3 gives an overview of the multi-region New-Keynesian (NK) model of the monetary union. Section 4 discusses the data and the calibration of

the model parameters. Section 5 discusses the main results, including simulations of the effectiveness of a fiscal transfer mechanism in the ECOWAS currency union and the welfare analysis. Section 6 concludes.

2.2 Literature review

This paper contributes to the literature on the conduct of optimal monetary and fiscal policy within a currency union. The question of risk-sharing as one condition for a successful Optimum Currency Area (OCA) was initially introduced by Mundell [1961], McKinnon [1963], and Kenen [1969]. According to these authors, in the absence of labor mobility, capital mobility, price and wage flexibility, and similarity in business cycle, the success of a currency area hinges upon the availability of a risk-sharing system. Since in a monetary union, member states cannot absorb idiosyncratic shocks through monetary policy, an intergovernmental fiscal transfer is needed in the absence of some fiscal capacity at the country level or if the national fiscal policy, which is also another adjustment mechanism, fails to stabilize the effects of asymmetric shocks. Following this classical literature on optimum currency areas, the idea of establishing some types of automatic insurance mechanism in the regions experiencing asymmetric shocks has been extensively discussed in the empirical literature on the EMU and the United States. The main idea behind these studies on international risk-sharing is that when a country/region is affected by an idiosyncratic shock, the effect of the shock should be smoothed so that the final impact on consumption will be lower than the initial effect on output (GDP). In their seminal paper on the United States, Sala-i Martin and Sachs [1991] introduce a methodology for assessing interstates risk-sharing and estimating the amount of income smoothed by the United States federal government through taxation and direct transfers to the local governments. Their main finding is that in the case of an asymmetric shock defined as a misalignment of a region GDP compared to the average of the United States, approximately 34% of the disturbance is absorbed through taxation, and 6% is absorbed through direct transfers. Considering also, the United States, Asdrubali, Sørensen and Yosha [1996] suggest that the federal tax-transfer and grant system smoothed 13% of income shocks in this country during the period 1963-1990; 39% was smoothed by cross-ownership of assets, and 23% by borrowing or lending. Their results show that the contribution of market institutions (capital market and credit market) in smoothing state-specific shocks in the United States is more than four times the contribution of the federal government.

With regards to EMU, Evers [2006], Evers [2012], and Evers [2015] are the most extensive study on inter-state fiscal risk-sharing in the EMU. The author uses a DSGE model to provide a quantitative analysis of the different forms of fiscal integration scenarios in a monetary

union. In Evers [2006], he explores the properties of federal fiscal transfer schemes with regard to their capability to stabilize national consumption, production, and employment. His results suggest that federal insurance schemes reduce fluctuations and, in particular, cyclical unemployment within the member states of the EMU. In Evers [2012], he considers federal fiscal transfers rules that automatically redistribute funds among members of monetary union to counteract adverse idiosyncratic shocks. The transfer rules target regional differences in nominal GDP, consumption spending, labor income, and fiscal deficits. He shows that targeting regional fiscal deficits is the only rule that reduces consumption fluctuations, and that promotes interregional consumption risk sharing. Still, the overall welfare effect is negative. In contrast, targeting regional differences in labor income yields the largest welfare gains, but it also yields the largest fluctuations in consumption and real GDP. He suggests that the optimal transfer rule essentially implies a combination of consumption spending and labor income targeting. In Evers [2015], the same author proceeds to a comparative assessment between a decentralized fiscal policy and two other federal fiscal arrangements: fiscal equalization system and central fiscal authority. He shows that a fiscal equalization system, in which nominal tax revenues are shared, dampens consumption fluctuations, and leads to welfare losses compared to a system with decentralized fiscal authorities. A common fiscal authority with a unitary tax system does stabilize output and consumption and leads to welfare gains.

Still, some economists, challenge to some extent the view that a monetary union requires more fiscal integration. Gadatsch, Hollmayr and Stähler [2016] show that the three fiscal union scenarios considered in the literature (fiscal revenue equalization, tax harmonization and a centralized fiscal authority) do not significantly improve international risk sharing in the EMU and they all lead to a welfare loss. Also, Kletzer and von Hagen [2000] show that inter-regional taxes and transfers cannot stabilize regional employment or consumption, and the welfare effect of such stabilization is ambiguous. However, the authors recognize that a monetary union needs fiscal shock absorbers that help the participating countries to cope with asymmetric shocks.

Even though the notion of risk-sharing in monetary unions has recently acquired high interest from policy-makers and researchers around the world, the question remains unexplored in the literature related to African monetary zones. For instance, the issue of risk-sharing has been marginalized in the literature about the existing monetary union in the ECOWAS area, i.e., the WAEMU. Indeed, the WAEMU does not have an explicit mechanism either to absorb asymmetric shocks or to insure against asymmetric shocks. Thus, there are very few papers on the risk-sharing mechanism between African states. Among these, the two significant

contributions that emerged include the analysis of Yehoue [2005] and Tapsoba [2011], which focus on the market institutions channel. Yehoue [2005] assesses risk-sharing within the two monetary unions of the CFA zone (WAEMU and CEMAC) and finds that French aid and the contributions of the central banks play an essential role in smoothing shocks to GDP. More than 60% of shocks affecting WAEMU are smoothed through the channel mentioned above, while 13% of the shocks are smoothed through the standard channels, i.e., capital market, credit market, and remittances. Tapsoba [2011] estimates risk-sharing channels among West African states from 1970 to 2004 and show that, compared to the OECD countries, the degree of risk-sharing among West African countries is quite low, and net saving represents the significant and stable risk-sharing channel in the region.

The key insight that can be drawn from this literature review is that there is no analysis of the potential impact of intergovernmental fiscal transfers within the existing monetary unions in Africa. Moreover, the question of moral hazard and fairness raised by the introduction of a transfer mechanism remains unexplored in the existing literature. The purpose of this paper is, therefore, to fill this gap by incorporating an automatic fiscal transfer mechanism into a multi-region NK model for the ECOWAS monetary union. The transfer in our model is represented by an equalization payment from the country with relatively strong economic growth to the country with relatively weaker growth.

2.3 Model description

We develop a three-region New-Keynesian Dynamic Stochastic General Equilibrium model (DSGE) that inherits many characteristics of a large class of DSGE model as developed by Smets and Wouters [2003], Christiano, Eichenbaum and Evans [2005], Gali and Monacelli [2005]. The three-regions (Nigeria (N), WAEMU (W) and RECOWAS(RE)) form a monetary union and interact not only among themselves but also with the rest of the world. Each region is inhabited by the following agents: two types of household (Ricardian and non-Ricardian), a competitive final goods producer, a continuum of intermediate goods producers, a fiscal authority, and a common central bank. The regions are identical in terms of the functional forms used to represent their preferences and technology; still, they do differ in terms of their actual shares of goods and input allocations.

The Ricardian households make optimal consumption, savings, and labor supply decisions and have access to the domestic and foreign bond markets. The non-Ricardian households act myopically without taking into consideration the future in their economic decisions.

In each region, final goods producers produce output for consumption and investment using a set of intermediate goods. Each producer of an intermediate good is a monopolistic supplier of a specific variety that is produced using capital and labor. The model accounts for

both tradable and non- tradable goods. Due to data limitations, we do not explicitly take into consideration the informal sector in the model.
The governments in each region collect taxes in order to finance their expenditures. They are linked by a fiscal transfer mechanism that is activated when an idiosyncratic shock hits the union. Hence, each fiscal authority pays or receives a transfer from the other if a member state is negatively affected by a shock. Each government can also borrow to balance its budget in each period. Households are subject to risk premiums on their foreign debt. Its level depends on the deviation of the external debt to GDP ratio from its steady state. The common central bank determines the nominal interest rate of the union following a Taylor rule, i.e., the nominal interest rate is adjusted in response to any change in inflation, output, or exchange rate. We consider both nominal and real frictions in the model. The price of intermediate goods is staggered, as proposed by Calvo [1983]. There are no trading frictions in the model so that the law of one price holds. It is costly to adjust capital intertemporally, and finally, productivity and terms-of-trade shocks drive business cycle fluctuations.

2.3.1 Firms

Intermediate goods producers

On the production side of the economy, there is a continuum of monopolistic competitive firms that use Cobb-Douglas production technologies to produce intermediate tradable and nontradable goods:

$$Y^s_{i,t}(j) = A^s_{i,t} K^s_{i,t}(j)^{\alpha^s} N^s_{i,t}(j)^{1-\alpha^s} \tag{2.1}$$

With $s = \{\text{Domestic Tradable (TH)}, \text{Non-tradable (N)}\}$, $A^s_{i,t}$ is a country-specific total factor productivity shock that follow an exogenous AR(1) process.

$$log(A^s_{i,t}) = log(A^s_{i,ss}) + z^s_{a_{i,t}} \tag{2.2}$$

$$z^s_{a_{i,t}} = \rho^s_{a_i} z^s_{a_{i,t-1}} + \epsilon^s_{a_{i,t}} \tag{2.3}$$

where $\epsilon^s_{a_{i,t}}$ is a serially uncorrelated shock with zero mean and standard deviation σ_{a_i} and $\rho^s_{a_i}$ is the persistent of the shock.
The intermediate goods firms take the factor price $W_{i,t}$ and $R^k_{i,t}$ as given and minimize their

costs. The cost minimization problem is then given by:

$$\underset{K^s_{i,t},N^s_{i,t}}{\text{Min}} \quad W_{i,t}N^s_{i,t} + R^k_{i,t}K^s_{i,t} \tag{2.4}$$

$$\text{subject to} \quad Y^s_{i,t} = A^s_{i,t}K^{s\alpha^s_i}_{i,t}N^{s1-\alpha^s_i}_{i,t} \tag{2.5}$$

From the first-order condition of the cost minimization problem of the firms, we get the expression for the capital-labour ratio and the marginal cost of firms producing domestic tradable and nontradable goods:

$$\frac{N_{i,t}}{K_{i,t}} = \frac{1-\alpha^s}{\alpha^s}\frac{R^k_{i,t}}{W_{i,t}} \tag{2.6}$$

$$mc^s_{i,t} = \frac{W_{i,t}}{1-\alpha^s}^{1-\alpha^s}\frac{R^k_{i,t}}{\alpha^s}^{\alpha^s}\frac{1}{A^s_{i,t}} \tag{2.7}$$

The equation (2.6) states that at the optimum, the marginal cost is affected negatively by technology and positively by the nominal wage and the rental rate of capital.

Final good producers

The final goods producers use all varieties $j \in (0,1)$ of intermediate goods as input to produce the final good $Y_{i,t}$ by adopting a Dixit-Stiglitz production function (Dixit and Stiglitz [1977]). They operate in a perfectly competitive market and face the following problem:

$$\underset{y^s_{i,t}(j)}{\text{Max}} \quad p^s_{i,t}y^s_{i,t} - \int_0^1 p^s_{i,t}(j)y^s_{i,t}(j)dj \tag{2.8}$$

$$\text{subject to} \quad y^s_{i,t} = \left[\int_0^1 y^s_{i,t}(j)^{\frac{\epsilon^p_i-1}{\epsilon^p_i}}dj\right]^{\frac{\epsilon^p_i}{\epsilon^p_i-1}} \tag{2.9}$$

The input demand function associated to this problem can be written as follow:

$$y^s_{i,t}(j) = \left(\frac{P^s_{i,t}(j)}{P^s_{i,t}}\right)^{-\epsilon^p_i}Y^s_{i,t} \tag{2.10}$$

The price of the final good is:

$$P^s_{i,t} = \left(\int_0^1 P^{s\,1-\epsilon^p_i}_{i,t}(j)dj\right)^{\frac{1}{1-\epsilon^p_i}} \tag{2.11}$$

Where $s = \{\text{Domestic Tradable (TH)}, \text{Non-tradable (N)}\}$

Price setting

Following Calvo [1983], we consider price setting in a staggered contract. A fraction $1-\theta_i^s$ of intermediate goods producers can optimally set their prices each period, while the other firms see their prices partially indexed to past inflation. The firms that have the opportunity to adjust their price level choose the optimal prices $p_{i,t}^*$ that maximize the expected present discounted value of their future profits.

$$\underset{p_{i,t}^{s*}(j)}{\text{Max}} \qquad \Pi = E_t \sum_{k=0}^{\infty} \theta_i^k \Delta_{k,t+k} \left[\frac{p_{i,t}^{s*}(j)}{P_{i,t+k}^s} y_{i,t+k}^s(j) - \frac{mc_{i,t+k}^s}{P_{i,t+k}^s} y_{i,t+k}^s(j) \right] \tag{2.12}$$

$$\text{subject to} \qquad Y_{i,t+k}^s(j) = \left[\frac{p_{i,t}^{s*}(j)}{P_{i,t+k}^s} \right]^{-\epsilon} y_{i,t+k}^s \tag{2.13}$$

Where $\Delta_{k,t+k}$ is the stochastic discount factor.
From the first-order condition of the profit maximization problem and by assuming that all firms choose the same price level, we obtain the following expression for the optimal price level:

$$P_{i,t}^{s*} = \frac{\epsilon_i^p}{\epsilon_i^p - 1} E_t \frac{\sum_{k=0}^{\infty} \theta_i^k \Delta_{k,t+s} \frac{mc_{i,t+k}^s}{1-\epsilon_i^p} y_{i,t+k}}{\sum_{k=0}^{\infty} \theta_i^k \Delta_{k,t+s} \frac{y_{i,t+k}^s}{p_{i,t+k}^{s(1-\epsilon)}}} \tag{2.14}$$

Given the optimal price that will be set by forward-looking firms if they are allowed to, the evolution of the price index is given by:

$$P_{i,t}^s = \left[(1-\theta_i) P_{i,t}^{s^{*(1-\epsilon_i^p)}} + \theta_i P_{i,t-1}^{s^{1-\epsilon_i^p}} \right]^{\frac{1}{1-\epsilon_i^p}} \tag{2.15}$$

After some algebraic manipulations, the following equation of the New-Keynesian Phillips curve that which links the inflation rate and the marginal cost:

$$\pi_{i,t}^s = \beta E_{i,t} \pi_{i,t+1}^s + \lambda_i^s mc_{i,t}^s \tag{2.16}$$

with

$$\lambda_i^s = \frac{(1-\beta\theta_i^s)(1-\theta_i^s)}{\theta_i^s} \tag{2.17}$$

2.3.2 Households

Each region is populated by a continuum of households on the interval [0,1], where a fraction h is non-Ricardian or rule-of-thumb households, and the other fraction *(1-h)* are Ricardian or forward-looking households. The non-Ricardian households do not have access to financial markets and consume all their disposable income each period. The Ricardian households maximize their expected lifetime utility. They hold government and foreign bonds, invest in private capital, rent capital to the firms, and receive profits from the monopolistic firms. The labor market is competitive, wages are the same across all households, and both household types work the same number of hours. The superscript R and NR indicate respectively variables associated with the Ricardian and non-Ricardian households.

Ricardian households

We have in each region, a representative infinitely-lived Ricardian household whose preferences is represented by the following lifetime utility function:

$$U(C_{i,t}^R, N_{i,t}) = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_{i,t}^{R^{1-\sigma}}}{1-\sigma_i} - \psi_i \frac{N_{i,t}^{R^{1+\phi_i}}}{1+\phi_i} \right) \tag{2.18}$$

where $i = \{N, W, RE\}$, $C_{i,t}$ and $N_{i,t}$ are respectively households consumption and labour supply, $\beta \in (0,1)$ is the discount factor, σ_i is the risk aversion parameter, ϕ_i is the inverse of elasticity of labor supply, ψ_i is the marginal disutility of participating in the labor market, and E is the expectation operator.

The household maximizes its lifetime utility subject to a sequence of intertemporal budget constraints:

$$\begin{aligned}(1+\tau_i^c)P_{C_{i,t}}C_{i,t}^R + B_{i,t+1} + e_{i,t}B_{i,t+1}^* + P_{I_{i,t}}I_{i,t}^R = (1-\tau_i^l)W_{it}N_{i,t}^R + (1-\tau_i^k)R_{i,t}^k K_{i,t}^R + \\ B_{i,t}(1+r_{i,t}) + e_{i,t}B_{i,t}^*(1+r_{i,t}^*) + (1-\tau_i^k)\Pi_{i,t}^R\end{aligned} \tag{2.19}$$

where τ_i^c, τ_i^l, τ_i^k are respectively tax rate on consumption spending, labor income, capital income and profit; $P_{C_{i,t}}$ and $P_{I_{i,t}}$ are the aggregate prices index of, respectively, private consumption and investment. $B_{i,t}$ and $B_{i,t}^*$ are respectively the households holding of domestic and foreign bonds that give respectively a real return $r_{i,t}$ and $r_{i,t}^*$.
The prospect that the agent plays a Ponzi game and accumulate an infinite amount of assets

is ruled out by imposing the following transversality conditions:

$$\lim_{t\to\infty} E_0\left(\frac{B_{i,t}}{1+r_{i,t}}\right)=0 \tag{2.20}$$

$$\lim_{t\to\infty} E_0\left(\frac{B^*_{i,t}}{1+r^*_{i,t}}\right)=0 \tag{2.21}$$

The physical capital stock which is owned by the Ricardian household evolves according to the following motion law:

$$K^R_{i,t+1}=(1-\delta_i)K^R_{i,t}+I^R_{i,t}\left[1-S\left(\frac{I^R_{i,t}}{I^R_{i,t-1}}\right)\right] \tag{2.22}$$

where δ_i denotes the physical rate of depreciation and $S\left(\frac{I^R_{i,t}}{I^R_{i,t-1}}\right)=\frac{\kappa_i}{2}\left(\frac{I^R_{i,t}}{I^R_{i,t-1}}-1\right)^2$ is the investment adjustment costs. From the household maximization problem, we obtain the following first-order conditions:

$$\left(C^R_{i,t}\right)^{-\sigma_i}=\lambda_{i,t}(1+\tau^c_i)P_{C_{i,t}} \tag{2.23}$$

$$\psi_i N^{R^{\phi_i}}_{i,t}=\lambda_{i,t}(1-\tau^l_i)W_{i,t} \tag{2.24}$$

$$\lambda_{i,t}=\beta E_t\lambda_{i,t+1}(1+r_{i,t+1}) \tag{2.25}$$

$$\lambda_{i,t}=\beta E_t\lambda_{i,t+1}\frac{e_{i,t+1}}{e_{i,t}}(1+r^*_{i,t+1}) \tag{2.26}$$

$$Q_{i,t}=\frac{\mu_{i,t}}{\lambda_{i,t}} \tag{2.27}$$

$$Q_{i,t}=\beta E_t\left(\frac{\lambda_{i,t+1}}{\lambda_{i,t}}\right)\left[(1-\delta_i)Q_{i,t+1}+R^k_{i,t+1}(1-\tau^k_i)\right] \tag{2.28}$$

$$P_{I_{i,t}}=Q_{i,t}-Q_{i,t}S\left(\frac{I^R_{i,t}}{I^R_{i,t-1}}\right)-Q_{i,t}S'\left(\frac{I^R_{i,t}}{I^R_{i,t-1}}\right)\frac{I^R_{i,t}}{I^R_{i,t-1}}+\beta E_t\frac{\lambda_{i,t+1}}{\lambda_{i,t}}Q_{t+1}S'\left(\frac{I^R_{i,t+1}}{I^R_{i,t}}\right)\left(\frac{I^R_{i,t}}{I^R_{i,t-1}}\right)^2 \tag{2.29}$$

where $\lambda_{i,t}$ is the Lagrange multiplier associated with the budget constraint; $\mu_{i,t}$ is the Lagrange multiplier associated with the capital accumulation equation (equation 2.22) and $Q_{i,t}$ is the shadow value, in consumption units, of one unit of $K_{i,t+1}$ at time t.

Equations 2.23- 2.28 provide the inter-temporal households' decisions in goods and asset markets. $\lambda_{i,t}$ represents the shadow price i.e., the maximum price that the consumer is willing to pay to have an extra unit of consumption in the future. This shadow price is

equal to the marginal utility of aggregate consumption in equation 2.23. $\mu_{i,t}$ is the marginal benefit in terms of the utility of one unit of investment. Equation 2.24 is the standard labor supply condition and shows that the real wage must be equal to the consumption-leisure marginal rate of substitution. Equations 2.25 and 2.26 suggest that the marginal utility of consuming one more unit today is equal to the expected present value of the additional future consumption, obtained by investing in domestic and foreign bonds. Equation 2.27 represents Tobin's Q, i.e., the marginal value of an additional unit of installed capital. Finally, equation 2.28 indicates that the value of currently installed capital depends on its future expected value, considering the depreciation rate and the expected rate of return.

Non-Ricardian household

The representative non-Ricardian household has the same instantaneous utility function as the representative forward-looking household. Still, the former can neither save nor borrow; they consume their labor income net of taxes in each period. Their budget constraint is:

$$(1+\tau_i^c)P_{C_{i,t}}C_{i,t}^{NR} = (1-\tau_i^l)W_{i,t}N_{i,t}^{NR} \tag{2.30}$$

The optimization problem of the non-Ricardian household leads to the following FOC:

$$\frac{W_{i,t}}{(1+\tau_i^c)P_{C_{i,t}}} = \frac{\psi_i N_{i,t}^{NR^{\phi_i}}}{(1-\tau_i^l)(C_{i,t}^{NR})^{-\sigma_i}} \tag{2.31}$$

Intratemporal optimization

Consumption

The aggregate consumption is described by a weighted sum of consumptions of the Ricardian and the non-Ricardian households:

$$C_{i,t} = h_i C_{i,t}^{NR} + (1-h_i)C_{i,t}^{R} \tag{2.32}$$

The aggregate consumption thus defined is expressed as a CES composite of tradable and nontradable goods. The total consumption bundle of households in region i, $C_{i,t}$, is defined as:

$$C_{i,t} = \left((1-\omega_i) C_{i,t}^{T\,\frac{\eta_i-1}{\eta_i}} + \omega_i C_{i,t}^{N\,\frac{\eta_i-1}{\eta_i}} \right)^{\frac{\eta_i}{\eta_i-1}} \tag{2.33}$$

where $C_{i,t}^{T}$ is the consumption of tradable goods and $C_{i,t}^{N}$ the consumption of nontradable goods. The share of nontradable in consumption is denoted by ω_i , η_i is the elasticity of substitution between tradable and nontradable goods. The bundle of tradable goods is composed of both home-produced goods $C_{i,t}^{TH}$ and imported foreign goods $C_{i,t}^{TF}$:

$$C_{i,t}^{T} = \left((1-\alpha_i) C_{i,t}^{TH\,\frac{\epsilon_i - 1}{\epsilon_i}} + \alpha_i C_{i,t}^{TF\,\frac{\epsilon_i - 1}{\epsilon_i}} \right)^{\frac{\epsilon_i}{\epsilon_i - 1}} \tag{2.34}$$

where α_i is the share of imported foreign goods, and ϵ_i is the elasticity of substitution between domestic and foreign goods.

The bundle of imported foreign goods is composed of goods produced in the union $C_{i,t}^{TU}$ and goods imported from the rest of the world $C_{i,t}^{TROW}$:

$$C_{i,t}^{TF} = \left((1-\chi_i) C_{i,t}^{TROW\,\frac{\upsilon_i - 1}{\upsilon_i}} + \chi_i C_{i,t}^{TU\,\frac{\upsilon_i - 1}{\upsilon_i}} \right)^{\frac{\upsilon_i}{\upsilon_i - 1}} \tag{2.35}$$

The parameter υ_i is the elasticity of substitution between goods produced in the union and the rest of the world, and χ_i measures the weight of the tradable bundle produced in the union.

Finally ($C_{i,t}^{TU}$) is a composite basket of goods imported from other countries j ($j \neq i$) and is given by :

$$C_{i,t}^{TU} = \left[\sum_{j} (\Omega_{i,j}) C_{i,t}^{Tj\,\frac{\Gamma_i - 1}{\Gamma_i}} \right]^{\frac{\Gamma_i}{\Gamma_i - 1}} \tag{2.36}$$

where Γ_i is the elasticity of substitution between goods produced in the different regions j, $\Omega_{i,j}$ is the share of tradable goods produced in each region j.

The consumption demand functions for each variety of goods can be derived from the intratemporal optimization:

$$C_{i,t}^{T} = (1-\omega_i)\left(\frac{P_{C_{i,t}}^{T}}{P_{C_{i,t}}}\right)^{-\eta_i} C_{i,t} \tag{2.37}$$

$$C_{i,t}^{N} = \omega_i\left(\frac{P_{i,t}^{N}}{P_{C_{i,t}}}\right)^{-\eta_i} C_{i,t} \tag{2.38}$$

$$C_{i,t}^{TH} = (1-\alpha_i)\left(\frac{P_{i,t}^{TH}}{P_{C_{i,t}}^{T}}\right)^{-\epsilon_i} C_{i,t}^{T} \tag{2.39}$$

$$C_{i,t}^{TF} = \alpha_i\left(\frac{P_{C_{i,t}}^{TF}}{P_{C_{i,t}}^{T}}\right)^{-\epsilon_i} C_{i,t}^{T} \tag{2.40}$$

$$C_{i,t}^{TU} = \chi_i\left(\frac{P_{C_{i,t}}^{TU}}{P_{C_{i,t}}^{TF}}\right)^{-\upsilon_i} C_{i,t}^{TF} \tag{2.41}$$

$$C_{i,t}^{TROW} = (1-\chi_i)\left(e_{i,t}\frac{PM_{i,t}^{ROW}}{P_{C_{i,t}}^{TF}}\right)^{-\upsilon_i} C_{i,t}^{TF} \tag{2.42}$$

$$C_{i,t}^{Tj} = \Omega_i\left(\frac{P_{C_{i,t}}^{Tj}}{P_{C_{i,t}}^{TU}}\right)^{-\Gamma_i} C_{i,t}^{TU} \tag{2.43}$$

The price indexes are defined as follows:

$$P_{C_{i,t}} = \left((1-\omega_i)P_{C_{i,t}}^{T^{1-\eta_i}} + \omega_i P_{i,t}^{N^{1-\eta_i}}\right)^{\frac{1}{1-\eta_i}} \tag{2.44}$$

$$P_{C_{i,t}}^{T} = \left((1-\alpha_i)P_{C_{i,t}}^{TF^{1-\epsilon_i}} + \alpha_i P_{i,t}^{TH^{1-\epsilon_i}}\right)^{\frac{1}{1-\epsilon_i}} \tag{2.45}$$

$$P_{C_{i,t}}^{TF} = \left(\tau_i P_{C_{i,t}}^{TU^{1-\upsilon_i}} + (1-\tau_i)e_{i,t}PM_{i,t}^{ROW^{1-\upsilon_i}}\right)^{\frac{1}{1-\upsilon_i}} \tag{2.46}$$

$$P_{C_{i,t}}^{TU} = \left[\sum_j \Omega_{ij}(P_{C_{j,t}}^{Tj})^{1-\Gamma_i}\right]^{\frac{1}{1-\Gamma_i}} \tag{2.47}$$

where $PM_{i,t}^{ROW}$ is the import price from the rest of the world and $e_{i,t}$ is the nominal exchange rate.

Investment

Only the Ricardian households can invest. They rent out capital, which is assumed to be invested in a homogeneous investment good. Aggregate capital $K_{i,t}$ and investment $I_{i,t}$ are

given by:

$$K_{i,t} = (1 - h_i)K_{i,t}^R \tag{2.48}$$

$$I_{i,t} = (1 - h_i)I_{i,t}^R \tag{2.49}$$

The total investment bundle in each region i is defined as a composite of tradable and nontradable:

$$I_{i,t} = \left((1 - \iota_i) I_{i,t}^{T \frac{\zeta_i - 1}{\zeta_i}} + \iota_i I_{i,t}^{N \frac{\zeta_i - 1}{\zeta_i}} \right)^{\frac{\zeta_i}{\zeta_i - 1}} \tag{2.50}$$

with ι_i the share of nontradable in total investment and ζ_i the elasticity of substitution between tradable, $I_{i,t}^T$ and nontradable $I_{i,t}^N$ investment goods. Moreover, the tradable investment good is a composite of home tradable good, $I_{i,t}^{TH}$ and the composite of foreign tradable goods, $I_{i,t}^{TF}$; its expression is given by:

$$\tag{2.51}$$

$$I_{i,t}^T = \left((1 - \nu_i) I_{i,t}^{TF \frac{\chi_i - 1}{\chi_i}} + \nu_i I_{i,t}^{TH \frac{\chi_i - 1}{\chi_i}} \right)^{\frac{\chi_i}{\chi_i - 1}} \tag{2.52}$$

where ν_i is the share of domestic tradable in investment good and χ_i is the elasticity of substitution between home and foreign tradable. The foreign tradable investment is a composite of tradable investment goods imported from the rest of the world, $I_{i,t}^{TROW}$ and of the composite investment goods imported from the other regions of the union, $I_{i,t}^{TU}$.

$$I_{i,t}^{TF} = \left(\psi_i I_{i,t}^{TU \frac{\mu_i - 1}{\mu_i}} + (1 - \psi_i) I_{i,t}^{TROW \frac{\mu_i - 1}{\mu_i}} \right)^{\frac{\mu_i}{\mu_i - 1}} \tag{2.53}$$

where ψ_i is the share of tradable investment from the union and μ_i is the degree of substitution between goods produced in the union and the rest of the world. Finally, the tradable investment in the union is a composite of home investment tradable goods of the other regions of the union, $I_{i,t}^{Tj}$; its expression is given by:

$$I_{i,t}^{TU} = \left[\sum_j (\kappa_{ij}) I_{i,t}^{Tj \frac{\xi_i - 1}{\xi_i}} \right]^{\frac{\xi_i}{\xi_i - 1}} \tag{2.54}$$

κ_i measures the degree of substitution between investment goods in foreign countries ($j \neq i$), and ξ_i measures the share of tradable imported investment in the country j. The optimal

demand function of investment goods and the associated prices indexes are defined by:

$$I_{i,t}^{T} = (1-\iota_i)\left(\frac{P_{I_{i,t}}^{T}}{P_{I_{i,t}}}\right)^{-\zeta_i} I_{it} \tag{2.55}$$

$$I_{i,t}^{N} = \iota_i\left(\frac{P_{i,t}^{N}}{P_{I_{i,t}}}\right)^{-\zeta_i} I_{it} \tag{2.56}$$

$$I_{i,t}^{TF} = (1-\nu_i)\left(\frac{P_{I_{i,t}}^{TF}}{P_{I_{i,t}}^{T}}\right)^{-\chi_i} I_{i,t}^{T} \tag{2.57}$$

$$I_{i,t}^{TH} = \nu_i\left(\frac{P_{i,t}^{TH}}{P_{I_{i,t}}^{T}}\right)^{-\chi_i} I_{i,t}^{T} \tag{2.58}$$

$$I_{i,t}^{TU} = (1-\psi_i)\left(\frac{P_{I_{i,t}}^{TU}}{P_{I_{i,t}}^{TF}}\right)^{-\mu_i} I_{i,t}^{TF} \tag{2.59}$$

$$I_{i,t}^{TROW} = \psi_i\left(\frac{e_{i,t}PM_{i,t}^{ROW}}{P_{I_{i,t}}^{TF}}\right)^{-\mu_i} I_{i,t}^{TF} \tag{2.60}$$

$$I_{i,t}^{Tj} = \kappa_i\left(\frac{P_{I_{i,t}}^{Tj}}{P_{I_{i,t}}^{TU}}\right)^{-\xi_i} I_{i,t}^{TU} \tag{2.61}$$

$$P_{I_{i,t}} = \left((1-\iota_i)P_{I_{i,t}}^{T^{1-\zeta_i}} + \iota_i P_{i,t}^{N^{1-\zeta_i}}\right)^{\frac{1}{1-\zeta_i}} \tag{2.62}$$

$$P_{I_{i,t}}^{T} = \left((1-\nu_i)P_{I_{i,t}}^{TF^{1-\chi_i}} + \nu_i P_{i,t}^{TH^{1-\chi}}\right)^{\frac{1}{1-\epsilon_i}} \tag{2.63}$$

$$P_{I_{i,t}}^{TF} = \left((1-\psi_i)P_{I_{i,t}}^{TU^{1-\upsilon_i}} + \psi_i e_{i,t}PM_{i,t}^{ROW^{1-\upsilon_i}}\right)^{\frac{1}{1-\upsilon_i}} \tag{2.64}$$

$$P_{I_{i,t}}^{TU} = \left[\sum_j \kappa_{ij}(P_{I_{j,t}}^{Tj})^{1-\xi_i}\right]^{\frac{1}{1-\xi_i}} \tag{2.65}$$

2.3.3 Common monetary authority

We consider a common monetary authority that conducts a single policy for the whole ECOWAS area. Following existing work in the DSGE literature (Justiniano and Preston [2010]; Smets and Wouters [2007]), we approximate the monetary policy using the Taylor-type rule. We introduce the exchange rate in the standard Taylor rule to take into consideration the fact that central banks in these countries conduct the monetary policy through the management of interest rates and the foreign exchange interventions (Algozhina [2012]). Hence, the common monetary authority adjusts the policy instrument in response to the economic conditions in the union, i.e. the change in the union-wide output, inflation, and

the nominal exchange rate.

$$\frac{R_t^U}{R_{ss}^U} = \left(\frac{R_{t-1}^U}{R_{ss}^U}\right)^{\gamma^r} \left(\left(\frac{Y_t^U}{Y_{ss}^U}\right)^{\gamma^y} \left(\frac{\Pi_t^U}{\Pi_{ss}^U}\right)^{\gamma^\pi} \left(\frac{e_t^U}{e_{ss}^U}\right)^{\gamma^e} \epsilon_t^m\right)^{1-\gamma^r} \tag{2.66}$$

$$P_t^U Y_t^U = \sum_i Y_{i,t} w_i^{pop} \tag{2.67}$$

$$P_t^U = \prod_i P_{i,t}^{w_i^p} \tag{2.68}$$

$$\Pi_t^U = \frac{P_t^U}{P_t^U} \tag{2.69}$$

where Y_t^U is the aggregate GDP of the union and is the sum of the output in each region (Equation 2.67), w_i^{pop} is the share of each region in the union-wide population. P_t^U is the aggregate GDP deflator in the union and is represented by the geometric mean of the country level GDP deflators (Equation 2.68), and Π_t^U is the union-wide inflation level. The relative weight w_i^p and $w_i^\pi \in [0, 1]$ are respectively calculated on the basis of the participation of the country i in the aggregate output and consumption of the union:

$$w_i^p = \frac{Y_{i,t}}{\sum_i P_{i,t} Y_{i,t}} \tag{2.70}$$

$$w_i^\pi = \frac{c_{i,t}}{\sum_i c_{i,t}} \tag{2.71}$$

2.3.4 Regional fiscal authorities

The government in each region consumes and finances any shortfall in his revenue or repay any surplus by levying tax $T_{i,t}$ on consumption spending, labour income and capital income. It can also be a receiver or contributor in the intergovernmental transfer mechanism. The government faces a period-by-period budget constraint with taxes, transfers, and newly issued government bonds on the income side. On the expenditures side of the government budget constraint, we have public spending and the maturing bonds. We assume that government spending is on nontradable goods alone and follows an exogenous stochastic process. The Government budget constraint is:

$$P_{i,t}^N G_{i,t} + R_{i,t} B_{i,t} = T_{i,t} + B_{i,t+1} + TR_{i,t} \tag{2.72}$$

Where $R_{i,t}$ is the interest rate on the bonds issued by the government, $TR_{i,t}$ is the

intergovernmental transfer, $T_{i,t}$ is the aggregate tax level and is given by:

$$T_{i,t} = \tau_i^c P_{C_{i,t-1}} C_{i,t} + \tau_i^l W_{i,t} N_{i,t} + \tau_i^k (R_{i,t+1}^k K_{i,t} + \Pi_{i,t}) \tag{2.73}$$

We assume that $G_{i,t}$ is a constant and equal to its level at the steady state:

$$log(G_{i,t}) = log(G_{i,ss}) \tag{2.74}$$

2.3.5 Fiscal equalization

Following Evers [2015], we consider a fiscal equalization scheme where regional tax systems remain unchanged, but there is a redistribution of tax revenue between member states of the union in order to equalize fiscal capacities. Whether a region contributes or receives from the fiscal equalization scheme depends on its relative fiscal capacity, which is computed using an average union-wide tax rate. The fiscal capacity is defined as the net revenue a region would raise if it applies the standard average union-wide tax rate. Member states where the fiscal position is below (above) the average will be recipients (contributors) in the fiscal equalization mechanism.

In order to ensure equitable treatment between countries with different size, we consider a transfer system that depends on the difference between the initial revenue of the region and its revenue after the negative shock, instead of the actual revenue. Also, we consider a transfer scenario based on a fraction of revenue loss and another scenario based on full compensation.

Let's assume that the tax revenue of region i is given by:

$$T_i = \tau_i Y_i \tag{2.75}$$

where τ_i is the marginal tax rate and Y_i the market income. Under this tax system, the budget constraint of the government of each region is given by:

$$P_{i,t}^N G_{i,t} + R_{i,t} B_{i,t} = \tau_i Y_i + B_{i,t+1} + TR_{i,t} \tag{2.76}$$

Now, we define an average union-wide tax system τ_u such that it generates the same net tax revenue as the union-wide tax system, i.e.:

$$\sum_i \tau_i Y_i = \tau_u Y_t^U \tag{2.77}$$

$$\Rightarrow \tau_u = \frac{\sum_i \tau_i Y_i}{Y_t^U} \tag{2.78}$$

Given the union-wide standardized tax rate, the fiscal capacity of region i is given by:

$$FC_{i,t} = \tau_u Y_{i,t} \tag{2.79}$$

Finally, the transfer received or contributed by each country in the equalization payment is given by the difference between the weighted average union-wide fiscal capacity and the fiscal capacity of each region, weighted by the parameter, γ^e, that captures the degree of compensation:

$$TR_{i,t} = \gamma^e(\tau_u \Delta Y_t^U * w_i^{pop} - \tau_u \Delta Y_{i,t}) \tag{2.80}$$

where w_i^{pop} is the weight of each region in the total union-wide population, $\gamma^e \in [0,1]$ is the fraction of revenue that is compensated in the equalization system. $\gamma^e = 1$ corresponds to full compensation, while $\gamma^e < 1$ corresponds to partial compensation.
$TR_{i,t} < 0$ means that the region is the contributor, while with $TR_{i,t} > 0$, the region will be the receiver in the equalization system. We consider a hypothetical federal fiscal authority that collects revenue from one region and rebates the transfer receipts to the other region. It serves as a balance sheet only, and its budget constraint is such that the sum of transfers is equal to zero :

$$\sum_i TR_{i,t} = 0 \tag{2.81}$$

2.3.6 International price

The ECOWAS countries are small compared to the global economies, and therefore, they consider the world interest rate as given. Hence, we assume $r_{i,t}^*$ is a constant and equal to the interest rate at the steady state:

$$log(r_{i,t}^*) = log(r_{i,ss}^*) \tag{2.82}$$

The bilateral terms-of-trade between the domestic economy and the rest of the world is defined by:

$$TOT_{i,t} = \frac{PX_{i,t}^{ROW}}{PM_{i,t}^{ROW}} \tag{2.83}$$

Each region is a price-taker vis-a-vis the rest of the world markets, and hence, the export and import prices from the ROW are exogenous.

$$log(PX_{i,t}^{ROW}) = log(PX_{i,ss}^{ROW}) + z_{i,t}^{px} \tag{2.84}$$

$$z_{i,t}^{px} = \rho_i^{px} z_{i,t-1}^{px} + \epsilon_{i,t}^{px} \tag{2.85}$$

$$log(PM_{i,t}^{ROW}) = log(PM_{i,ss}^{ROW}) + z_{i,t}^{pm} \tag{2.86}$$

$$z_{i,t}^{pm} = \rho_i^{pm} z_{i,t-1}^{pm} + \epsilon_{i,t}^{pm} \tag{2.87}$$

where $\epsilon_{i,t}^{px}$ and $\epsilon_{i,t}^{pm}$are respectively the exports and imports price shocks, and ρ_i are the persistence of the shocks.

2.3.7 Market clearing conditions and model dynamics

We end the model description with the specification of the market-clearing conditions. In equilibrium, all markets clear. The market-clearing condition in the domestic tradable sectors implies that the goods in that sector are either consumed, invested domestically, or sold abroad:

$$Y_{i,t}^{TH} = C_{i,t}^{TH} + I_{i,t}^{TH} + EX_{i,t}^{ROW} + \sum_j EX_{i,t}^{j} \tag{2.88}$$

where $EX_{i,t}^{ROW}$ and $EX_{i,t}^{j}$ represent respectively the exports of region i to the rest of the world and to the other regions of the union.

$$EX_{i,t}^{ROW} = \tau \left(\frac{PX_{i,t}^{ROW}}{P_{i,t}^{TH}} \right)^{-\upsilon} Y_{i,t}^{ROW} \tag{2.89}$$

$$EX_{i,t}^{j} = C_{j,t}^{Ti} + I_{j,t}^{Ti} \tag{2.90}$$

Equation (2.88) says that all tradable goods produced in the economy are sold at home and abroad. The expression for the exports demands from the rest of the world is given in Equation (2.89). Equation (2.90) indicates that the exports of each region i to region j is equal to the imports of consumption and investment goods by region j.
The output level for the rest of the world is assumed to be fixed and equal to its level at the steady state:

$$log(y_{i,t}^{ROW}) = log(y_{i,ss}^{ROW}) \tag{2.91}$$

Similarly, the market-clearing condition in the nontradable sectors imply that the nontradable goods are either consumed, invested, or purchased by the government:

$$Y_{i,t}^{N} = C_{i,t}^{N} + I_{i,t}^{N} + G_{i,t} \tag{2.92}$$

The market-clearing condition in the labour and capital markets are such that:

$$K_{i,t} = \int_{0}^{1} K_{i,t}^{TH} + \int_{0}^{1} K_{i,t}^{N} \tag{2.93}$$

$$N_{i,t} = \int_{0}^{1} N_{i,t}^{TH} + \int_{0}^{1} N_{i,t}^{N} \tag{2.94}$$

The dynamic of the model is represented by the sectoral NKPC (2.17), the intertemporal decision in the goods and asset market (2.23)-(2.28), the equations for the common monetary policy (2.66)-(2.69) and the government budget constraint (2.76). The other equations of the model are the sectoral production function (2.1), the real marginal cost (2.6), the intratemporal consumption decision (2.37)-(2.42) and investment decision (2.55)-(2.60), the equations for the fiscal equalization mechanism (2.77)-(2.80) and the equilibrium conditions (2.88)-(2.92).

2.4 Data, calibration, and results

This section presents the data used in the model, the calibration of the parameters as well as the simulation results.

2.4.1 Data and calibration

The model is calibrated for the 15 ECOWAS countries, using annual data covering the period 1981-2012. As in many studies, the calibration exercise consists in either borrowing the parameters from the literature on the economies of similar structure or estimating them from time-series data for the economies studied, or a mix of both. In this study, we calibrate the parameters following the standard methodology in the literature in order to reproduce the observed first moments of the endogenous variables. For simplicity, we assume that the three regions are symmetric, and hence, all the elasticity parameters are identical, but the share parameters in the various functional forms are not identical. The latter reflects the observed shares in the data in each region. Table 2.1 presents the calibrated values of the parameters used in the model.

2.4.2 Business cycle analysis and variance decomposition

This section presents some business cycle statistics related to the intergovernmental fiscal arrangement considered in this paper. In particular, Tables 2.2- 2.8 display the standard deviations of selected variables following an adverse productivity shock affecting each region individually, the regional cross-correlation, and the decomposition of the variances. The standard deviation allows us to explore the capability of the fiscal equalization scheme to stabilize business cycle fluctuation. The regional cross-correlation serves as an indicator of interregional risk sharing, and finally, the variance decomposition of the different shocks provides the contribution of the shocks to the variability of some macroeconomic variables. Overall, the model performs well in matching the patterns observed in the data. As display in Table 2.2- 2.4, the simulated standard deviation statistics follow the same patterns as in observed data. One important business cycle fact to highlight is that consumption is more volatile than output. This result is consistent with the facts observed in developing countries and can mainly be explained by the presence of non-Ricardian households which has no consumption smoothing behavior.

The result also suggests that regardless of the origin of the shock, GDP, investment, consumption, and labour supply of both Ricardian and non-Ricardian households are less volatile under the fiscal equalization regime as compared to the benchmark case of no transfers in the three regions. Moreover, the variability of these indicators depends on the value of γ^e i.e., on the share of fiscal needs that is compensated in the equalization system. In the full equalization scenario ($\gamma^e = 1$), the variables remain more volatile compared to the moderate equalization system ($\gamma^e = 1/2$ or $\gamma^e = 1/3$). This is explained by the fact that providing full compensation to a vast country like Nigeria can represent a considerable burden to the other region and hence contributes to more significant economic fluctuations.

On the other hand, the comparison between the first and the second panels of Table 2.6 shows that the regional cross-correlation of GDP, consumption, investment, and labour supply decrease with the implementation of the intergovernmental federal fiscal transfers. This drop in the co-movement between these macroeconomic variables indicates that the transfer mechanism plays a limited role as a risk-sharing tool. Moreover, there is a negative correlation between the fiscal transfers and GDP in each region, which means that the transfers are countercyclical, and in general, the prospering region is the contributor to the equalization system. It follows from this analysis that, overall, the fiscal equalization mechanism can help stabilize business cycle fluctuations compared to the regime without transfers. However, the optimality of such a system depends on the large extent on the value of γ^e.

Tables 2.7 and 2.8 present the contribution of each shock, namely the tradable productiv-

ity shock and the terms-of-trade shock, to the variability of selected endogenous variables for each block of countries. It follows from the results that tradable productivity shocks hitting the Nigerian economy are the main driver of the business cycle fluctuation in the three regions. However, the introduction of the fiscal equalization payment reduces the contribution of productivity shock from Nigeria to business cycle fluctuations in the region.
For a better understanding of these findings, we explore in the next section, the impulse responses of selected macroeconomic variables to country-specific productivity and terms-of-trade shock.

2.4.3 Impulse response analysis

We consider two types of shock that hit each region individually: productivity and terms-of-trade shocks. Figures 2.4-2.12 present the impulse responses [5] of selected variables to country-specific negative productivity and terms-of-trade shocks in the three regions considering the scenario of fiscal transfer with full compensation (red line) and the scenario without transfer (blue dashed line). For simplicity, in our discussions, we denote "home region", the region where the shock originates, and the "partner regions", the two other regions in the model.
We start with a negative 1% productivity shock that hits each economy. Before elaborating on the efficiency of the transfer mechanism, let us describe the effect of the shocks in the baseline scenario. The responses of the main variables are similar in the three regions. With the negative productivity shock, inflation increase in the home region because of the rise in the firms' marginal cost. Consequently, the central bank raises its nominal interest rate, and thus, households prefer to consume less. The negative relationship between the interest rate and consumption is indeed due to the intertemporal trade-off between consumption and saving by the Ricardian households. The shock has a negative effect on total output and labour supply. Both consumption and labour supply of Non-Ricardian households respond more to the shock as compared to the Ricardian households. In fact, the former are credit constrained and cannot smooth their consumption over time, while the latter can increase their consumption by increasing debt over time, knowing that the shock is temporary. Moreover, with the increase in inflation in the home regions, their competitiveness falls, shifting demand away from home goods. This is observed in Figure 2.2, with a decline in total exports in Nigeria following the shock. However, because of the decline in households' wealth, there is a decrease in total imports as well as imports from the union.
The shock is negatively propagated across regions with a decline in output, consumption,

[5] Note that on the graph the y-axis of the regime without transfer is on the left side and transfer mechanism is on the right side

investment and labour supply in the partner regions. This negative cross-border effect is, on the one hand, explained by the drop in aggregate demand in the home region, which leads to a drop in their demand for foreign goods. Also, the union-wide interest rate hikes following the shock leading the households to reduce consumption and save more.
Now let's consider the introduction of the transfer system. The transfer impacts the different economies through two opposing effects. First, the positive effect of the increase in government revenue in the recipient region, which reduces the extent to which deficits are debt-financed. Hence, there is an increase in aggregate income in the recipient region in the short run, a decline in its government debt, and an increase in households' consumption and investment. Second, the negative effect due to the decrease in output in the contributing region. Regardless of the source of the productivity shock, the net effect is positive with a more stable output in the three regions, but some differences are observed across regions regarding the stabilization property of the transfer.

When the intergovernmental fiscal transfer is introduced with shocks originating from Nigeria, it reduces the negative effect of the drop in productivity on total output. As shown in Figure 2.2, the negative productivity shock in Nigeria leads to 1%, 0.7%, and 0.8% drop in aggregate output in respectively Nigeria, WAEMU, and RECOWAS. Under the transfer mechanism, the drop in output is 0.04%, 0.02%, and 0.01% for Nigeria, WAEMU, and RECOWAS, respectively, showing a high absorption of the shock. Another important point to highlight is that output becomes more stable in WAEMU and RECOWAS compared to Nigeria, with the transfer mechanism. This can be explained by the fact that the volume of transfer needed to absorb the shock hitting Nigeria and WAEMU is very small compared to the volume of transfer required to absorb a shock of the same magnitude in Nigeria. As an example, with the negative productivity shock hitting RECOWAS, the decline in its total output moves from 0.2% to nearly 0% with the transfer.

We now move to the macroeconomic responses of selected indicators to terms-of-trade deterioration in each region, considering the two fiscal arrangements (Figures 2.8- 2.12). The shock is represented by a one standard deviation decrease in the export price to the rest of the world in each region taken individually. Following the adverse terms-of-trade shock, consumption and production fall temporarily below their long-term levels in the home region, with inflationary pressure as a result. However, since they are in a currency union setting, the increase in domestic inflation induced by the shock affects the average union-wide inflation rate only slightly. The reason for this is that the ability of the common central bank to respond to this country-specific shock is limited. With the implementation of the transfer mechanism, revenue flow from the well-performing regions to the other regions negatively affected by the shock. The inter-regional fiscal transfers in this scenario play a limited role

in stabilizing the negative effect of the terms-of-trade shock. As shown in Figure 2.8, no significant change is observed in the initial drop in output, following the introduction of the transfer system. Overall, it follows from the analysis that the stabilization properties of the transfer system depend on the nature of the shocks and on the region directly affected by the negative shock. Compensating loss encounters by large regions like Nigeria seems unrealistic with the transfer system, while the opposite is observed when the compensation is directed toward the small regions.

2.5 Welfare analysis

In order to assess whether the intergovernmental transfer scheme could be beneficial for the three regions, we proceed in this session to the analysis of its long-run welfare implication. For this welfare analysis, the model has been simulated for 50 periods corresponding to 50 years in the future, considering stochastic terms-of-trade and productivity shock affecting each region.

Following Schmitt-Grohé and Uribe [2004] and Kim et al. [2008], we compute utility-based welfare using the second-order approximation of the utility function.
The welfare of households in each region i is defined by:

$$U_i = \sum_{t=0}^{\infty} EU(c_{i,t}, N_{i,t}) \tag{2.95}$$

The second-order Taylor approximation of the utility around the steady-state is:

$$EU(C_{i,t}, N_{i,t}) = U(C_i, N_i) + C_i^{1-\sigma_i} E(\tilde{C}_{i,t}) + \psi_i N_i^{1+\phi} E(\tilde{N}_{i,t}) - \frac{1}{2}\sigma_i C_i^{1-\sigma_i} var(\tilde{C}_{i,t}) - \frac{1}{2}\psi_i \phi N_i^{1+\phi} var(\tilde{N}_{i,t}) \tag{2.96}$$

where $\tilde{X}_{i,t} = (\tilde{C}_{i,t}, \tilde{N}_{i,t})$ is the deviation of $X_{i,t}$ from its steady-state value. and $var(\tilde{X}_{i,t})$ is the variance of $X_{i,t}$

The unconditional welfare gain or loss ϖ^{total} resulting from the introduction of the transfer regime is represented by the permanent change in the steady-state consumption required to achieve the same expected utility function.

$$EU^{FI}((1 + \varpi_i^{total})C_{i,t}, N_{i,t}) = EU^{FU}(C_{i,t}, N_{i,t}) \tag{2.97}$$

where EU^{FU} and EU^{FI} are respectively the utility associated with the regime with federal fiscal transfer and the regime without fiscal transfer. If $\varpi^{total} > 0$, then the households are better off under federal fiscal transfers compared to the situation without transfer. The

unconditional welfare can be decomposed into two components: the change in consumption due to the effect of the shock on the mean of the variables ϖ^{mean} and the effect of the shock on the variance of the variables ϖ^{var} (see Kollmann [2002] and Bergin, Shin and Tchakarov [2007]). Hence the total welfare change is given by:

$$\varpi_i^{total} = \varpi_i^{mean} + \varpi_i^{var} \tag{2.98}$$

Tables 2.9 and 2.10 present the results of the welfare analysis considering stochastic productivity and terms-of-trade shocks hitting each region. It reports the change in consumption relative to the steady-state level for the three regions that would be needed to have the same utility under both scenarios.

The results show that regardless of the source and the type of shocks, the recipients of the transfers always experience a welfare gain while there is welfare loss in the contributing region. In the case of productivity shocks in Nigeria, welfare increase by 1.6% in Nigeria while it decreases respectively by 1.8%, and 2.4% in WAEMU and RECOWAS. Indeed, the transfer affects the government deficit and hence reduce or increase the need to rely on bonds to finance the exogenous government spending. Therefore, the households in the contributing (receiving) region will have less (more) resources for consumption and investment following the transfer, and as a consequence, their welfare deteriorates (improves). However, with the productivity shock affecting WAEMU and RECOWAS individually, only Nigeria encounters a welfare loss. This can be explained by the fact that it is the biggest region in the ECOWAS area and is more likely to always contribute more to the transfer system. Similar results are also observed when the regions are hit by terms-of-trade shocks. Note that the welfare loss (gain) is mostly driven by the decrease (increase) in consumption mean.

2.6 Conclusion

In a monetary union where both monetary and exchange rate policy are not available as stabilizing tools, common fiscal instruments are essential to deal with asymmetric shocks. This can take the form of intergovernmental fiscal transfers from the booming regions to the ones in recession in order to stabilize business cycle fluctuations. Using a multi-region, multi-sector DSGE model, we investigate the question in order to contribute to the current debate on the economic implications of the ECOWAS monetary union project. Specifically, we provide a quantitative assessment of the effect of an intergovernmental fiscal transfer mechanism and its role in stabilizing business cycle fluctuations in the upcoming monetary union in the ECOWAS region. For this purpose, we divide the ECOWAS region into three blocks (Nigeria, WAEMU, RECOWAS) that are negatively affected by country-specific pro-

ductivity and terms-of-trade shocks, and we simulate a multi-region New-Keynesian model using data covering the period 1981-2012. Due to the dependence of the transfer on the relative size of the regions, we ensure as much as possible that the system is equitable. We also take into consideration the moral hazard issue that the transfer scheme can raise. We consider a transfer system based on the change in revenue relative to the baseline scenario and also by considering both full and partial compensation systems.

The main lesson that can be drawn from this analysis is that, in general, the transfer system stabilizes output fluctuations in each region following idiosyncratic shocks. It also reduces the standard deviation of the fluctuations of the main variables. However, the results depend on the size of the affected region and whether the transfer mechanism is full or partial. Considering the scenario of full compensation of loss in revenue following an adverse shock, our results show that the transfer mechanism plays an important role in absorbing idiosyncratic productivity shocks in the union as a whole. However, with the transfer, output is more stabilized in WAEMU and RECOWAS compared to Nigeria. Also, the stabilization property of the transfer is limited, with the idiosyncratic terms-of-trade shocks hitting the different regions. Moreover, the intergovernmental fiscal transfer system with full compensation of loss in revenue leads to an overall welfare loss for the contributors and welfare gain for the recipients. This suggests that the optimality of the system also depends on whether to introduce a full or a partial equalization system.

Even though the optimal design of the fiscal transfer mechanism that will maximize the welfare of the whole region is beyond the scope of this paper, it is essential to consider such an analysis in future work. Our results are in line with those obtained in the case of the European Monetary Union by (Evers [2012], Hefeker and Neugart [2015], Hebous and Weichenrieder [2015], etc.). They found that the effectiveness of the transfer system in a monetary union depends critically on several factors, including the way it is designed and the size of the regions.

Appendix Chapter 2

Table 2.1: Calibration of model parameters

Parameter	Description	Nigeria	WAEMU	RECOWAS
σ	Risk aversion parameter	2.61	2.61	2.61
ϕ	Inverse labor supply elasticity	1	1	1
β	Discount factor	0.96	0.96	0.96
δ	Depreciation rate of capital	0.05	0.05	0.05
η, ζ	Elast. of subst. between T and NT consumption and investment goods	0.9	0.9	0.9
ϵ, χ, υ, μ, Γ, φ	Elast. of subst. between varieties of Tradable consumption and investment goods	1.5	1.5	1.5
ϱ	Elast. of subst. between the varieties of export goods	1.5	1.5	1.5
$\rho_a^{TH,NT}$	Persistence in domestic T and NT productivity	0.9	0.9	0.9
ρ_{pm}	persistence in world import price	0.75	0.75	0.75
$\sigma_a^{TH,NT}$	Standard deviation of productivity shock	0.01	0.01	0.01
σ_{pm}	Standard deviation of import price shock	0.01	0.01	0.01
$\theta^{TH,NT}$	Calvo parameter for domestic T and NT firms	0.8	0.8	0.8
γ^{π}	Inflation parameter in the Taylor rule	1.5	1.5	1.5
γ^{y}	Output parameter in the Taylor rule	0.8	0.8	0.8
γ^{r}	Interest rate smoothing parameter	0.6	0.6	0.6
γ^{e}	Exchange rate parameter in the Taylor rule	0.8	1.7	0.8
τ^{c}	Consumption tax rate	0.073	0.175	0.142
τ^{l}	Labour income tax rate	0.024	0.025	0.018
τ^{k}	Capital income tax rate	0.010	0.025	0.015
	Steady state value			
C/Y	Ratio of private consumption to GDP	0.68	0.73	0.77
I/Y	Ratio of Investment GDP	0.13	0.16	0.21
G/Y	Ratio of government spending to GDP	0.09	0.15	0.10
X/Y	Ratio of export to GDP	0.31	0.24	0.26
I/Y	Ratio of Import to GDP	0.21	0.34	0.38

Table 2.2: Standard deviations (Productivity shock from NIGERIA)

		Data	Without federal fiscal arrangement	With federal fiscal arrangement		
				$\gamma^e = 1$	$\gamma^e = 1/2$	$\gamma^e = 1/3$
Output	Nigeria	0.137	0.060	0.039	0.037	0.033
	WAEMU	0.276	0.149	0.096	0.092	0.080
	RECOWAS	0.120	0.092	0.054	0.052	0.045
Consumption	Nigeria	0.159	0.154	0.102	0.098	0.085
	WAEMU	0.271	0.148	0.096	0.092	0.081
	RECOWAS	0.135	0.188	0.112	0.108	0.094
Investment	Nigeria	0.394	0.194	0.142	0.138	0.125
	WAEMU	0.146	0.882	0.569	0.546	0.478
	RECOWAS	0.459	0.099	0.056	0.053	0.046

Source: Author's calculation.

Table 2.3: Standard deviations (Productivity shock from WAEMU)

		Data	Without federal fiscal arrangement	With federal fiscal arrangement		
				$\gamma^e = 1$	$\gamma^e = 1/2$	$\gamma^e = 1/3$
Output	Nigeria	0.137	0.277	0.210	0.209	0.205
	WAEMU	0.276	0.865	0.517	0.514	0.505
	RECOWAS	0.120	0.425	0.291	0.289	0.284
Consumption	Nigeria	0.159	0.688	0.522	0.519	0.509
	WAEMU	0.271	0.666	0.499	0.496	0.487
	RECOWAS	0.135	0.862	0.594	0.591	0.580
Investment	Nigeria	0.394	0.697	0.539	0.535	0.522
	WAEMU	0.146	4.047	3.052	3.037	2.991
	RECOWAS	0.459	0.449	0.291	0.287	0.278

Source: Author's calculation.

Table 2.4: Standard deviations (Productivity shock from RECOWAS)

		Data	Without federal fiscal arrangement	With federal fiscal arrangement		
				$\gamma^e = 1$	$\gamma^e = 1/2$	$\gamma^e = 1/3$
Output	Nigeria	0.137	0.104	0.082	0.079	0.077
	WAEMU	0.276	0.259	0.193	0.192	0.189
	RECOWAS	0.120	0.158	0.108	0.107	0.106
Consumption	Nigeria	0.159	0.260	0.197	0.196	0.192
	WAEMU	0.271	0.256	0.192	0.191	0.188
	RECOWAS	0.135	0.318	0.217	0.216	0.212
Investment	Nigeria	0.394	0.263	0.201	0.200	0.195
	WAEMU	0.146	1.519	1.131	1.126	1.111
	RECOWAS	0.459	0.165	0.107	0.106	0.103

Source: Author's calculation.

Table 2.5: Correlation of selected variables with GDP

Monetary union without federal fiscal arrangement			
	NIGERIA	WAEMU	RECOWAS
GDP	1	1	1
Consumption	0.9256	0.9463	0.9275
Labour supply	0.9989	0.9879	0.9923
Investment	0.8614	0.8945	0.8273
Monetary union with federal fiscal arrangement			
GDP	1	1	1
Consumption	0.8011	0.8619	0.9094
Labour supply	0.995	0.9898	0.9921
Investment	0.3554	0.8552	0.7734
Transfers	-0.9241	-0.6075	-0.6655

Source: Author's calculation.

Table 2.6: Regional cross-correlation of selected aggregate variables

Monetary union without federal fiscal arrangement						
	NIGERIA		WAEMU		RECOWAS	
	WAEMU	RECOWAS	NIGERIA	RECOWAS	NIGERIA	WAEMU
GDP	0.96	0.98	0.96	0.96	0.98	0.96
Consumption	0.96	0.99	0.96	0.99	0.85	0.89
Investment	0.98	0.95	0.98	0.98	0.74	0.83
Labour	0.97	0.99	0.97	0.96	0.99	0.97
Monetary union with federal fiscal arrangement						
GDP	0.86	0.90	0.86	0.96	0.90	0.96
Consumption	0.94	0.97	0.94	0.99	0.64	0.87
Investment	0.94	0.90	0.96	0.97	0.44	0.76
Labour	0.91	0.95	0.91	0.96	0.95	0.96

Source: Author's calculation.

Table 2.7: Variance decomposition: Monetary union without federal fiscal arrangement (in percentage)

	ϵ_{ath} (NG)	ϵ_{tot}(NG)	ϵ_{ath} (W)	ϵ_{tot}(W)	ϵ_{ath}(RE)	ϵ_{tot}(RE)
	NIGERIA					
GDP	69.3	0.37	27.31	1.07	0.1	1.85
Investment	66.25	0.4	29.24	1.26	0.15	2.7
Total Consumption	68.94	0.37	27.44	1.12	0.04	2.09
Ricardian	69.19	0.34	26.61	1.18	0.09	2.58
Non ricardian	68.93	0.37	27.54	1.1	0.05	2
Total Labour supply	68.93	0.37	27.61	1.09	0.08	1.92
Ricardian	68.93	0.37	27.6	1.09	0.08	1.92
Non ricardian	68.93	0.37	27.54	1.1	0.05	2
	WAEMU					
GDP	67.88	0.3	28.54	1.26	0.09	1.93
Investment	67.15	0.28	28.67	1.39	0.06	2.44
Total Consumption	66.87	0.29	29.05	1.37	0.03	2.39
Ricardian	65.31	0.28	30.18	1.44	0.07	2.72
Non ricardian	67.61	0.29	28.5	1.34	0.03	2.23
Total Labour supply	68.3	0.3	27.98	1.3	0.06	2.07
Ricardian	68.15	0.3	28.1	1.31	0.04	2.11
Non ricardian	67.61	0.29	28.5	1.34	0.03	2.23
	RECOWAS					
GDP	67.76	0.29	28.78	1.17	0.03	1.96
Investment	67.53	0.28	28.42	1.25	0.04	2.48
Total Consumption	67.18	0.29	29.06	1.23	0.02	2.23
Ricardian	66.19	0.28	29.58	1.3	0.07	2.57
Non ricardian	67.62	0.29	28.83	1.19	0.01	2.07
Total Labour supply	67.76	0.29	28.75	1.18	0	2.01
Ricardian	67.75	0.29	28.76	1.18	0	2.02
Non ricardian	68.93	0.37	27.54	1.1	0.05	2

Source: Author's calculation.

Table 2.8: Variance decomposition: Monetary union with federal fiscal arrangement (in percentage)

	ϵ_{ath} (NG)	ϵ_{tot}(NG)	ϵ_{ath} (W)	ϵ_{tot}(W)	ϵ_{ath}(RE)	ϵ_{tot}(RE)
	NIGERIA					
GDP	38.97	0.04	19.79	2.52	23.55	15.13
Investment	16.27	2.42	36.2	3.42	22.69	18.99
Total consumption	35.11	0.08	17.88	2.5	28.36	16.06
Ricardian	83.28	1.05	12.44	0.74	0.77	1.71
Non Ricardian	35.99	0.03	18.15	2.51	27.37	15.95
Total labour supply	42.23	0.03	18.11	2.37	22.91	14.36
Ricardian	38.85	0.01	18.22	2.46	25.2	15.26
Non Ricardian	35.99	0.03	18.15	2.51	27.37	15.95
	WAEMU					
GDP	43.36	0.22	14.12	1.13	26.45	14.72
Investment	37.37	0.18	19.05	2.24	28.04	13.11
Total consumption	35.39	0.17	17.4	1.48	32.26	13.31
Ricardian	31.89	0.15	55.19	5.16	4.77	2.83
Non Ricardian	38.28	0.19	13.97	0.81	31.96	14.8
Total labour supply	40.19	0.2	18.26	0.93	26.33	14.09
Ricardian	39.66	0.2	15.85	0.79	28.91	14.6
Non Ricardian	38.28	0.19	13.97	0.81	31.96	14.8
	RECOWAS					
GDP	39.44	0.2	13	1.87	29.69	15.8
Investment	68.98	0.26	23.73	1.97	0.12	4.94
Total consumption	37.41	0.19	14.02	1.8	27.47	19.1
Ricardian	41.48	0.21	50.43	2.65	3.6	1.63
Non Ricardian	39.78	0.2	11.11	1.92	26.33	20.65
Total labour supply	41.93	0.22	14.17	2.11	22.28	19.29
Ricardian	40.8	0.21	12	2	24.71	20.28
Non Ricardian	39.78	0.2	11.11	1.92	26.33	20.65

Source: Author's calculation.

Table 2.9: Measures of welfare change for productivity shocks (% of steady state consumption)

	NIGERIA	WAEMU	RECOWAS
Productivity shock in NIGERIA			
ϖ^{mean}	1.626	-1.864	-2.447
ϖ^{var}	-0.001	-0.017	-0.006
ϖ^{total}	1.625	-1.881	-2.453
Productivity shock in WAEMU			
ϖ^{mean}	-0.356	1.320	0.956
ϖ^{var}	-0.003	-0.015	-0.004
ϖ^{total}	-0.358	1.305	0.952
Productivity shock in RECOWAS			
ϖ^{mean}	-0.017	2.049	3.967
ϖ^{var}	-0.003	-0.002	-0.042
ϖ^{total}	-0.020	2.047	3.925

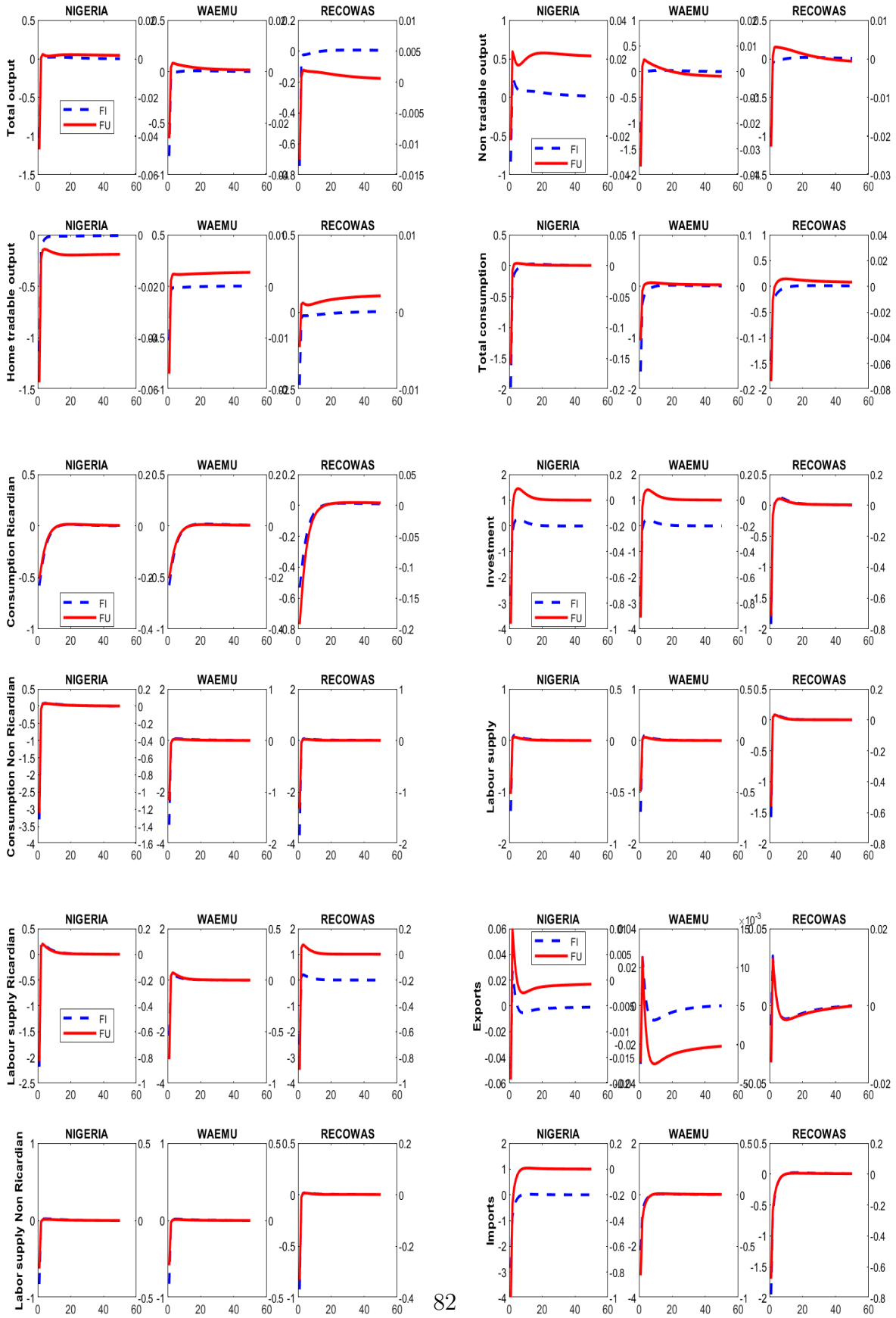
Source: Author's calculation.

Table 2.10: Measures of welfare change for terms-of-trade shocks (% of steady state consumption)

	NIGERIA	WAEMU	RECOWAS
terms-of-trade shock in NIGERIA			
ϖ^{mean}	0.031	-0.023	-0.023
ϖ^{var}	-0.002	-0.004	0.006
ϖ^{total}	0.029	-0.027	-0.017
terms-of-trade shock in WAEMU			
ϖ^{mean}	-0.784	0.994	0.038
ϖ^{var}	-0.001	-0.001	0.001
ϖ^{total}	-0.785	0.992	0.039
terms-of-trade shock in RECOWAS			
ϖ^{mean}	-0.988	-0.975	0.022
ϖ^{var}	-0.002	0.003	0.075
ϖ^{total}	-0.990	-0.972	0.096

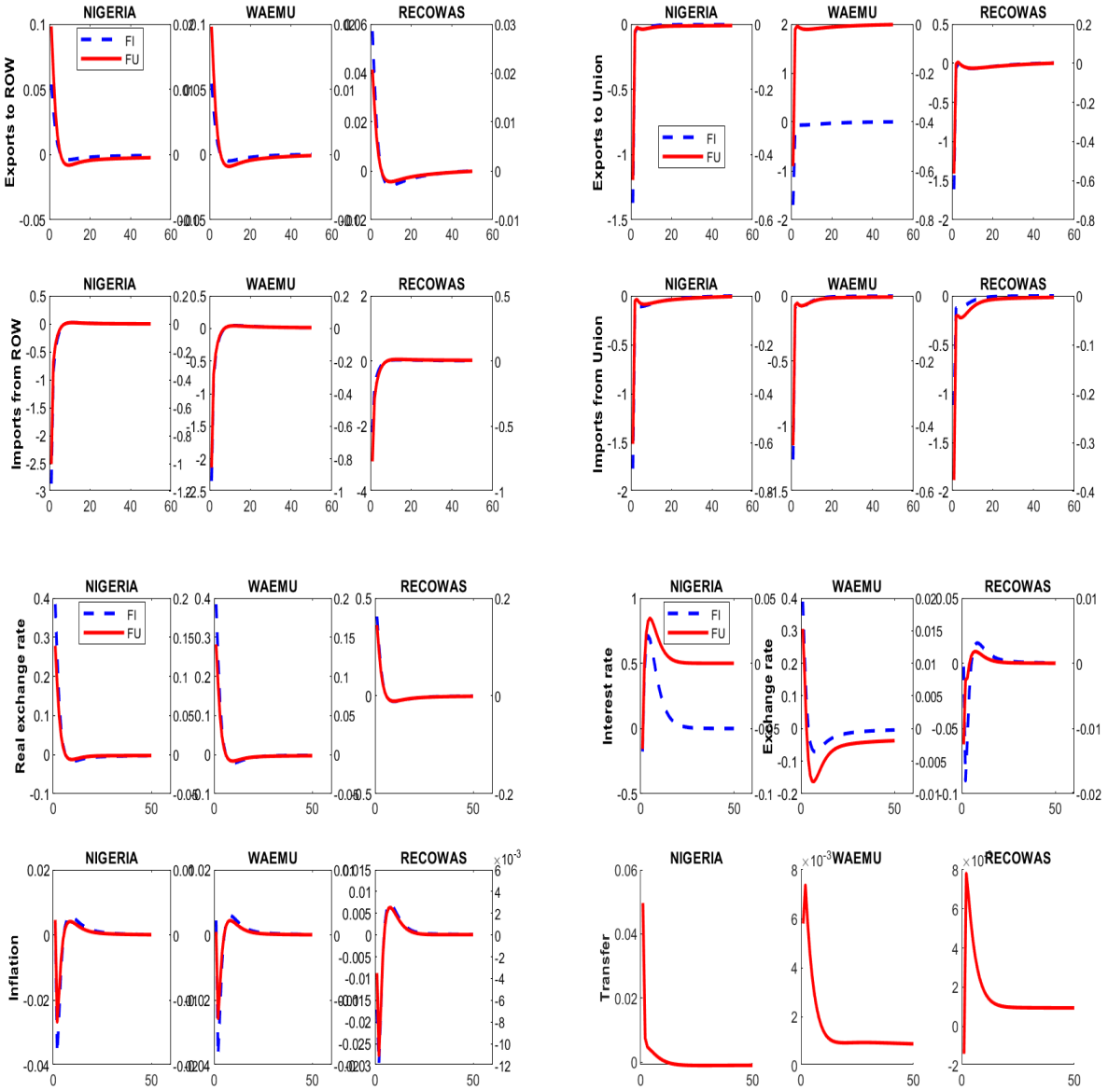
Source: Author's calculation.

Figure 2.1: **Effects of a tradable productivity shock originating from Nigeria (part 1)**



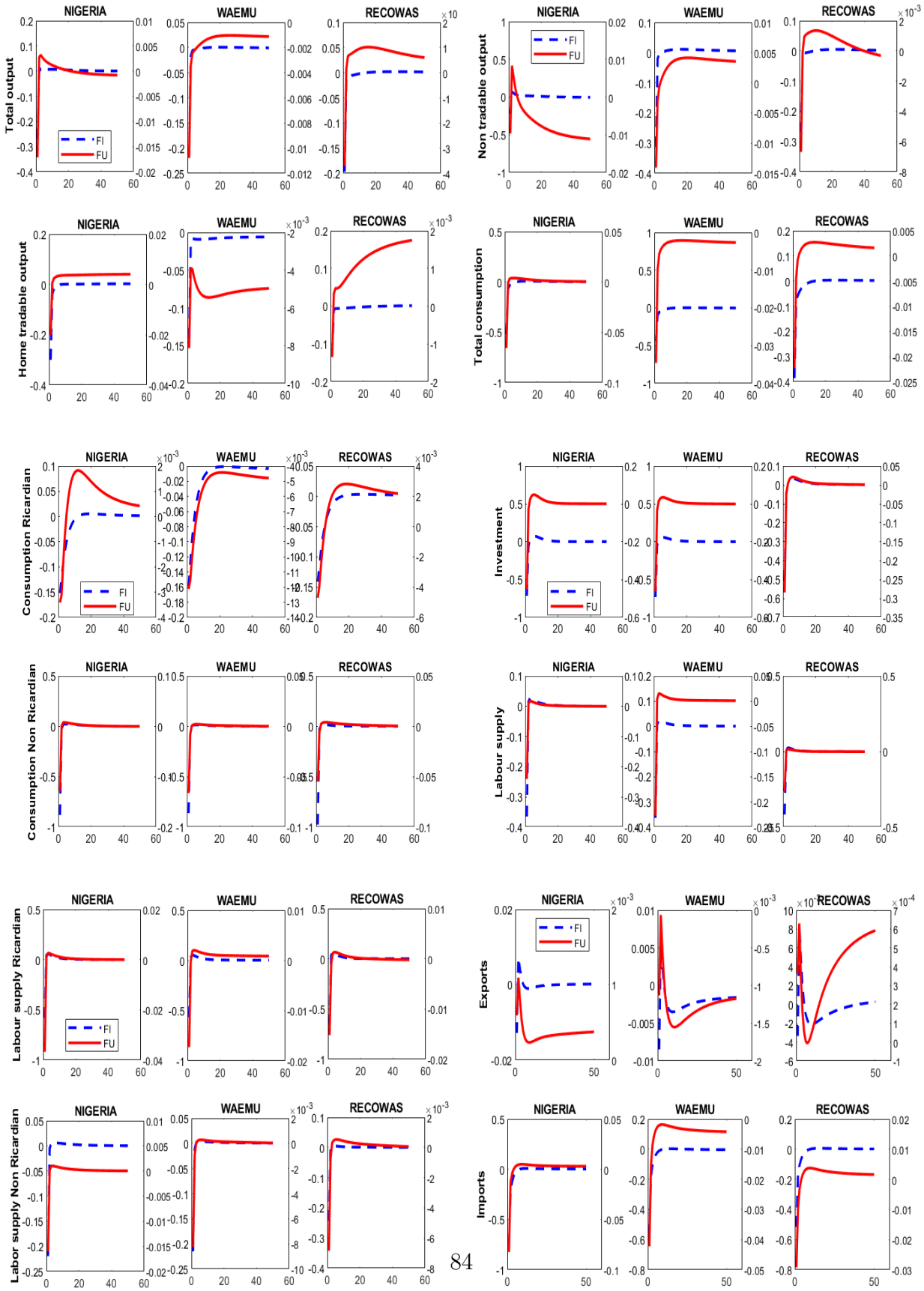
The IRFs are displayed in a two Y-axis: the left axis is for the scenario without transfer (blue dashed line) and the right axis is for the scenario of fiscal transfer with full compensation (red line).

Figure 2.2: **Effects of a tradable productivity shock originating from Nigeria (part 2)**



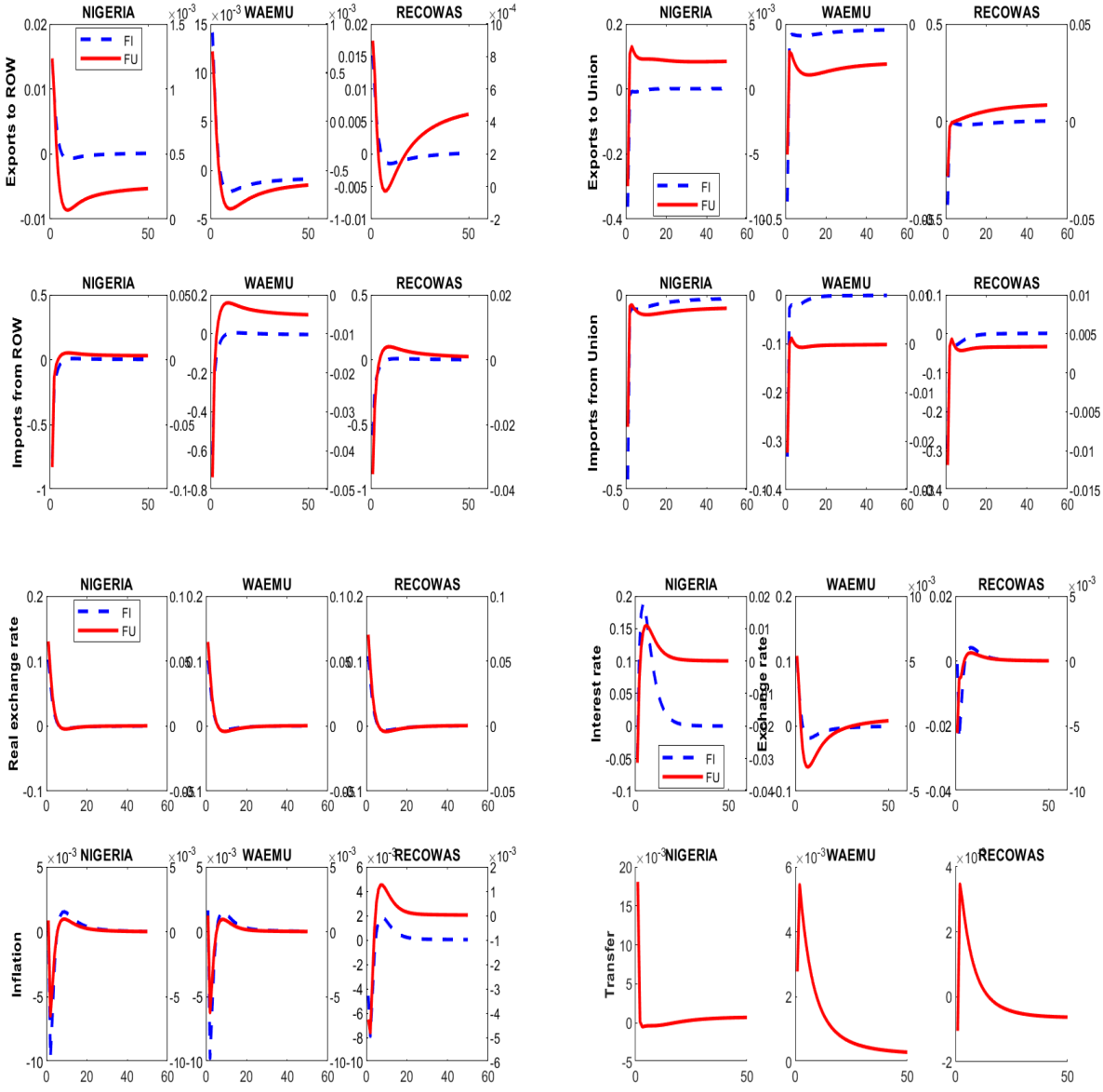
The IRFs are displayed in a two Y-axis: the left axis is for the scenario without transfer (blue dashed line) and the right axis is for the scenario of fiscal transfer with full compensation (red line).

Figure 2.3: **Effects of a tradable productivity shock originating from WAEMU (part 1)**



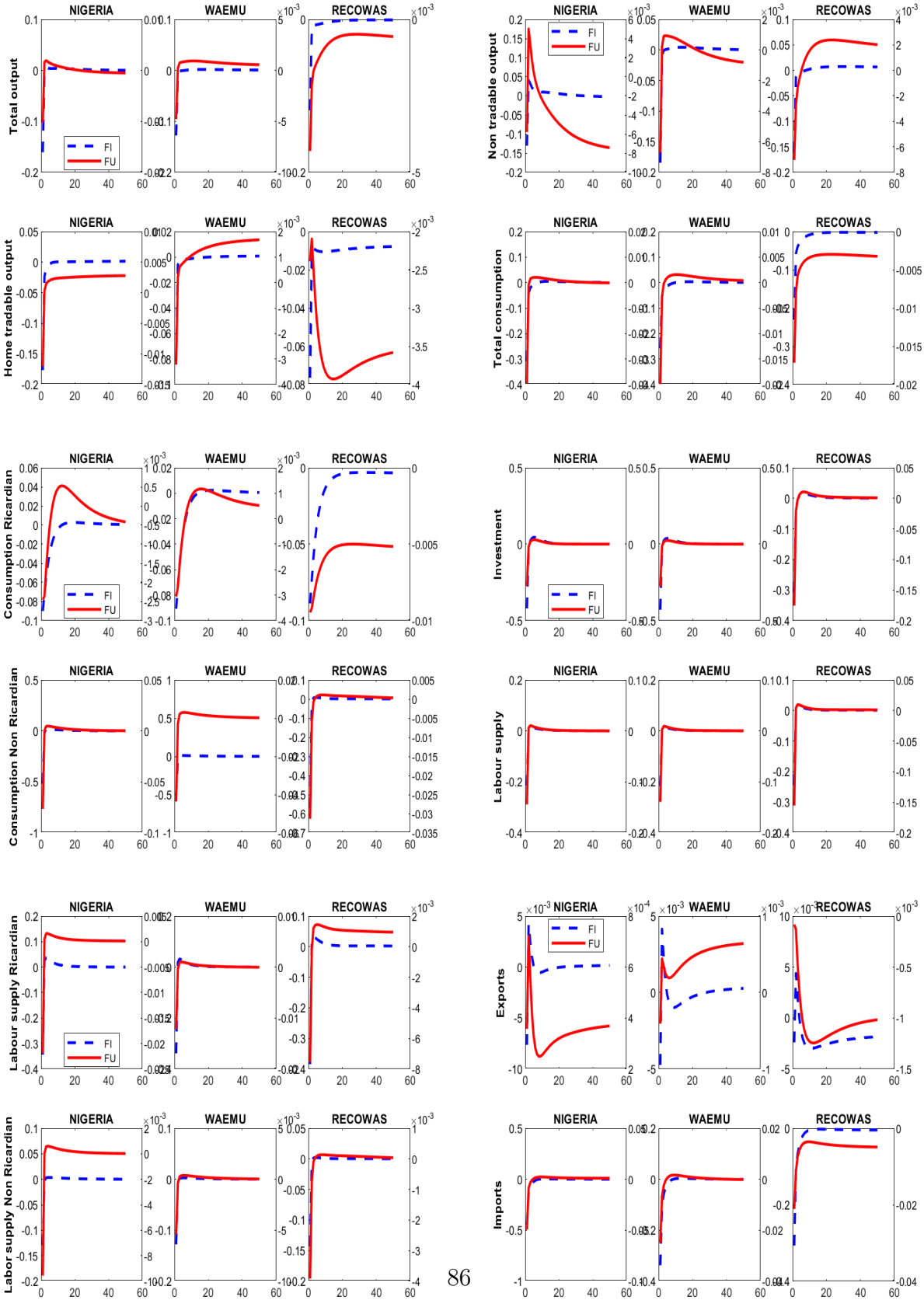
The IRFs are displayed in a two Y-axis: the left axis is for the scenario without transfer (blue dashed line) and the right axis is for the scenario of fiscal transfer with full compensation (red line).

Figure 2.4: **Effects of a tradable productivity shock originating from WAEMU (part 2)**



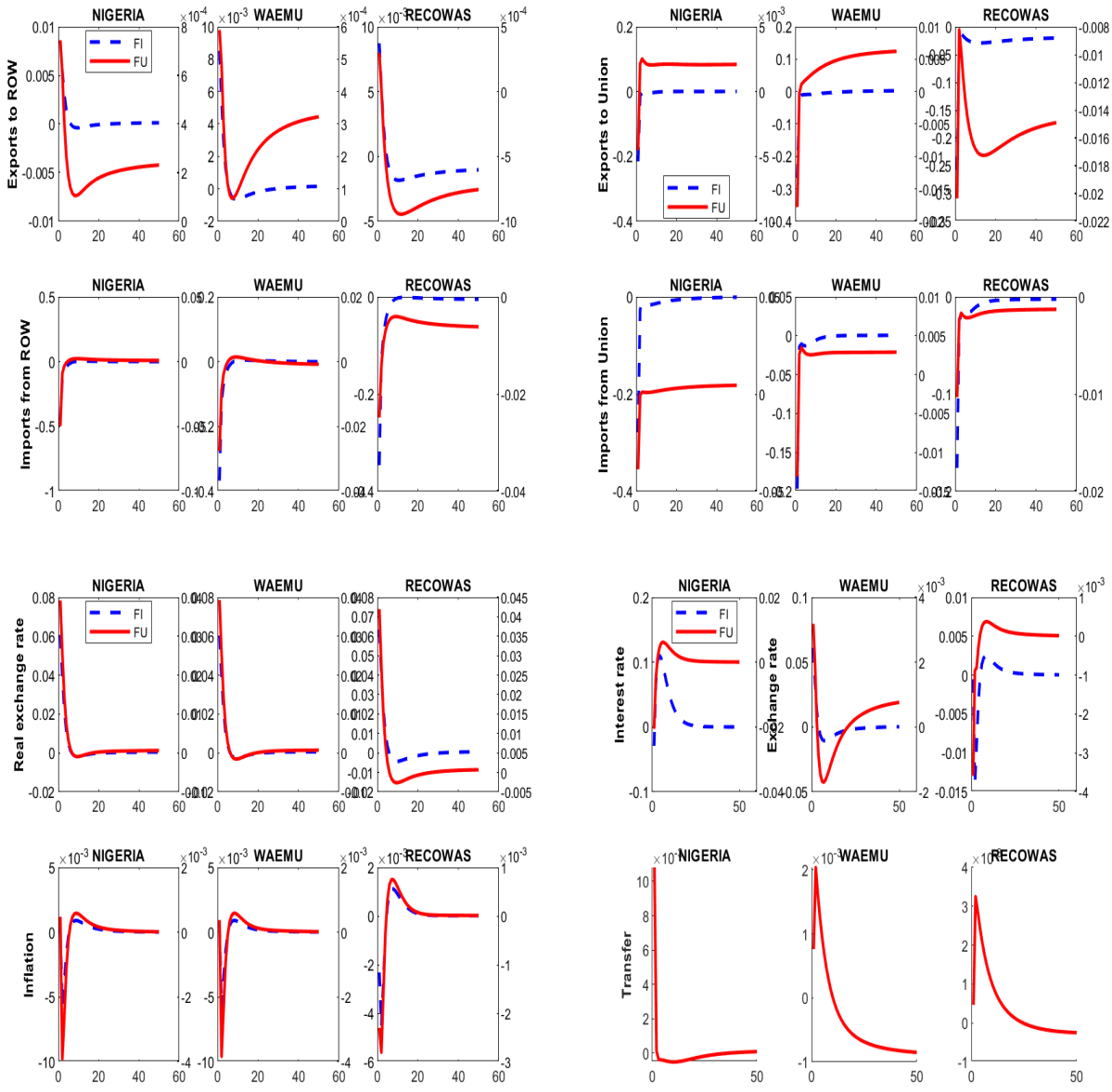
The IRFs are displayed in a two Y-axis: the left axis is for the scenario without transfer (blue dashed line) and the right axis is for the scenario of fiscal transfer with full compensation (red line).

Figure 2.5: **Effects of a tradable productivity shock originating from RECOWAS (part 1)**



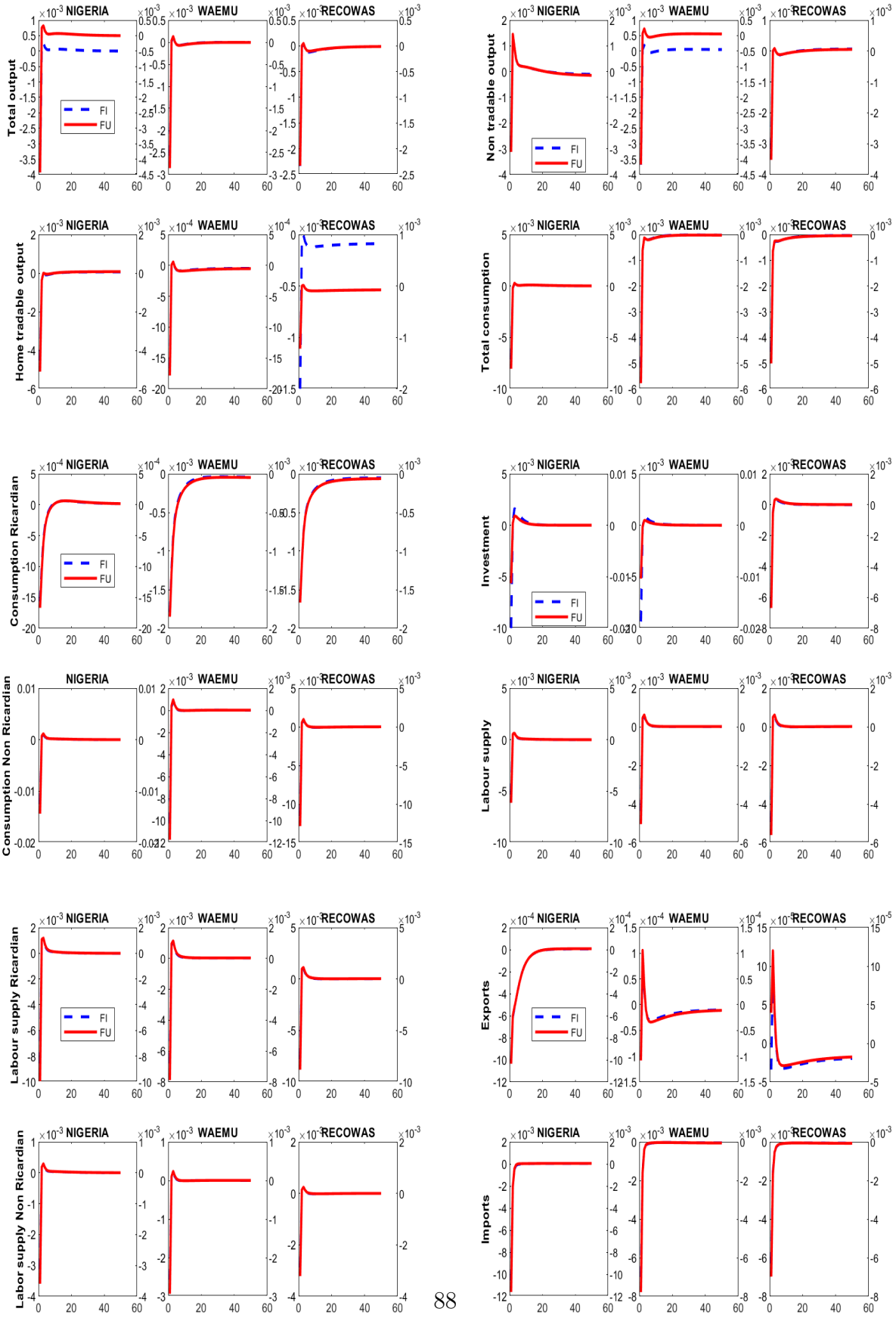
The IRFs are displayed in a two Y-axis: the left axis is for the scenario without transfer (blue dashed line) and the right axis is for the scenario of fiscal transfer with full compensation (red line).

Figure 2.6: **Effects of a tradable productivity shock originating from RECOWAS (part 2)**



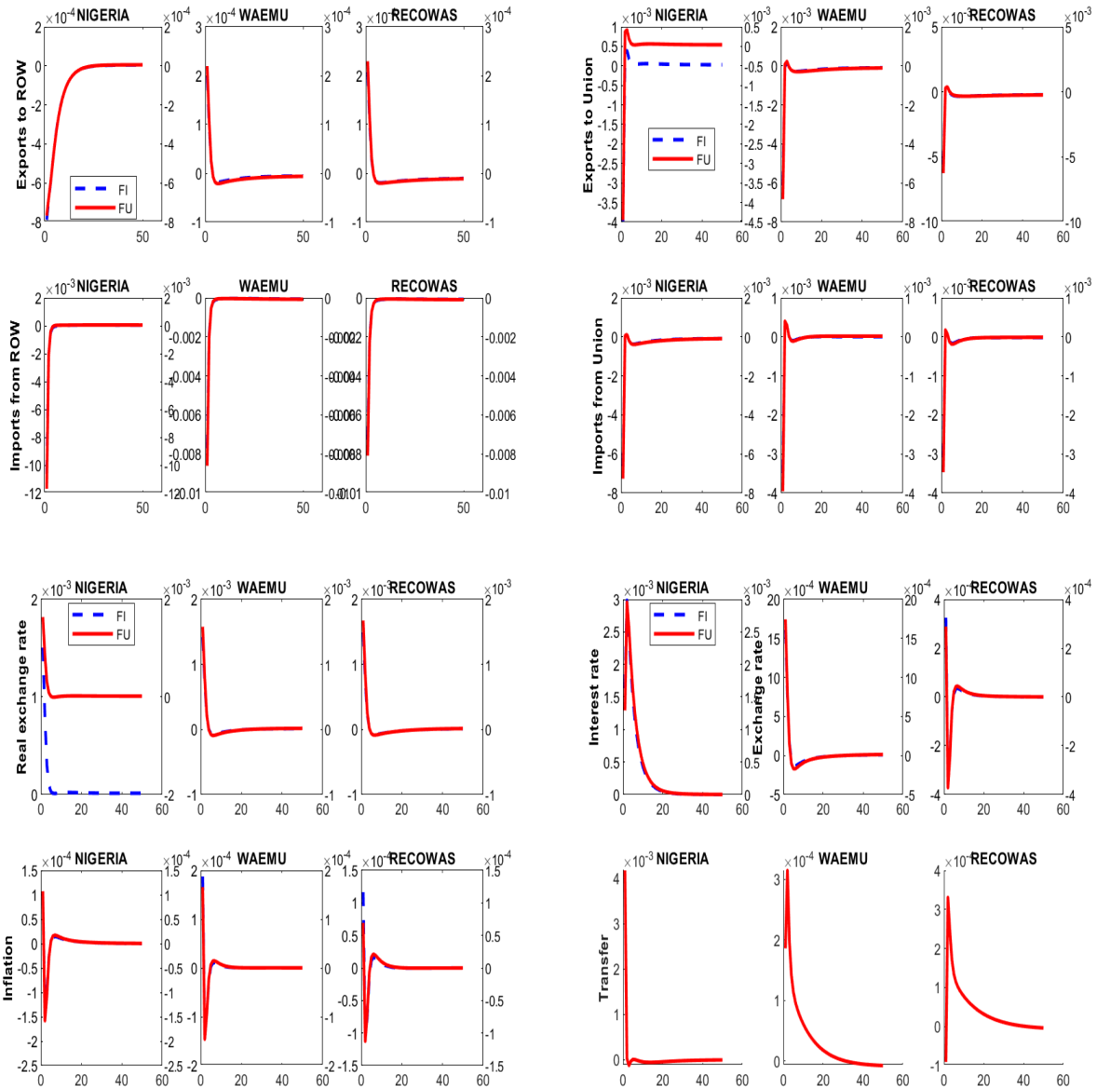
The IRFs are displayed in a two Y-axis: the left axis is for the scenario without transfer (blue dashed line) and the right axis is for the scenario of fiscal transfer with full compensation (red line).

Figure 2.7: **Effects of a terms-of-trade shock originating from Nigeria (part 1)**



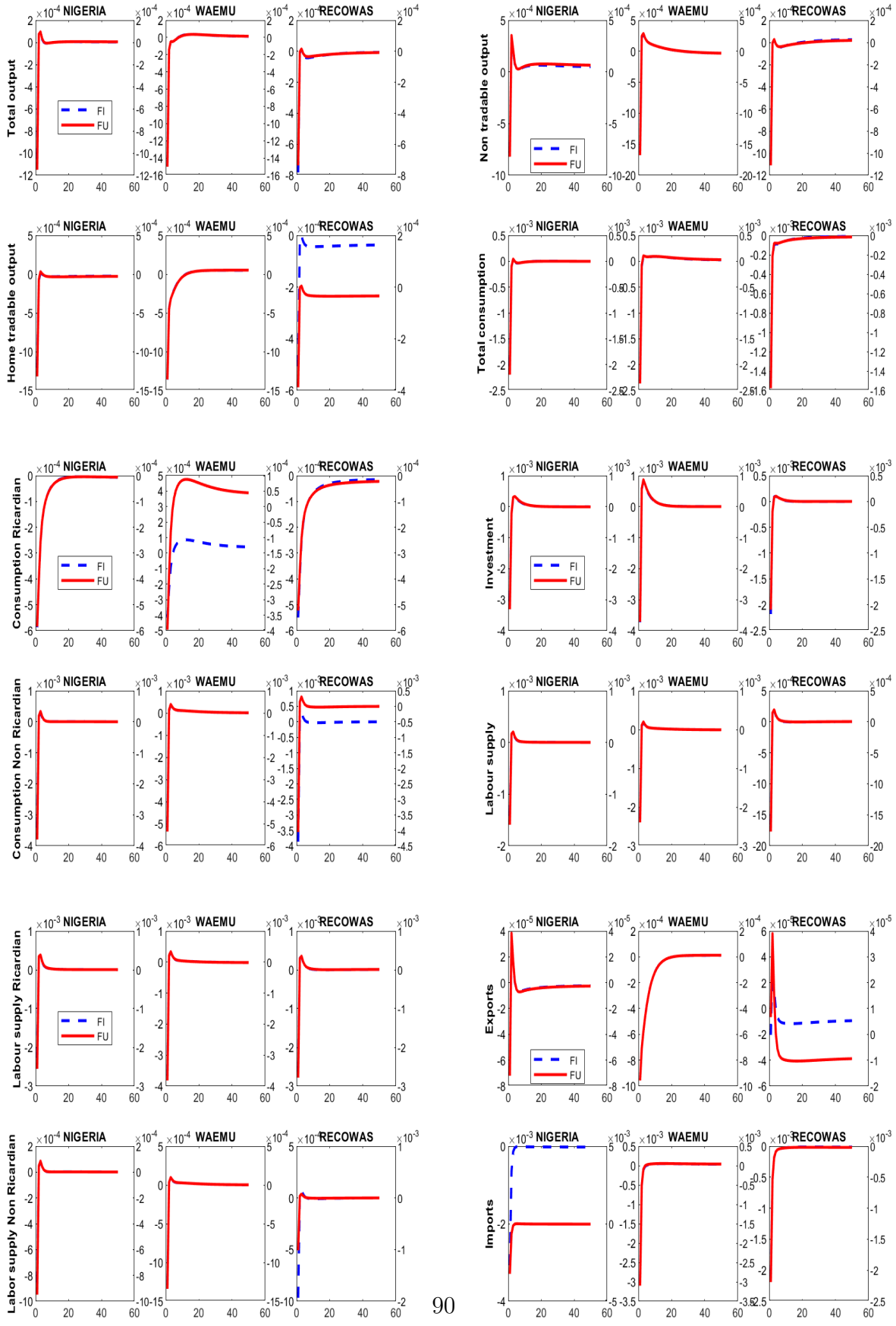
The IRFs are displayed in a two Y-axis: the left axis is for the scenario without transfer (blue dashed line) and the right axis is for the scenario of fiscal transfer with full compensation (red line).

Figure 2.8: **Effects of a terms-of-trade shock originating from Nigeria (part 2)**



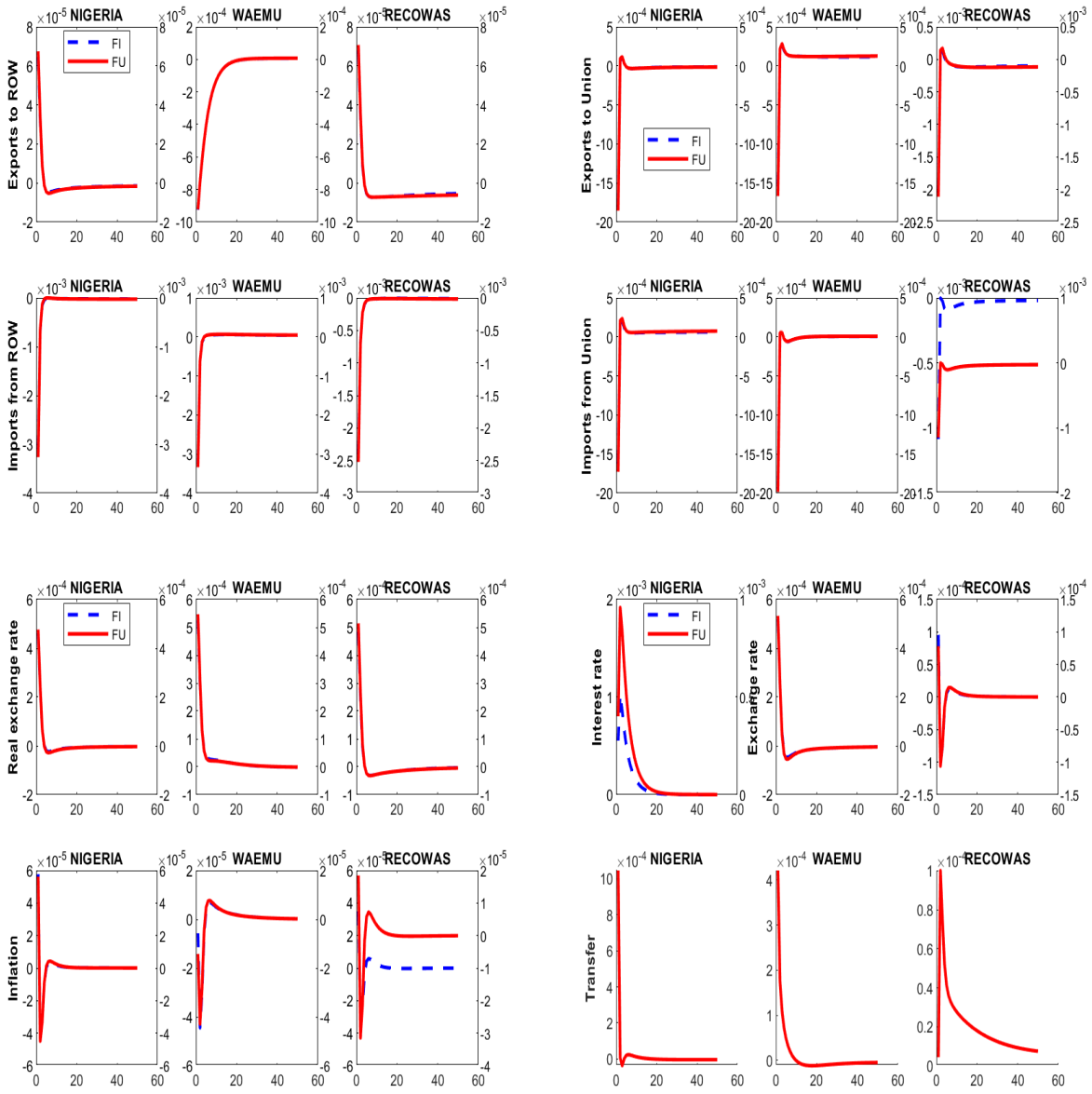
The IRFs are displayed in a two Y-axis: the left axis is for the scenario without transfer (blue dashed line) and the right axis is for the scenario of fiscal transfer with full compensation (red line).

Figure 2.9: **Effects of a terms-of-trade shock originating from WAEMU (part 1)**



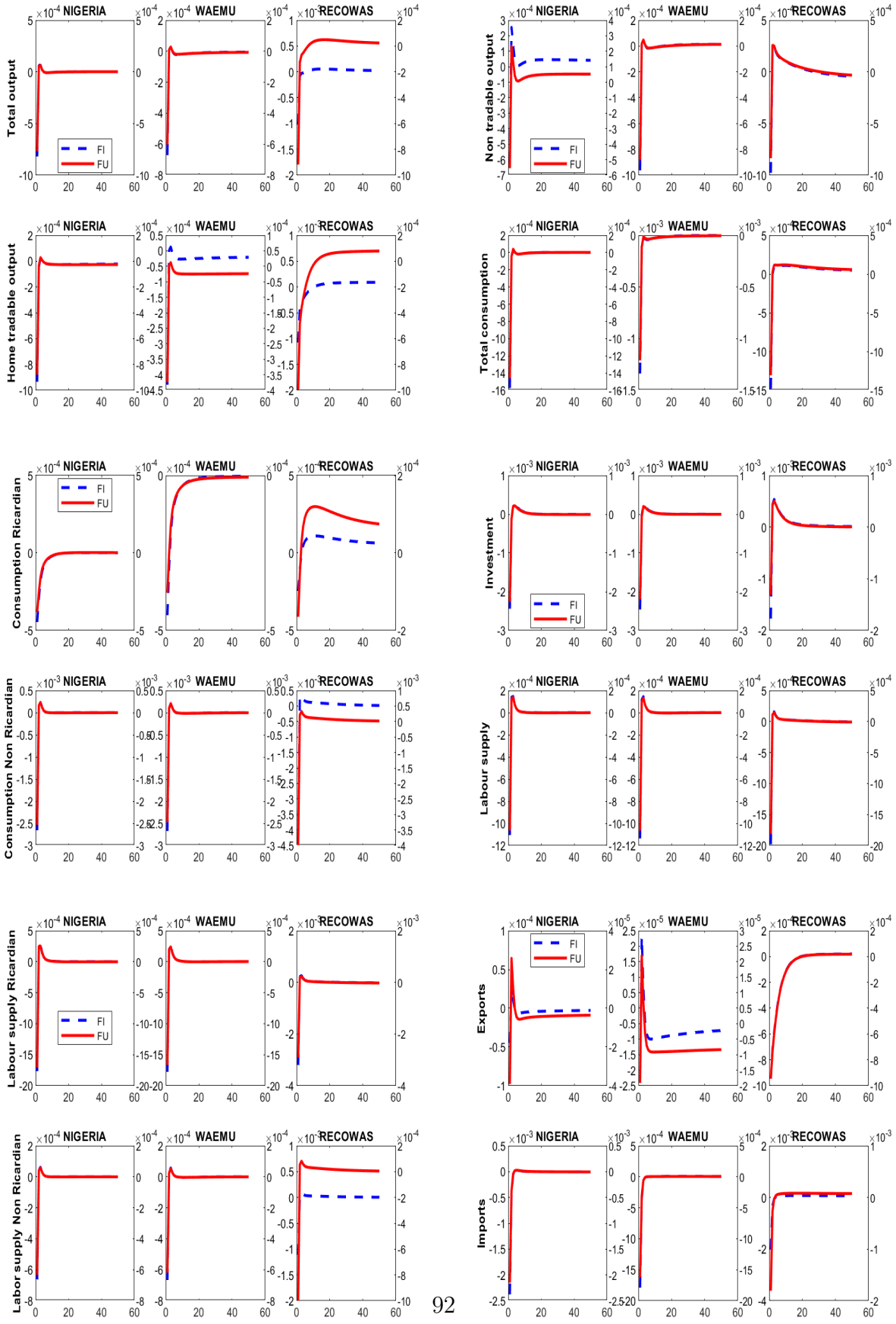
The IRFs are displayed in a two Y-axis: the left axis is for the scenario without transfer (blue dashed line) and the right axis is for the scenario of fiscal transfer with full compensation (red line).

Figure 2.10: **Effects of a terms-of-trade shock originating from WAEMU (part 2)**



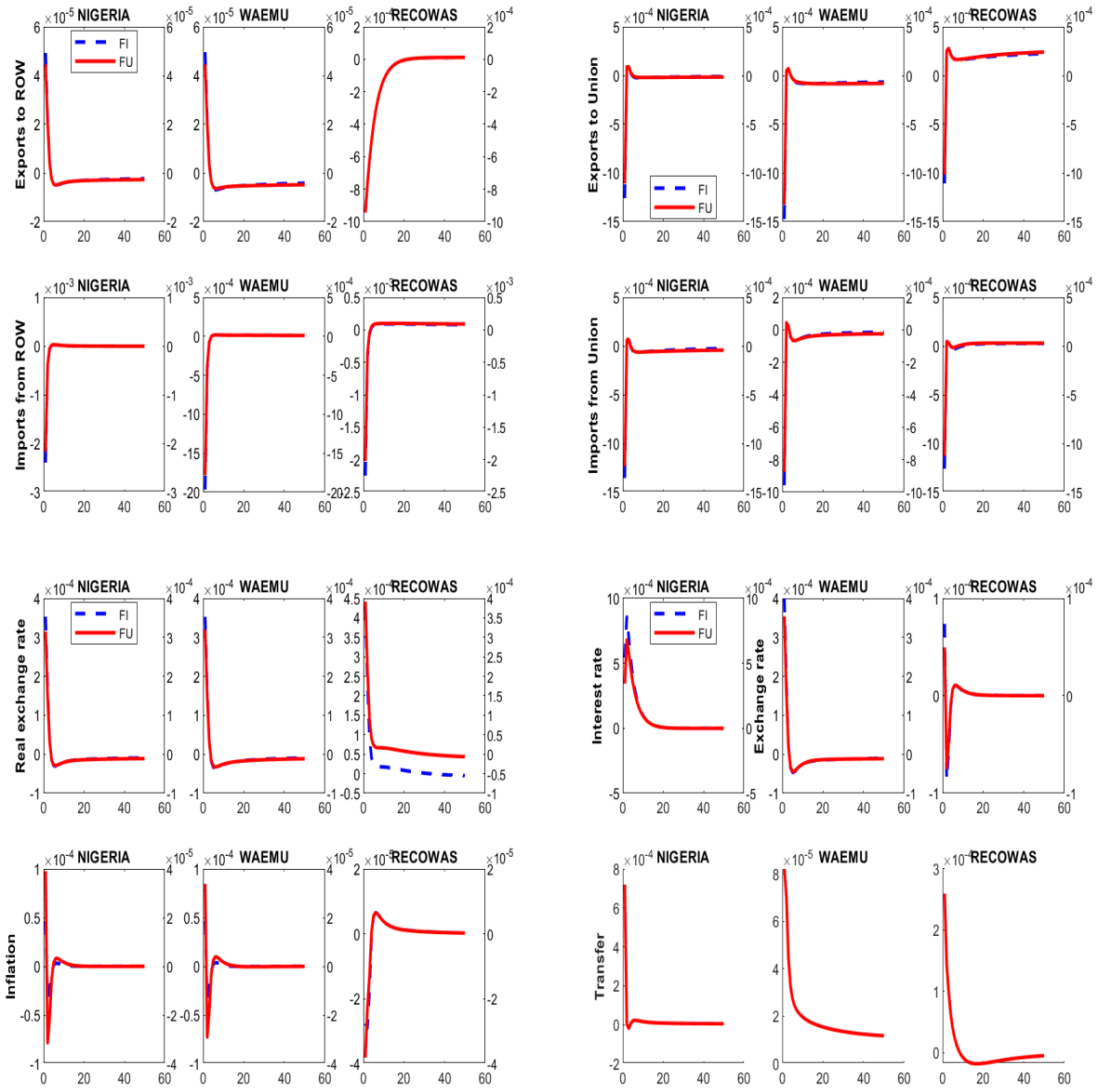
The IRFs are displayed in a two Y-axis: the left axis is for the scenario without transfer (blue dashed line) and the right axis is for the scenario of fiscal transfer with full compensation (red line).

Figure 2.11: **Effects of a terms-of-trade shock originating from RECOWAS (part 1)**



The IRFs are displayed in a two Y-axis: the left axis is for the scenario without transfer (blue dashed line) and the right axis is for the scenario of fiscal transfer with full compensation (red line).

Figure 2.12: **Effects of a terms-of-trade shock originating from RECOWAS (part 2)**



The IRFs are displayed in a two Y-axis: the left axis is for the scenario without transfer (blue dashed line) and the right axis is for the scenario of fiscal transfer with full compensation (red line).

Chapter 3

Fiscal Policy in the Transition to Monetary Union: A Global VAR Analysis for the West African Countries

3.1 Introduction

How a change in fiscal policy affects economic activity in developing countries, and how likely countries are to use their budgetary tools in ways that may not jeopardize aggregate economic stability in a monetary union? These are key questions to address in the current policy and academic debates over the creation of a monetary union in the Economic Community of West African States (ECOWAS)[1] . The ECOWAS is indeed an economic community launched in 1975 by 15 West African countries in order to foster economic and monetary integration in the region. As part of their regional integration goals, the ECOWAS initiated in 2000 a project of forming a monetary union. The region already contains a monetary union called the West African Economic and Monetary Union (WAEMU)[2], and their objective is to move to an enlarged monetary union for the whole region. This project raised legitimate doubt on the ability of these countries to create a successful monetary union.
The objective of this paper is to contribute to this debate by assessing the role fiscal policy will play in the smooth transition to this monetary union. We investigate whether fiscal policy plays a significant role in the dynamics of the leading macroeconomic indicators in these countries; we also provide a measure of fiscal spillovers in the region. Our goal is two-fold: first, we investigate the dynamic effects of variation in public spending and tax revenue on economic activity at the country and regional levels. Second, we provide evidence on the role fiscal policy can play in the success of the ECOWAS monetary union project. Understanding the effects of one country's fiscal policies on output in other members of the upcoming ECOWAS monetary union is indeed of high interest. It will allow their common central bank to better gauge the regional economic developments and assess the risks to price stability. Moreover, the size of the fiscal spillovers is important when assessing the stabilization effects of national fiscal policies. On the one hand, if the fiscal spillovers are sufficiently high, output can potentially be stimulated across the region. On the other hand, if the fiscal spillovers are small, then the existence of a central fiscal stabilization tool that can support national economies in the presence of large asymmetric shocks would make the union more resilient.

The macroeconomic analysis of fiscal policy shocks for countries that are intending to form a monetary union is of high interest since there is a consensus that national fiscal policies should play an enhanced role in the adjustment to macroeconomic shocks within a monetary union. Indeed, the absence of national monetary policy leaves fiscal policy as the

[1]The ECOWAS countries are: Benin, Burkina-Faso, Cabo verde, Côte d'Ivoire, Ghana, Gambia, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Sénégal, Sierra-Leone, Togo

[2]WAEMU is formed by Benin, Burkina-Faso, Cote d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, Togo

ultimate tool to offset country-specific shocks, and hence, the use of fiscal instruments needs to be active in a monetary union (Demertzis, Hallett and Viegi [1999]). Moreover, fiscal shocks in a monetary union cause significant spillover effects, and restrictions are required on member states to prevent excessive borrowing and debt that may threaten the stability of a single currency (Giuliodori and Beetsma [2004], Eichengreen and Von Hagen [1996]). Also, considering the importance of sound public policy in developing economies, understanding fiscal policy as an essential determinant of the cyclical dynamics of macroeconomic indicators can make a valuable contribution to the design of fiscal policy's coordination instruments in the West African Region.

In contrast to the large empirical evidence on the economic effects of monetary policy, research on the impact of fiscal policy has received much less attention, especially in developing countries. This is mainly due to the political dependence of budgetary policy, its complexity, and also to the lack of appropriate historical data on the government sector. Thus, the overall motivation of the paper is that empirical analysis on the effect of fiscal policy is essential in the current policy discussions in the ECOWAS region related to the formation of their monetary union. In particular, measuring the within and cross-country effect of fiscal shocks and determining the direction in which such shocks affect macroeconomic variables can help derive several insights on the effectiveness of the fiscal policy and the design of appropriate fiscal rules in the region.

Our empirical analysis is based on the Global Vector Autoregressive model (GVAR) pioneered by Pesaran, Schuermann and Weiner [2004] and extended by Dees et al. [2007]. The model allows consistent modeling of international interdependencies and transmission channels across countries. It consists of several individual country VAR models that are stacked together and simultaneously solved into a single multi-country model using weights related to the international linkages between the different countries. The choice of the GVAR specification is particularly interesting since it allows the analysis of both long-run and short-run relationships, which is consistent with the theory and data. It also offers a solution to the so-called 'curse of dimensionality' in which both the cross-section and time-series dimensions can be relatively large as a result of estimating the country-specific error-correction models. For the dynamic analysis, we consider both country-specific and regional shocks by dividing the ECOWAS area into three blocks: Nigeria- the largest country in the area, WAEMU - a group of eight countries that share the same currency and the rest which will be referred to as RECOWAS. The estimated shocks are country-specific negative shocks affecting tax revenue and public spending in Nigeria and negative regional negative shocks affecting tax

revenue and spending in WAEMU and RECOWAS.

The main insight derived from our analysis is that there is very little fiscal interlinkage within the ECOWAS countries. The results indicate a substantial heterogeneity of fiscal spillover within the ECOWAS countries, and the direction in which the main variables are affected is not straightforward. We also find that Nigeria and countries that are more integrated tend to generate more sizable fiscal spillovers. More specifically, our findings suggest that both the negative country-specific government spending shocks affecting Nigeria and the negative regional spending shocks affecting WAEMU and RECOWAS have a negative and persistent impact on real output in the shock-emitting country/regions. However, the spillover effect on the shock-receiving countries is heterogeneous. The contractionary government spending shock in Nigeria generates a long-lasting positive effect on output in Cote d'Ivoire, Mali, Benin, Gambia, while the shock is negatively transmitted to the remaining countries. On the other hand, the regional negative spending shock affecting WAEMU and RECOWAS is negatively transmitted to the other countries outside the respective regions, but the magnitude of the cross-border effect on output is relatively small, especially in Nigeria where it is almost zero. Movement in inflation shows that price competitiveness is the main channel through which fiscal shocks are transmitted across countries. Regarding the country-specific tax revenue shock originating from Nigeria, it leads to a decline in real GDP in the country, while the negative regional revenue shock affecting WAEMU and RECOWAS leads to a positive effect on output in the countries of these regions. The positive link between revenue shock and real GDP in Nigeria is explained by the fact that oil revenue represents a significant share of tax revenue in Nigeria. The cross-borders effect of the shocks is negative for the tax revenue shock affecting Nigeria and positive for the regional shocks. We also find that the effects of government spending shocks are larger and more persistent than those from the tax revenue shocks.
The remainder of the paper is organized as follows: the next section provides a literature review related to the topic. Section 3 describes the model and the data used. The results are discussed in Section 4, and the last section concludes.

3.2 Literature review

In the first part of this section, we briefly review the theoretical perspective of the analysis as well as the main studies that have used vector autoregressive models to analyze the macroeconomic effects of fiscal policy. In the second part, we briefly discuss the conduct of fiscal policy in the ECOWAS countries in other to have a better understanding of the context of this study.

3.2.1 Existing literature

This paper is closely related to the literature on the macroeconomic effect of fiscal shocks and their identification approach. Empirical research on the topic is mostly associated with developed and emerging countries, and various methodologies are used to identify fiscal shocks.

The extended contributions to the literature on both the short and long-run effects of fiscal policy on economic activities lead to mixed results. From the theoretical point of view, on the one hand, neoclassical models suggest that private consumption falls following a positive shock to government spending because of the so-called crowding-out effect. In contrast, the New-Keynesian models find the opposite effect (Woodford [2011]). On the other hand, the empirical literature has also struggled so far to provide robust stylized facts on the impact of fiscal policy shocks on economic activity (Perotti, Reis and Ramey [2007]). While some studies point to the positive link between positive government spending shocks and private consumption (Fatás and Mihov [2001]; Blanchard and Perotti [2002]; and Perotti [2005]), other strands of the literature provide a negative relationship between government spending shocks and consumption (Ramey [2011]). Other authors also argue that the response of private consumption to government spending shocks is non-significant (Mountford and Uhlig [2005]; Edelberg, Eichenbaum and Fisher [1999]).

Moreover, most of the empirical studies that assess the macroeconomic effects of fiscal shocks use the standard VAR approach, while only a few studies used the GVAR methodology. One of the most significant contributions in the first group was made by Blanchard and Perotti [2002] and extended by Perotti [2005]. The authors introduced a new method for identifying the fiscal shock using a structural VAR and institutional information on the tax and transfer system. Their results consistently show for the United States that positive government spending shocks have a positive effect on output, and positive tax shocks have a negative effect on output.

Canova and Pappa [2003] use a sign and near-zero restrictions of impulse responses in a VAR to study the effect of fiscal disturbances (regional expenditures and revenue shocks) on price differentials for 47 States in the United States and nine European Union countries. Their restrictions consist of making fiscal variables independent of both business cycle shocks and monetary policy shocks or by allowing tax revenues to increase while restricting government spending to do so. The sign restrictions are also applied so that fiscal variables do not respond for a certain time period. Their results suggest that, on average, expansionary fiscal disturbances produce a positive effect, while distortionary balance budget shocks produce negative price differential responses. The negative price differentials responses in some units are partially explained by spillovers and labor supply effects.

Mountford and Uhlig [2009]) use the same identification approach to analyze the effects of fiscal policy in the US from 1955 to 2000. Considering three scenarios of deficit-spending, deficit-financed tax cuts, and a balanced budget spending expansion, they find that deficit-financed tax cuts work best to improve GDP. Fatás and Mihov [2001] rely on the Cholesky ordering to identify fiscal shocks in a VAR model. They identify the fiscal shock by ordering government spending first, assuming that there is no contemporaneous relationship between the fiscal variables and the other endogenous variables in the model. Their results show that an increase in government spending in the United States from 1960Q1 to 1996Q4 is expansionary with a multiplier larger than one.
Finally, Romer and Romer [2010] use data such as presidential speeches, executive-branch documents, and congressional reports to assess the size, timing, and principal motivation for all major post-war tax policy actions. Their main findings indicate a substantial effect of tax changes on output and investment with multipliers above unity.

Studies relying on panel data have made use of reduced-form Panel VAR frameworks, which are well suited for investigating the transmission of idiosyncratic shocks across time and units. For instance, Beetsma and Giuliodori [2011] reviewed the theoretical and empirical literature on the consequences of discretionary impulses to government purchases using panel VAR for the European Monetary Union. They find a positive effect on output with a multiplier exceeding unity. Jawadi, Mallick and Sousa [2016] also use the same methodology to assess the macroeconomic impact of fiscal and monetary policy shocks in five key emerging economies. Their results suggest that government spending shocks have strong Keynesian effects. Other studies based on panel data have focused on structural Panel VAR models. For instance, Ravn, Schmitt-Grohé and Uribe [2012] studied the impact of an increase in government purchases on key macroeconomic indicators using a Panel Structural VAR model. They find that the expansionary government spending produces an increase in output and consumption, a depreciation of the real exchange rate, and a deterioration of the trade balance.

So far, there are only a few papers that have used a GVAR model to study fiscal policy shock and cross-border spillovers. Nickel and Vansteenkiste [2013] study the spillover of a government consumption shock to financial variables in the OECD countries over the period 1980–2008. They show that a fiscal expansion generated in Germany (or the USA) raises government bond yields elsewhere. Hebous and Zimmermann [2013] compare the output effects of national versus coordinated euro area-wide fiscal shocks (stemming from the budget balance or government investment spending) for twelve-euro area economies in the years

1979–2009. According to their results, the euro area-wide fiscal shock has a more significant impact on output than a national shock of similar size, pointing to the importance of coordinated fiscal measures within the euro area. For more details and exhaustive literature on the subject, Hebous [2011] provides a detailed survey of theoretical and applied VAR literature about the short-run effects of discretionary fiscal policy measures on macroeconomic variables.

Overall, although the literature related to the dynamic effects of fiscal shocks has increased in recent years, there are few empirical studies on the macroeconomic impact of fiscal policies in the developing countries, and there is little consensus among economists about the magnitude or the sign of such effects (Perotti [2005]). This lack of attention is even more considerable in West African countries. Fiscal policy plays a key role in these countries, particularly in the context where they are contemplating creating a monetary union, which will make monetary policy irrelevant for responding to idiosyncratic shocks.

3.2.2 Fiscal policy in ECOWAS countries

The economic context of most of the ECOWAS countries is marked by structural fiscal deficits resulting from rising public debt and the dependence on external aid. This is displayed in Figure 3.1, which shows that the average fiscal deficit to GDP ratio in the WAEMU and non-WAEMU regions between 2000 and 2019 are respectively 2.37% and 3.25%, while the debt to GDP ratios in the two blocs of countries over the same period are respectively 58.7% and 81.3%. This trend has always raised concerns among policymakers about the sustainability of public financing and the ability of West African countries to grow in the medium and long term (Beaugrand, Mlachila and Loko [2002]; Ekpo [2012], Anyanwu and Erhijakpor [2005]). The situation is particularly delicate, given the underlying fiscal challenges, due to inefficient public spending, high level of the informal sector in the region, persistent tax evasion, weak tax administrations, and poorly harmonized regional tax and fiscal policy rules. As displayed in Table 3.1, during the period 2010-2018, tax revenue represents, on average, 13.4% of GDP in the ECOWAS countries, which shows the weak revenue collection level in the region compared to the whole sub-Saharan Africa countries where the average revenue collection over the same period is about 20% of GDP. It is worth highlighting that taxes on international transactions constitute a significant part of tax revenue in the region, especially for countries like Nigeria and Cote d'Ivoire. The ECOWAS Commission is pushing to improve the fiscal environment in the area by coordinating and harmonizing their tax system through initiatives like the Common External Tariff (CET), the multilateral treaty which aims at consolidating the regional market and deepening pro-

ductive capacity [3]. Also, the macroeconomic convergence criteria set in preparation of their monetary union, which include a maximum public deficit of 3% of GDP, is another initiative for fiscal discipline in the region. However, these efforts seem to be not sufficient to mobilize adequate domestic resources to finance regional and national development plans. In the early 2000s, most ECOWAS member countries benefited from the IMF's Highly Indebted Poor Countries (HIPC) initiative, through which several developing countries received debt relief. Still, public debt continues to increase in the region and remains a considerable challenge to macroeconomic stability and sustainable economic growth.

3.3 Model description

In this study, we make use of the GVAR model pioneered by Pesaran, Schuermann and Weiner [2004], which consists of a two-step modeling process. In the first step, a set of country-specific VAR sub-models (VARX* models), in which the core domestic variables are related to country-specific foreign variables, is estimated. In the second step, the estimated coefficients from the country-specific VARX* models are stacked and solved simultaneously in a global system, generating the GVAR model. The solution can then be used for shock scenarios. We consider for each country i=0,1,2,... N, two types of variables: domestic and foreign variables. The inclusion of the country-specific foreign variables in the individual country models is systematic and crucial in the GVAR modeling since these variables provide the link between all countries included in the model, enabling an analysis of the transmission of shocks across countries. Furthermore, deterministic components are also included in the model. Specifically, each country i is modeled as a $VARX^*(p_i, q_i)$ of the following form:

$$X_{i,t} = c_{i,0} + c_{i,1}t + b_{i,1}X_{i,t-1} + b_{i,2}X_{i,t-2} + ...b_{i,p}X_{i,t-p} + d_{i,0}X^*_{i,t} + d_{i,1}X^*_{i,t-1} + d_{i,2}X^*_{i,t-2} + ...d_{i,q}X^*_{i,t-q} + u_{i,t} \tag{3.1}$$

where $X_{i,t} = (Y_{i,t}, REV_{i,t}, G_{i,t}, INFL_{i,t})$ is a vector of country-specific domestic variables and represents real GDP (Y), Tax revenue (REV), Public spending (G) and Inflation (INFL) ; $X^*_{i,t} = (Y^*_{i,t}, REV^*_{i,t}, G^*_{i,t}, INFL^*_{i,t})$ is a vector of country i's foreign variables. The foreign variables, which are treated as weakly exogenous, summarize developments in foreign countries and hence reduce the number of parameters in each individual VAR model. b_i and d_i are respectively matrices of coefficients associated with the lagged domestic and foreign variables; $c_{i,0}$ and $c_{i,1}$ are respectively, a vector of intercepts and vector of coefficients of the deterministic time trend; $u_{i,t}$ is a vector of idiosyncratic shocks, which is assumed to follow a white noise process.

[3] See ECOWAS annual report 2016

Considering a $VARX^*(2,2)$, equation 3.1 becomes:

$$X_{i,t} = c_{i,0} + c_{i,1}t + b_{i,1}X_{i,t-1} + b_{i,2}X_{i,t-2} + d_{i,0}X^*_{i,t} + d_{i,1}X^*_{i,t-1} + d_{i,2}X^*_{i,t-2} + u_{i,t} \tag{3.2}$$

Let $Z_{i,t} = (X_{i,t}, X^*_{i,t})$ be a vector stacking both domestic and foreign variables. The equation 3.2 can be rewritten as follow in an error correction form-$VECMX^*(2,2)$ because of the presence of unit root variables.

$$\Delta X_{i,t} = c_{i,0} + c_{i,1}t + d_{i,0}\Delta X^*_{i,t} + \Gamma_{i,0}\Delta Z_{i,t-1} - \Lambda_i ECM_{i,t-1} + u_{i,t} \tag{3.3}$$

Where $ECM_{i,t}$ is the error correction term and Δ is the first difference operator.
The foreign variables are defined as weights reflecting the relative importance of economic development in country j for country i:

$$X^*_{i,t} = \sum_{j=1}^{N} w_{i,j}X_{j,t} \tag{3.4}$$

where $w_{i,j}$ represents the country-specific weight of country j in the total trade of country i. The weights must satisfy the following conditions: $w_{i,i} = 0$ and $\sum_{j=1}^{N} w_{i,j} = 1$.
Once the country-specific VARX* models are estimated in their vector error-correcting form because of the presence of unit root variables, they are combined and stacked to form the global model. The trade weights $w_{i,j}$ is used to define the link matrix $W_{i,t}$ and obtain the identity: $Z_{i,t} = W_{i,t}X_t$, with X_t the global vector that contains all endogenous country-specific variables, $X_t = (X_{1,t}, X_{2,t}, ...X_{N,t})$.
The link matrix allows the country-specific models to be written in terms of the global vector X_t as follows:

$$A_{i,0}W_{i,t}X_t = c_{i,0} + c_{i,1}t + A_{i,1}W_{i,t-1}X_{t-1} + A_{i,2}W_{i,t-2}X_{t-2} + u_{i,t} \tag{3.5}$$

Finally, we build the GVAR model by stacking up each country model, so that:

$$G_0X_t = c_0 + c_1t + G_1X_{t-1} + G_2X_{t-2} + u_t \tag{3.6}$$

Since G_0 is a nonsingular matrix, we can pre-multiply the previous equation by G_0^{-1} and obtain the following reduced form GVAR model:

$$X_t = b_0 + b_1t + F_1X_{t-1} + F_2X_{t-2} + v_t \tag{3.7}$$

where $F_m = G_0^{-1}G_m$; $b_k = G_0^{-1}c_k$; $v_t = G_0^{-1}u_t$

As described by Dees et al. [2007]; and Chudik and Pesaran [2016], four sufficient conditions must hold to ensure the validity of the model's results: first, the weak exogeneity of the foreign variables with respect to the model's long-run parameters; second, the stability of the global model, i.e., the eigenvalues of the F matrix defined in equation 3.7 must be either one or inside the unit circle; third, the smallness of the weights utilized for the construction of the country-specific foreign variables; and fourth the weak cross-dependence of the idiosyncratic shocks. These conditions will be analyzed in the results section.

Interactions among the economies in the GVAR model occur via three channels, that allow a sufficient degree of interlinkages to model the effect of national and regional shocks on the global economy (Nickel and Vansteenkiste [2013]). These channels are: the contemporaneous effects of $X_{i,t}^*$ on $X_{i,t}$; the dependencies of $X_{i,t}$ on the lagged values of $X_{i,t}^*$, and the contemporaneous cross-country dependencies between the error terms.

We focus on impulse responses to analyze the international dynamics, using fiscal shocks. The identification of shocks in the GVAR setting is subject to the same issues as in the standard VARs. Still, it is further complicated due to the cross-country interactions and the high dimensionality. We identify the fiscal shocks using the generalized impulse response functions, GIRF (Koop, Pesaran and Potter [1996]). The GIRF is used primarily in the GVAR literature as an alternative to the Orthogonalized Impulse Response Function (OIRF) of Sims [1980]. The OIRF approach requires the impulse responses to be computed for a set of orthogonalized shocks using the Cholesky decomposition. The choice of the Cholesky factor is not unique and depends on the ordering of variables in the model.

The GIRF approach, on the other hand, considers shocks to individual errors and integrates the effects of the other shocks using the distribution of all the shocks without orthogonalization. More specifically, let Ω_{t-1} be the known information set of the economy up to time $t-1$, the GIRF of X_t at horizon n, is defined by:

$$GIRF(n, u_{jt}, \Omega_{t-1}) = E[X_{t+n}|u_{jt}, \Omega_{t-1}] - E[X_{t+n}|\bar{\Omega_{t-1}}] \tag{3.8}$$

Equation 3.8 stipulate that the GIRF is a random variable given by the difference between the conditional expectation of X_{t+n} given the history Ω_{t-1} and a given shock u_{jt} and the conditional expectation of X_{t+n} given the observed history. Thus all other contemporaneous and future shocks are integrated out. Unlike the OIRF, the impulse responses that are derived from the GIRF are unique and invariant to the ordering of the variable and the countries of the system, which is an important consideration. Therefore, the GIRFs do not require the identification of shocks to some canonical system or a priori economic theory but

consider a counterfactual exercise where the historical correlations of shocks are assumed as given. So it is not convenient to interpret such economic shocks in a structural sense even though they do provide enough information about the mechanism of propagation of shocks among different countries (Hebous and Zimmermann [2013]).

3.3.1 Data

In this section, we discuss the data used in the model and their statistical properties. We estimate a GVAR model for 11 ECOWAS countries using annual data covering the period 1980-2018. Due to data availability, four ECOWAS countries, namely, Cabo-verde, Guinea-Bissau, Sierra-Leonne, and Liberia, are not considered in the analysis. The source of the data is the World Bank (World Development Indicators) and IMF (World Economic Outlook). Four variables are included in the country-specific VARX model, namely: real GDP, inflation, public expenditures, and tax revenue. All the variables except inflation are log-transformed. The revenue variable refers to the net tax revenue, i.e., total tax revenue minus transfers and interest payments, while the expenditures refer to government consumption and investment.

As mentioned previously, the first step in the GVAR methodology is to construct the country-specific foreign variables from their corresponding domestic variables. We build four country-specific foreign variables using trade weights, which are calculated as the share of foreign countries in the total of exports and imports of country i over the period 2014–2018. The trade weights matrix is displayed in Table 3.9 in Appendix 3, where the trade share of each country is displayed in columns. This matrix plays a crucial role in the analysis since it connects the models of the different countries and also shows the dependency relationships among the economies under study.
The descriptive statistic of the domestic variables in the 11 countries divided into three blocks are displayed in Table 3.2.
One caveat regarding our analysis is that the VAR approach usually requires the existence of reliable and non-interpolated quarterly data over a sufficiently long period. However, due to the lack of quarterly data in the countries under study, we use annual data for the analysis.

3.3.2 Specification and Estimation of the Country-Specific Models

We estimate 11 country-specific models, using the same specification by including real GDP, inflation rate, public expenditure, and tax revenue as endogenous variables and foreign real GDP, foreign inflation, and foreign public expenditure and revenue as weakly exogenous

variables.

The specification of each country-specific VARX* model is based on an appropriate choice of the lag lengths of the domestic and foreign variables as well as the cointegration rank. We select the lag order of the domestic variables (p_i) according to the Akaike information criterion (AIC) with the condition that its maximum value should not be greater than two. Also, due to data limitations, the lag order of the foreign variables (q_i) is set not to be more than one in all countries (Pesaran, Schuermann and Weiner [2004]). We then proceed to the estimation of the cointegrating VAR models and the determination of the rank of their cointegrating space. Trace statistics (at the 95% critical value level) are used to assess the cointegration, which can be interpreted as long-term relationships among domestic variables and/or between domestic and foreign variables.
The results presented in Table 5 in Appendix 3 show that VARX (2,1) is favorable for all countries except for Senegal, where VARX*(1,1) was selected by the AIC criteria. Regarding the number of cointegrating relationships, which can be interpreted as long-term relationships among variables, we find three for Mali and Niger; two for Burkina-Faso, Nigeria, Togo, and one for Benin, Cote d'Ivoire, Gambia, Ghana, Guinea, and Senegal.

Diagnostic test

As mentioned previously, we formally check in this section, the four sufficient conditions for the GVAR estimation to be valid: the weak exogeneity hypothesis, the stability of the model, the weak cross-dependence of idiosyncratic shocks and the smallness of the trade weights.
We first examine the integration properties of the individual series under consideration. The GVAR model can be applied to both stationary and/or I(1) variables. The inclusion of variables that contain a higher order of integration might lead to severe bias. The objective of using integrated variables of order one, I(1) is to distinguish between short- and long-run relations and interpret the long-run ones as cointegrating relations. We investigate the order of integration of the series under consideration using the Augmented Dickey-Fuller (ADF) (Dickey and Fuller [1979]) and the Weighted-Symmetric Dickey-Fuller (WS) (Park and Fuller [1995]) unit root tests for the domestic and foreign variables in levels, first differences, and second differences. The WS test was performed in addition to the traditional ADF test because of the weak performance power of the ADF tests. The Akaike Information Criterion (AIC) is used to select the lag order in the regressions from which ADF and WS unit root statistics are generated. The results for all the country-specific domestic and foreign variables in level, first differences, and second differences are displayed in Tables 3.5 and 3.6 in Appendix 3. Both the WS and the ADF test results indicate that all the variables included

in the model are stationary or integrated of order 1, I(1).

After estimating the individual VARX* models, weak exogeneity of the country-specific foreign variables is formally tested. In particular, F-tests for the joint significance of the error-correcting terms for the country-specific foreign variables were conducted. The weakly exogenous foreign variable can be defined as a variable whose value is independent of the contemporaneous values of the endogenous variables but may depend on the lagged values of these variables. In other words, the weak exogeneity of $X^*_{i,t}$ means that $X_{i,t}$ does not affect $X^*_{i,t}$ in the long-run. The results which are presented in Table 3.7 in Appendix 3 suggest that the weak exogeneity condition is valid in all cases except for government revenue in Benin, and inflation and public spending in Nigeria.

Next, we see how the idiosyncratic shocks of the individual country models are correlated across countries. The residual must be weakly correlated so that, for the dynamical analysis, the simulated shocks would be idiosyncratic i.e. $cov(u_{i,t}, x^*_{i,t}) \to 0$ as $N \to \infty$. The cross-correlation of the error term is verified by computing the average pair-wise cross-section correlations of the VARX* residuals. Table 3.8 in Appendix 3 reports the average pair-wise cross-section correlations for the levels and first differences of each domestic variable, as well as the associated VARX* residuals. It follows from the results that the average pair-wise cross-section correlations are in general high for the variables in levels, but they drop drastically for the variables in first differences, and further decline as their dynamics are modeled by VARX* residual. A low correlation of the residual suggests that the cross-dependence of idiosyncratic shocks is weak. Hence, the GVAR model is quite successful in capturing the common effects driving the endogenous variables and should be considered fairly effective in explaining cross-country interdependencies.
Finally, the weights calculated from the trade flow data are displayed in Table 3.9 in Appendix 3. The smallness condition implies that $\sum_{j=1}^{N} w_{i,j}^2 \to 0$ as $N \to \infty$. It ensures that all countries receive small enough weights so that there is no dominant unit. As shown by Pesaran, Schuermann and Weiner [2004], the weights will always be relatively small as long as each country i is small relative to the rest of the world.

Contemporaneous effects of foreign variables on their domestic counterparts

Table 3.3 presents the contemporaneous effects of foreign variables on their domestic counterparts along with their corresponding t-ratios computed using the Newey-West heteroskedasticity and autocorrelation-consistent variance estimator for all the countries. These estimates represent the impact elasticities between domestic variables and their foreign counterparts.

It follows from the results that most of these impact elasticities are not significant, showing the lack of international linkages among the ECOWAS countries. Focusing on fiscal indicators (tax revenue and public spending), we can see that changes in foreign fiscal variables have no significant impact on their domestic counterparts in all the countries. An exception is observed for tax revenue in Mali. For the other variables, we observe for some of the WAEMU countries (Burkina-Faso, Mali, Niger, Togo), that change in foreign production significantly affects their domestic production. For instance, a 1% increase in production leads respectively to 0.36% and 0.57% increase in their domestic counterpart in Burkina-Faso and Mali. Also, a change in foreign inflation leads to a significant change in their domestic counterpart in Benin, Burkina-Faso, Mali, Senegal, Togo.

3.3.3 Dynamic analysis

The objective of this study is to assess the within and cross-country effects of fiscal shocks in the ECOWAS region. The dynamic responses of the shocks are assessed using the Generalized Impulse Response Function (GIRF). We consider negative shocks to spending and revenue affecting three main countries and block of countries in the area: Nigeria, WAEMU, and RECOWAS. The regional shocks are applied to regional variables constructed as a weighted average of the country-specific variables corresponding to each region (WAEMU, RECOWAS). The aggregation weight is based on Purchased Power Parity (PPP) adjusted GDP with the PPP-GDP of each country within a region divided by the total sum across the region.
The simulated shocks can be described as follow:

- A one standard error negative country-specific shock to Nigeria public spending
- A one standard error negative country-specific shock to Nigeria tax revenue
- A one standard error negative regional shock to WAEMU AND RECOWAS public spending, taken individually.
- A one standard error negative regional shock to WAEMU AND RECOWAS tax revenue, taken individually.

The impulse responses (figures 3.2-3.16) are displayed in Appendix 3 with a 90% bootstrap confidence interval in the blue dashed line.
Finally, we analyze the channels of transmission of economic fluctuations across countries using the Generalized Forecast Error Variance Decompositions (GFEVD). Specifically, at each moment, the GFEVD measures the proportion of the forecast error variance of the

simulated shock that is explained by present and future innovations in the variables of each country.

Country-specific shocks to public spending and tax revenue affecting Nigeria

Figures 3.2-3.4 show the domestic and cross-border effects of a negative one standard error government spending shock affecting the Nigerian economy. The negative government spending shock is associated with an instantaneous decline of about 0.01 % in the real GDP in the country and an increase in inflation of about 2%. The drop in output continues and reaches a peak of 0.03%. After that, the GDP starts increasing to stabilize. These results are consistent with some findings in the literature, including the contribution of Blanchard and Perotti [2002], who establish a positive relationship between government spending shock and output. Regarding the spillover effect of the shocks in the other countries, The IRFs show that all the other ECOWAS countries are negatively affected by the shock, except Mali and Gambia. The movement in inflation following the shock can explain this latter result through the price competitiveness of foreign goods. As shown in the right panel of Figure 3.2-3.7, there is an increase in inflation in the group of countries negatively affected by the spending shock in Nigeria. As a consequence, there is a deterioration in their terms-of-trade and a decrease in real GDP as a corollary. The opposite is observed for countries positively affected by the spending shock in Nigeria.

Regarding the negative one standard error tax revenue shock in Nigeria, Figure 3.7 in Appendix 3 shows that it leads to a decline in real GDP in Nigeria and an increase in inflation. Specifically, the decline in tax revenue in Nigeria is related to an instantaneous drop of around 0.01% in the country's output. This reduction in production following the decline in tax revenue can be explained by the fact that a large share of tax revenue in Nigeria comes from oil export. As a result, a decline in tax revenue is more likely to be triggered by a decline in oil revenue than an expansionary fiscal policy. The cross-country effect shows that the decrease in tax revenue in Nigeria leads to a reduction in output in all the other ECOWAS countries. The magnitudes of the effects differ across countries where Niger (-0.02%) and Senegal (-0.015%) are the most affected. This negative cross-country spillover effect is due to the increase in inflation in the different countries following the shock. Overall, the results suggest the existence of a certain degree of spillover effects of fiscal shocks, especially spending shocks from Nigeria to the other ECOWAS countries.

Regional shock to public spending and tax revenue affecting WAEMU and RECOWAS

Figures 3.8-3.16 present the GIRFs of a negative one standard error regional shock to government spending and tax revenue, affecting the regions WAEMU and RECOWAS individually. The regional negative spending shock in WAEMU results in a decline in real GDP and an increase in price in all the WAEMU countries. The most substantial effects are observed in Niger and Togo, with a peak of 0.04%, and 0.03% percentage points decrease in their real GDP, respectively. Regarding the cross-country spillover effects on real GDP, the shock leads to a decline in real GDP in the rest of ECOWAS countries. The strongest effects are observed for Ghana (-0.001%), and the weakest effects are found for Nambia (-0.002%). Overall, we find more substantial effects of the shocks within the WAEMU countries compared to Nigeria and RECOWAS countries.

Regarding the negative tax revenue shock affecting WAEMU, it leads to a positive effect on output in WAEMU countries and also a positive cross-country effect, except for Nigeria, where we observe a decline in production, but the magnitude is almost zero. Also, the spillover effect of the shocks is relatively small, with the highest increase in output of 0.03% observed in Guinea. The positive cross-country effect, which can be referred to as the expenditure boosting channel, is explained by the fact that the decline in tax in WAEMU is associated with an increase in household's disposable income. This increase in disposable income will lead to an increase in total demand (including the demand for non WAEMU foreign goods) with a positive effect on output in foreign countries (because of the rise in their export). Considering the impact on inflation, we observe a decrease in price in all the countries except Nigeria. The inflationary pressure in Nigeria following the shock can, to some extent, explain the negative effect observed on output in the country. The consequence of the high inflation will be the worsening terms-of-trade in Nigeria, with a negative impact on real GDP in the country.
We observe a similar pattern of results for the regional spending and tax revenue shocks affecting RECOWAS, with a negative (positive) within and cross-country effect of the spending (tax revenue) shock. The spillover effects on the other countries are relatively low and fluctuate around zero for Nigeria, showing the low degree of the fiscal link between Nigeria and the other ECOWAS countries.

Overall, we find a large amount of heterogeneity regarding the spillover effects of fiscal shocks within the ECOWAS area. Trade relationships between these countries can explain, to a large extent, this heterogeneity, as can be seen from the impulse responses for inflation.

Also, larger economies like Nigeria and countries that are more integrated tend to generate more sizeable fiscal spillovers.

Generalized Forecast Error Variance Decomposition

In this section, we provide additional intuition on the channels of transmission of shocks across countries using the generalized forecast error variance decompositions (GFEVD). In the structural VAR framework, the forecast error variance decomposition (FEVD) is performed on a set of orthogonalized shocks. It can be interpreted as the contribution of the innovation to the variance of the N-step ahead forecast of the model, and the sum of the single innovation contributions add up to one. An alternative approach in the GVAR setting is to compute the Generalized FEVD (Dees et al. [2007]). This approach, like the GIRF, has the advantage of being invariant to the ordering of variables and countries in the model. The GFEVD computes the proportion of the N-step ahead forecast error variance of the simulated shock that is explained by present and future innovations in the variables of each country. Because of the existence of contemporaneous correlations among innovations, the sum of the contributions to the GFEVD does not sum to one. Consequently, the contribution of each region to the forecast error variance of the shock cannot be considered as a proportion; however, it remains useful for explaining the transmission channel of shocks across regions.

Tables 3.10-3.12 in Appendix 3 show the Generalized Forecast Error Variance Decomposition of ECOWAS countries (Nigeria, WAEMU, RECOWAS) fiscal indicators in terms of their top ten determinants at the five years horizon.

We can see from Table 3.10 that Nigeria's variables explain most of the historical shock to Nigerian tax revenue and public spending. Considering the Nigerian tax revenue, for instance, it explains 58% of the forecast error variance of revenue in the first year; however, the share decreases over time. Moreover, very few shares of the forecast error variance of Nigerian tax revenue and public spending is explained by variables of other countries in the ECOWAS area. An exception is observed for Ghana's variables, which explain respectively about 8 % and 6% of the forecast error variance of Nigerian tax revenue and spending in the first year.

The forecast error variance decomposition of the WAEMU and RECOWAS fiscal indicators (Tables 3.11 and 3.12) show a strong contribution of their domestic variables but also of Nigeria's variables. Considering the foreign variables, Nigeria's variables explain respectively, approximately 10% and 4% of the forecast error variance of WAEMU tax revenue and spending in the first year. The contribution is even more substantial for total variances of

revenue and expenditure in RECOWAS, with more than 12% explained by Nigeria's variables in the short run. In particular, real GDP and public spending in Nigeria play the role of the main determinant.

These results provide evidence of the strong impact of fiscal shocks from Nigeria on the rest of ECOWAS countries, while the feedback from the other ECOWAS countries to Nigeria is weak.

3.4 Conclusion

We investigate in this paper the economic effect of fiscal shocks in the ECOWAS countries considering the domestic and international perspectives. For the empirical analysis, we adopt the GVAR methodology, which is a multi-country model that allows us to explore the cross-country transmission of the fiscal shocks in the ECOWAS area. We study both country-specific and regional public spending and tax revenue shocks that affect three regions in the ECOWAS area: Nigeria, WAEMU, and RECOWAS. Our results indicate a substantial heterogeneity of fiscal spillover within the ECOWAS countries, and the direction in which the main variables are affected is not straightforward. We also find that larger economies like Nigeria tend to generate more sizeable fiscal spillovers.

More specifically, our results show that both the negative government spending shock affecting Nigeria and the negative regional spending shock affecting WAEMU and RECOWAS lead to a negative and persistent impact on real output in the shock-emitting country. However, the spillover effect on the shock-receiving countries is heterogeneous. The contractionary government spending shock in Nigeria generates a long-lasting cross-border decrease in output in most of the ECOWAS countries with some difference in the magnitude of the effect. On the other hand, the regional negative spending shock affecting WAEMU and RECOWAS is negatively transmitted to all countries, but the magnitude of the effect on output is relatively small and almost zero for Nigeria. Price competitiveness is the main channel through which fiscal shock is transmitted to the other countries. Regarding the negative tax revenue shock affecting Nigeria, it leads to a decline in real GDP in the country, while the opposite is observed for the regional tax revenue shock affecting WAEMU and RECOWAS. The positive link between tax revenue shock and real GDP in Nigeria is explained by the fact that oil revenue represents a significant share of tax revenue in Nigeria. The cross-country effect is positive in all the shock receiving countries for the regional tax revenue shocks in WAEMU, and RECOWAS, while the country-specific tax-revenue shock in Nigeria is negatively transmitted to the other countries. We also find that the effects of government spending shocks are larger and more persistent than those from the tax revenue shocks.

Finally, we assess further the transmission mechanism of the shocks by considering the Generalized Forecast Error Variance Decomposition (GFEVD), which shows that domestic variables are the main determinant of variability in fiscal variables in all the countries. However, Nigeria's variables (especially real output and spending) explain a significant share of the total variance in revenue and expenditures in WAEMU and RECOWAS countries.

The results of this study suggest the existence of very little fiscal interlinkage within the

ECOWAS countries. The spillover effect from Nigeria to the other ECOWAS countries is high, while the feedback from the rest of ECOWAS countries to Nigeria is weak. The main policy insight that can be drawn is that fiscal policy is a potentially relevant instrument that can be used to stabilize economic activities in each ECOWAS country. Still, our results also suggest for the ECOWAS monetary union project that the weakness of the cross-border spillover effects of fiscal shocks within the region calls for the creation of a central fiscal authority that will set up more coordinated fiscal policies in order to stabilize the economies in the advent of large shocks.

Appendix Chapter 3

Table 3.1: Public spending and tax revenue (average 2010-2018, % GDP)

	Public spending	**Tax revenue**
Benin	10.8	14.15
Burkina Faso	22.92	15.63
Cote d'Ivoire	12.58	14.6
Ghana	10.03	13.64
Gambia	10.64	9.98
Guinea	16.29	12.94
Mali	16.61	13.45
Niger	15.47	14.18
Nigeria	6.82	6.88
Senegal	13.86	15.38
Togo	16.65	17.06
Average ECOWAS	13.88	13.44

Source: Author's calculation using IMF data.

Table 3.2: Descriptive statistics of selected domestic variables (Average 1980-2018)

	Mean	Maximum	Minimum	Std. Dev.
Nigeria				
Real GDP (Billion, USD)	233.27	469.38	107.86	124.09
Tax revenue (Billion, USD)	21.09	40.72	12.25	8.20
Public spending (Billion, USD)	11.25	32.82	1.38	12.33
Inflation (%)	22.08	219.00	0.69	35.02
WAEMU				
Real GDP (Billion, USD)	61.86	124.16	36.20	24.18
Tax revenue (Billion, USD)	8.63	18.78	4.92	3.91
Public spending (Billion, USD)	9.20	19.17	5.57	3.52
Inflation (%)	4.16	34.01	-1.65	6.06
RECOWAS				
Real GDP (Billion, USD)	28.74	66.72	11.93	15.92
Tax revenue (Billion, USD)	3.61	9.56	1.41	2.40
Public spending (Billion, USD)	3.03	6.88	1.08	1.79
Inflation (%)	19.41	60.89	4.69	13.78

Source: Author's calculation using IMF data.

Table 3.3: Contemporaneous effects of foreign variables on their domestic counterparts

	Y	REV	G	INFL
BENIN	0.40	-0.04	-0.16	0.91
	(1.84)	(-0.16)	(-1.19)	**(12.32)**
BURKINA FASO	0.36	0.01	0.30	0.28
	(2.14)	(0.05)	(1.45)	**(4.16)**
COTE DIVOIRE	0.35	-0.30	0.00	0.03
	(1.47)	(-1.37)	(-0.06)	(0.42)
GAMBIA	-1.02	-0.38	-0.35	-0.35
	(-2.86)	(-0.66)	(-1.41)	((-0.98)
GHANA	0.21	0.22	-0.12	-1.05
	(0.92)	(0.50)	(-0.72)	(-3.94)
GUINEA	0.26	-0.11	0.30	0.51
	(1.75)	(-0.46)	(1.15)	(0.79)
MALI	0.57	1.00	-0.85	1.05
	(2.16)	**(2.81)**	(-1.22)	**(12.30)**
NIGER	0.85	0.03	-0.02	0.44
	(3.69)	(0.27)	(-0.34)	**(2.75)**
NIGERIA	-0.48	0.07	0.09	-0.17
	(-1.65)	(0.15)	(0.12)	(-0.61)
SENEGAL	0.27	-0.03	0.06	0.42
	(1.16)	(-0.34)	(1.17)	**(3.25)**
TOGO	1.35	-0.54	0.15	0.26
	(4.65)	(-1.38)	(0.33)	**(3.79)**

Newey-West t-ratios in bracket. Values in bold means significant at 5% level.

Table 3.4: VARX* order and number of cointegration relationships in the country-specific models

Countries	VARX*(p,q)		# cointegration relation
	p	q	
BENIN	2	1	1
BURKINA FASO	2	1	2
COTE DIVOIRE	2	1	1
GAMBIA	2	1	1
GHANA	2	1	1
GUINEA	2	1	1
MALI	2	1	3
NIGER	2	1	3
NIGERIA	2	1	2
SENEGAL	1	1	1
TOGO	2	1	2

p: lag order of domestic variables, q: lag order of foreign variables.

Table 3.5: Unit root test for domestic variables

Variables	Statistic	Critical Value	BENIN	BURKINA FASO	COTE DIVOIRE	GAMBIA	GHANA	GUINEA	MALI	NIGER	NIGERIA	SENEGAL	TOGO
y (with trend)	ADF	-3.45	**-1.62**	**-2.42**	**-0.60**	**-2.57**	**-0.61**	**-1.71**	-3.56	**-2.28**	**-1.52**	**-0.30**	**-2.15**
y (with trend)	WS	-3.24	**-1.46**	**-0.94**	**-1.17**	**-2.37**	**-0.62**	**-0.53**	**-1.85**	**-0.30**	**-0.78**	**-1.09**	**-1.73**
y (no trend)	ADF	-2.89	**1.00**	**2.26**	**1.81**	**-1.05**	**1.54**	**2.06**	**0.30**	**2.12**	**-0.30**	**1.83**	**1.45**
y (no trend)	WS	-2.55	**0.73**	**0.84**	**0.99**	**0.89**	**-0.62**	**0.71**	**0.30**	**0.87**	**-1.47**	**1.00**	**0.61**
Dy	ADF	-2.89	-4.63	-3.02	**-1.89**	-4.17	**-2.56**	**-1.05**	-5.17	-4.45	-4.14	**-2.01**	-3.93
Dy	WS	-2.55	-4.70	-2.99	**-2.09**	-4.39	**-1.82**	**0.14**	-3.33	**-2.22**	**-1.07**	**-2.37**	-4.04
DDy	ADF	-2.89	-5.86	-4.96	-6.54	-5.34	-5.70	-5.68	-5.97	-4.94	-4.62	-4.64	-4.88
DDy	WS	-2.55	-6.29	-5.39	-6.37	-5.85	-4.08	-6.21	-4.45	-5.33	-3.26	-4.94	-5.20
rev (with trend)	ADF	-3.45	**-1.98**	**-2.49**	**-0.20**	**-1.65**	**-2.23**	**-0.97**	**-3.04**	**-2.53**	**-2.65**	**-1.90**	**-2.27**
rev (with trend)	WS	-3.24	**-2.10**	-1.56	**-0.93**	**-2.02**	**-2.13**	**-0.80**	**-2.43**	**-0.07**	**-2.75**	**-1.19**	**-2.06**
rev (no trend)	ADF	-2.89	**-0.41**	**1.20**	**1.02**	**-1.10**	**-0.45**	**1.27**	**-0.31**	**0.18**	**-1.71**	**1.64**	**-0.34**
rev (no trend)	WS	-2.55	**0.70**	**0.80**	**0.49**	**-1.33**	**-0.51**	**0.53**	**-0.23**	**-1.78**	**-1.95**	**1.34**	**-0.68**
Drev	ADF	-2.89	-4.56	-4.75	-4.37	-5.34	-4.24	-4.05	-3.93	-3.51	-5.46	-3.07	-4.37
Drev	WS	-2.55	-4.87	-5.06	-4.68	-5.66	-4.46	-4.30	-3.89	**-0.23**	-5.68	-3.33	-4.61
DDrev	ADF	-2.89	-5.95	-5.33	-8.92	-6.19	-7.86	-7.00	-4.10	-5.39	-8.54	-6.23	-5.46
DDrev	WS	-2.55	-6.40	-5.88	-9.32	-6.66	-8.27	-7.39	-4.47	**-2.00**	-8.99	-6.52	-5.88
g (with trend)	ADF	-3.45	**-2.60**	**-2.87**	**-2.23**	**-2.30**	-3.86	**-1.54**	**-2.10**	**-2.90**	**-1.96**	**-1.79**	**-0.30**
g (with trend)	WS	-3.24	**-1.89**	**-1.45**	**-2.53**	**-1.48**	-4.16	**-1.64**	**-1.87**	**-2.92**	**-1.58**	**-0.65**	**-0.06**
g (no trend)	ADF	-2.89	**-1.64**	**-1.12**	**-0.89**	**-2.49**	**-1.64**	**-0.05**	**0.16**	**-0.25**	**-0.53**	**1.09**	**1.76**
g (no trend)	WS	-2.55	**0.79**	**2.61**	**-1.26**	**-1.52**	**-0.56**	**-0.54**	**0.07**	**-0.05**	**-0.92**	**-0.31**	**0.28**
Dg	ADF	-2.89	-3.76	-8.26	-4.14	-4.66	-6.16	**-2.55**	-4.17	-4.62	-4.47	-2.91	**-2.71**
Dg	WS	-2.55	-3.27	-7.32	-4.44	**-2.48**	-5.78	-2.80	-4.36	-4.36	-4.72	**-1.85**	**-1.19**
DDg	ADF	-2.89	-8.03	-5.49	-5.61	-10.03	-6.11	-5.15	-7.03	-4.71	-7.63	-7.06	-6.94
DDg	WS	-2.55	-8.38	-6.03	-5.74	-4.73	-5.42	-5.47	-7.41	-5.15	-8.01	-7.01	-7.66
infl (with trend)	ADF	-3.45	**-3.31**	-4.55	-3.70	-4.43	-5.11	**-3.06**	-4.19	-3.57	-3.54	-3.98	-4.28
infl (with trend)	WS	-3.24	-3.35	-4.22	-3.85	-4.52	**-3.19**	-3.34	-4.33	**-3.09**	**-3.15**	-4.12	-4.46
infl (no trend)	ADF	-2.89	-3.36	-4.66	-3.64	-4.19	-4.66	-2.94	-4.21	-3.67	-3.10	-3.76	-4.00
infl (no trend)	WS	-2.55	-3.18	-4.00	-3.63	-4.41	**-1.71**	-3.16	-4.24	-2.90	**-2.11**	-3.60	-3.91
Dinfl	ADF	-2.89	-5.05	-6.24	-6.18	-6.68	-4.84	-5.82	-5.59	-6.04	-7.19	-6.18	-5.86
Dinfl	WS	-2.55	-5.44	-6.58	-6.26	-7.03	-4.63	-6.16	-6.02	-6.18	-4.57	-6.53	-6.30
DDinfl	ADF	-2.89	-6.51	-5.58	-5.41	-5.86	-6.44	-6.40	-7.67	-6.04	-5.10	-5.02	-5.53
DDinfl	WS	-2.55	-6.96	-5.77	-5.73	-6.50	-6.31	-6.88	-8.32	-6.52	**-1.70**	-5.58	-5.86

Values in bold suggest that we fail to reject the null hypothesis of unit root at 5% significance level.

Table 3.6: Unit root test for foreign variables

Foreign Variables	Statistic	Critical Value	BENIN	BURKINA FASO	COTE DIVOIRE	GAMBIA	GHANA	GUINEA	MALI	NIGER	NIGERIA	SENEGAL	TOGO
ys (with trend)	ADF	-3.45	**-0.87**	**0.43**	**-1.31**	**-0.22**	**-1.84**	**1.29**	**0.98**	**-1.42**	**1.70**	**-1.83**	**-1.59**
ys (with trend)	WS	-3.24	**-0.17**	**-0.77**	**-0.51**	**-0.58**	**-0.22**	**-0.49**	**-0.73**	**-0.13**	**-0.35**	**-0.30**	**-0.11**
ys (no trend)	ADF	-2.89	**2.29**	**1.94**	**0.39**	**2.73**	**1.65**	**2.56**	**2.21**	**2.22**	**3.04**	**1.19**	**3.17**
ys (no trend)	WS	-2.55	**-0.37**	**0.34**	**-1.46**	**1.24**	**-0.80**	**0.19**	**0.79**	**-0.88**	**0.11**	**-1.10**	**-0.69**
Dys	ADF	-2.89	-4.83	-3.05	-5.19	**-2.06**	-5.01	-3.10	**-2.39**	-5.61	**-1.47**	-4.71	-3.56
Dys	WS	-2.55	**-2.05**	**-2.17**	**-0.71**	**-1.98**	**-1.55**	**-1.72**	**-2.15**	**-1.29**	**-1.09**	**-0.57**	**-0.43**
DDys	ADF	-2.89	-5.31	-4.11	-5.25	-3.46	-5.94	-4.21	-3.90	-5.91	-5.49	-7.07	-6.25
DDys	WS	-2.55	-4.70	-4.35	-2.97	-3.82	-4.64	-3.96	-4.23	-3.96	-5.61	-4.52	-5.23
revs (with trend)	ADF	-3.45	**-2.50**	**-1.24**	**-2.73**	**0.05**	**-3.09**	**-1.39**	**-0.59**	**-3.23**	**-1.63**	**-2.95**	**-2.67**
revs (with trend)	WS	-3.24	**-1.48**	**-0.59**	**-2.28**	**-0.36**	**-2.25**	**-0.95**	**-0.17**	**-2.33**	**-1.02**	**-1.95**	**-0.88**
revs (no trend)	ADF	-2.89	**0.17**	**2.22**	**-0.68**	**2.60**	**-0.29**	**1.52**	**2.89**	**-0.23**	**1.32**	**-0.16**	**0.89**
revs (no trend)	WS	-2.55	**-0.19**	0.35	**-0.69**	**1.67**	**-0.38**	**1.13**	**1.64**	**-0.25**	**0.99**	**-0.19**	**0.72**
Drevs	ADF	-2.89	-4.71	-3.45	-5.31	**-2.44**	-4.85	**-2.78**	**-2.35**	-5.30	**-2.66**	-4.94	-3.24
Drevs	WS	-2.55	-4.71	-3.36	-5.45	-2.61	-4.96	-2.71	**-2.37**	-5.44	-2.60	-4.91	-2.65
DDrevs	ADF	-2.89	-7.45	-5.12	-8.52	-9.18	-7.28	-10.68	-9.40	-7.81	-10.07	-7.68	-8.66
DDrevs	WS	-2.55	-7.85	-5.55	-8.96	-9.48	-7.67	-11.17	-9.57	-8.22	-10.52	-8.09	-9.10
gs (with trend)	ADF	-3.45	**-2.13**	**-1.75**	**-2.00**	**-1.87**	**-1.87**	**-3.27**	**-1.28**	**-2.02**	**-2.71**	**-1.97**	**-2.32**
gs (with trend)	WS	-3.24	**-0.60**	**-1.35**	**-1.52**	**-1.79**	**-1.37**	**-2.79**	**-1.32**	**-1.52**	**-2.20**	**-1.29**	**-2.38**
gs (no trend)	ADF	-2.89	**0.47**	**1.32**	**-0.20**	**0.94**	**0.09**	**0.77**	**1.54**	**0.00**	**0.76**	**0.15**	**0.50**
gs (no trend)	WS	-2.55	**-0.41**	**0.46**	**-0.47**	**0.25**	**-0.23**	**0.50**	**0.65**	**-0.28**	**0.36**	**-0.28**	**0.96**
Dgs	ADF	-2.89	-3.78	-4.35	-4.73	-3.97	-4.78	-5.25	-3.75	-4.96	-4.85	-4.64	-4.53
Dgs	WS	-2.55	-3.00	-4.31	-4.93	-4.24	-5.04	-5.04	-3.98	-5.19	-3.89	-4.86	-4.14
DDgs	ADF	-2.89	-5.96	-5.04	-6.09	-5.90	-8.18	-5.50	-5.47	-8.01	-6.14	-5.13	-5.29
DDgs	WS	-2.55	-6.24	-5.57	-6.47	-6.05	-8.60	-5.51	-5.75	-8.43	-5.94	-5.80	-5.39
infls (with trend)	ADF	-3.45	-4.47	-3.85	-3.72	-3.79	**-3.40**	-4.74	-3.76	-3.91	-4.88	**-3.42**	-5.34
infls (with trend)	WS	-3.24	-3.29	-3.28	**-3.02**	-3.81	**-3.10**	-3.45	-3.79	**-3.24**	-3.47	**-3.11**	-3.27
infls (no trend)	ADF	-2.89	-3.69	-3.67	-3.13	-3.60	-3.01	-4.40	-3.56	-2.95	-4.40	-2.93	-4.77
infls (no trend)	WS	-2.55	**-1.74**	**-2.38**	**-1.74**	**-3.30**	**-2.12**	**-2.27**	-3.25	**-1.90**	**-2.11**	**-2.00**	**-1.89**
Dinfls	ADF	-2.89	-5.01	-6.06	-5.96	-6.17	-6.28	-4.43	-6.04	-5.68	-4.53	-6.03	-5.17
Dinfls	WS	-2.55	-3.46	-6.24	-3.97	-6.37	-4.52	-4.86	-6.30	-3.97	-4.98	-4.64	-3.92
DDinfls	ADF	-2.89	-6.97	-5.35	-5.09	-5.65	-7.31	-5.80	-4.89	-6.80	-5.82	-5.21	-6.02
DDinfls	WS	-2.55	-7.06	-5.42	**-2.29**	-6.16	-7.08	-6.06	-5.38	-6.74	-6.03	-2.79	-4.85

Values in bold suggest that we fail to reject the null hypothesis of unit root at 5% significance level.

Table 3.7: Weak exogeneity tests of the country-specific foreign variables

Country	Critical values	Y*	REV*	G*	INFL*
BENIN	4.23	1.38	0.08	0.12	0.91
BURKINA FASO	3.39	0.26	0.04	0.05	0.93
COTE D'IVOIRE	4.23	0.20	0.00	0.32	0.35
GAMBIA	4.23	2.70	**4.43**	1.50	0.30
GHANA	4.23	4.13	3.86	0.15	**5.17**
GUINEA	4.32	0.40	0.81	0.13	0.02
MALI	3.13	0.07	0.55	1.49	0.90
NIGER	3.13	0.05	0.11	0.76	2.36
NIGERIA	3.49	0.34	1.71	0.89	0.42
SENEGAL	4.32	0.56	0.02	0.07	2.15
TOGO	3.49	0.02	0.64	0.95	0.75

Values in bold suggest that the weakly exogenous condition is rejected at 5% significance level.

Table 3.8: Average pair-wise cross-section correlation

	Y			**REV**		
	Levels	First Differences	VECMX* Residuals	Levels	First Differences	VECMX* Residuals
BENIN	0.98	0.18	-0.01	0.81	-0.05	-0.08
BURKINA FASO	0.98	0.29	0.05	0.86	0.08	-0.01
COTE DIVOIRE	0.94	0.27	0.03	0.64	0.06	-0.03
GAMBIA	0.96	-0.15	0.05	0.53	-0.03	-0.05
GHANA	0.98	0.17	-0.06	0.80	0.01	0.00
GUINEA	0.98	0.17	-0.02	0.84	0.04	-0.05
MALI	0.98	0.17	0.03	0.85	-0.01	-0.06
NIGER	0.96	0.29	0.03	0.87	0.11	-0.02
NIGERIA	0.97	0.14	-0.06	0.62	-0.05	0.00
SENEGAL	0.98	0.26	0.00	0.87	0.05	-0.07
TOGO	0.97	0.16	-0.09	0.83	0.08	0.02
	G			**INFL**		
	Levels	First Differences	VECMX* Residuals	Levels	First Differences	VECMX* Residuals
BENIN	0.74	-0.01	-0.03	0.50	0.45	0.09
BURKINA FASO	0.77	-0.01	-0.01	0.36	0.33	0.03
COTE DIVOIRE	0.66	0.07	-0.07	0.48	0.42	0.12
GAMBIA	0.29	-0.06	-0.06	-0.16	-0.11	0.00
GHANA	0.71	-0.03	-0.03	0.13	-0.01	-0.06
GUINEA	0.80	-0.01	-0.02	-0.03	0.04	-0.05
MALI	0.80	0.07	0.00	0.46	0.37	0.04
NIGER	0.81	0.04	-0.07	0.48	0.41	0.16
NIGERIA	0.75	0.03	-0.03	0.24	0.01	-0.16
SENEGAL	0.84	0.09	-0.05	0.50	0.45	0.13
TOGO	0.80	0.06	-0.03	0.45	0.42	0.07

The numbers represent the average pair-wise cross-section correlation between the endogenous variables and the foreign variables and between the residuals and the foreign variables

Table 3.9: Trade weight matrix

Country	BENIN	BURKINA FASO	COTE D'IVOIRE	GAMBIA	GHANA	GUINEA	MALI	NIGER	NIGERIA	SENEGAL	TOGO
BENIN	0.00	0.05	0.03	0.00	0.03	0.01	0.09	0.08	0.06	0.02	0.16
BURKINA FASO	0.01	0.00	0.10	0.00	0.14	0.00	0.04	0.08	0.00	0.03	0.17
COTE D'IVOIRE	0.16	0.44	0.00	0.55	0.09	0.50	0.35	0.20	0.35	0.15	0.14
GAMBIA	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
GHANA	0.15	0.14	0.11	0.01	0.00	0.30	0.04	0.09	0.33	0.03	0.23
GUINEA	0.00	0.00	0.02	0.09	0.01	0.00	0.01	0.00	0.02	0.05	0.00
MALI	0.01	0.05	0.09	0.09	0.04	0.08	0.00	0.02	0.00	0.24	0.06
NIGER	0.05	0.03	0.02	0.00	0.02	0.00	0.02	0.00	0.00	0.01	0.09
NIGERIA	0.27	0.02	0.53	0.01	0.42	0.02	0.01	0.41	0.00	0.39	0.11
SENEGAL	0.03	0.04	0.06	0.26	0.03	0.09	0.38	0.02	0.17	0.00	0.03
TOGO	0.32	0.21	0.04	0.00	0.21	0.01	0.06	0.10	0.08	0.02	0.00
TOTAL	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

The trade weights represent the average annual shares of total exports and imports.
The weights are displayed in columns by country, so that each column, but not a row, sums to one.

Table 3.10: Generalized Forecast Error Variance Decomposition: Revenue and spending Nigeria

Years	0	1	2	3	4	5
	Tax Revenue					
REV NIGERIA	0.58	0.52	0.45	0.39	0.36	0.34
INFL GHANA	0.15	0.12	0.11	0.10	0.09	0.08
G GHANA	0.08	0.06	0.05	0.05	0.04	0.04
INFL COTE D'IVOIRE	0.06	0.04	0.03	0.03	0.03	0.03
INFL NIGERIA	0.01	0.01	0.02	0.02	0.02	0.01
Y TOGO	0.01	0.02	0.02	0.02	0.02	0.02
G COTE D'IVOIRE	0.01	0.01	0.01	0.02	0.02	0.02
REV TOGO	0.00	0.00	0.00	0.00	0.00	0.00
INFL SENEGAL	0.00	0.00	0.00	0.00	0.00	0.00
G BENIN	0.00	0.01	0.01	0.01	0.01	0.01
	Public Spending					
G NIGERIA	0.85	0.74	0.73	0.68	0.67	0.65
REV GHANA	0.05	0.04	0.03	0.03	0.02	0.02
Y COTE D'IVOIRE	0.03	0.06	0.10	0.13	0.15	0.16
INFL GHANA	0.03	0.03	0.02	0.02	0.02	0.01
Y GHANA	0.01	0.02	0.03	0.03	0.03	0.03
INFL COTE D'IVOIRE	0.01	0.00	0.01	0.02	0.02	0.02
Y SENEGAL	0.01	0.01	0.01	0.01	0.01	0.01
INFL NIGERIA	0.00	0.01	0.01	0.02	0.02	0.02
Y TOGO	0.00	0.00	0.01	0.00	0.00	0.00
G GHANA	0.00	0.03	0.02	0.02	0.02	0.02

The figures represent the top ten determinants of error variance of tax revenue and public spending in WAEMU considering five years horizon.

Table 3.11: Generalized Forecast Error Variance Decomposition: Revenue and spending WAEMU

Years	0	1	2	3	4	5
	Tax Revenue					
REV COTE D'IVOIRE	0.53	0.41	0.37	0.32	0.30	0.29
REV NIGERIA	0.10	0.05	0.03	0.03	0.03	0.03
INFL GHANA	0.08	0.04	0.04	0.03	0.02	0.02
REV SENEGAL	0.07	0.09	0.10	0.09	0.09	0.09
Y COTE D'IVOIRE	0.04	0.19	0.27	0.31	0.34	0.36
INFL COTE D'IVOIRE	0.04	0.02	0.02	0.03	0.02	0.02
REV MALI	0.03	0.02	0.01	0.01	0.01	0.01
REV BURKINA FASO	0.02	0.03	0.03	0.03	0.03	0.03
Y NIGERIA	0.02	0.01	0.01	0.01	0.01	0.01
REV BENIN	0.02	0.03	0.03	0.03	0.03	0.03
	Public Spending					
G COTE DIVOIRE	0.36	0.14	0.12	0.11	0.11	0.11
G MALI	0.18	0.08	0.05	0.05	0.04	0.04
INFL COTE D'IVOIRE	0.11	0.28	0.23	0.15	0.11	0.09
Y COTE D'IVOIRE	0.09	0.27	0.40	0.50	0.54	0.57
G BENIN	0.08	0.04	0.02	0.02	0.01	0.01
G BURKINA FASO	0.04	0.01	0.01	0.00	0.00	0.00
Y NIGERIA	0.04	0.08	0.06	0.04	0.04	0.03
INFL GHANA	0.04	0.04	0.03	0.02	0.02	0.01
G NIGER	0.03	0.01	0.00	0.00	0.00	0.00
G SENEGAL	0.03	0.02	0.01	0.01	0.01	0.01

The figures represent the top ten determinants of error variance of tax revenue and public spending in WAEMU considering five years horizon.

Table 3.12: Generalized Forecast Error Variance Decomposition: Revenue and spending RECOWAS

Years	0	1	2	3	4	5
	Tax Revenue					
REV GHANA	0.87	0.86	0.85	0.85	0.84	0.83
G NIGERIA	0.08	0.06	0.07	0.07	0.08	0.08
INFL GHANA	0.05	0.07	0.08	0.07	0.08	0.08
G GHANA	0.02	0.01	0.01	0.02	0.02	0.02
INFL NIGERIA	0.01	0.01	0.01	0.01	0.01	0.01
INFL COTE D'IVOIRE	0.01	0.01	0.01	0.01	0.01	0.01
REV NIGERIA	0.01	0.02	0.02	0.02	0.02	0.03
Y NIGERIA	0.01	0.01	0.01	0.00	0.00	0.00
REV GUINEA	0.01	0.00	0.00	0.01	0.01	0.01
G TOGO	0.00	0.00	0.00	0.00	0.00	0.00
	Public Spending					
G GHANA	0.65	0.65	0.61	0.60	0.57	0.57
REV NIGERIA	0.08	0.06	0.04	0.03	0.03	0.02
INFL COTE D'IVOIRE	0.04	0.03	0.02	0.02	0.02	0.02
INFL GHANA	0.03	0.03	0.02	0.03	0.02	0.02
Y NIGERIA	0.02	0.01	0.01	0.01	0.01	0.01
Y GHANA	0.02	0.06	0.13	0.17	0.22	0.24
G NIGERIA	0.01	0.02	0.06	0.05	0.07	0.07
Y TOGO	0.01	0.02	0.01	0.01	0.01	0.01
REV TOGO	0.01	0.01	0.01	0.01	0.01	0.01
G GUINEA	0.01	0.01	0.01	0.01	0.01	0.01

The figures represent the top ten determinants of error variance of public revenue and spending in RECOWAS considering five years horizon.

Figure 3.1: **Primary balance and public debt (% GDP)**

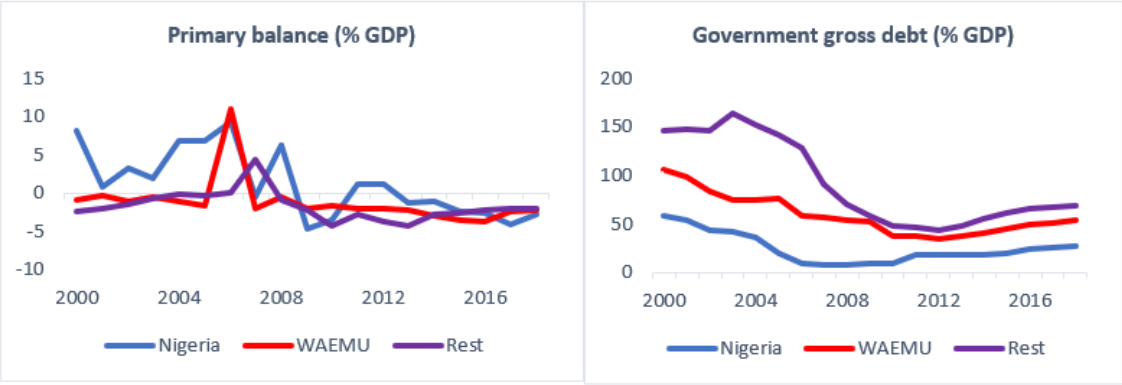
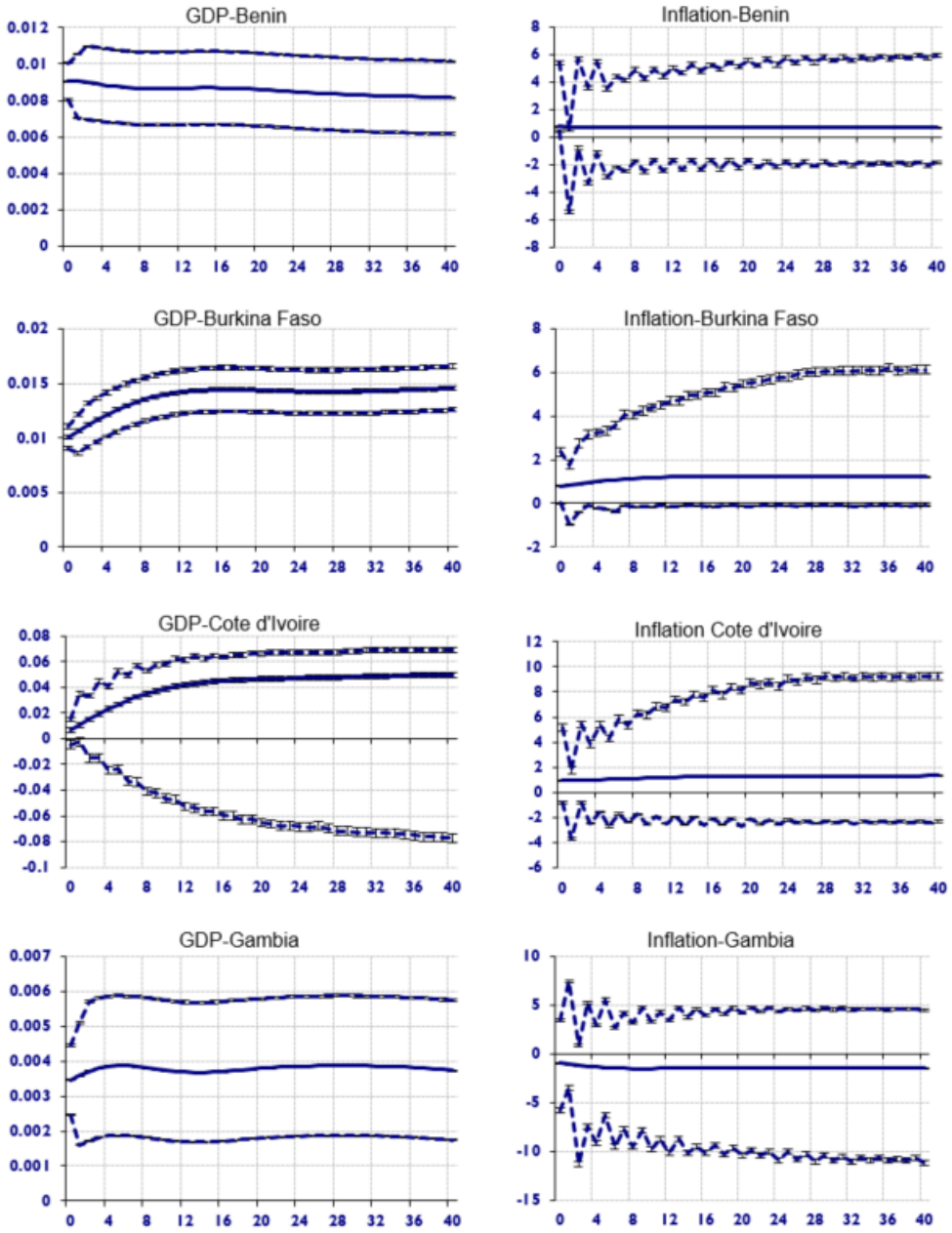
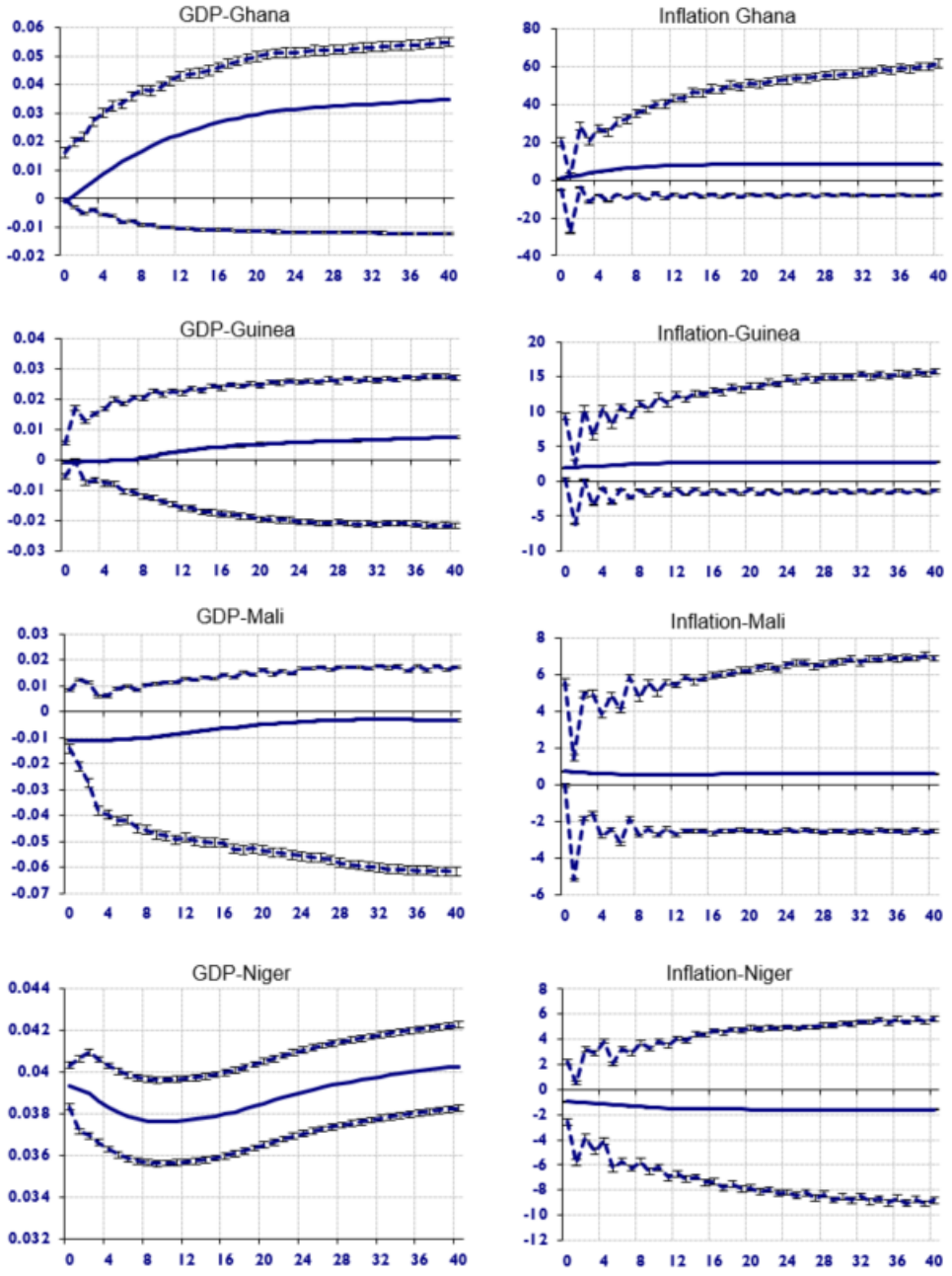


Figure 3.2: **Impulse responses of country-specific negative spending shock affecting Nigeria**



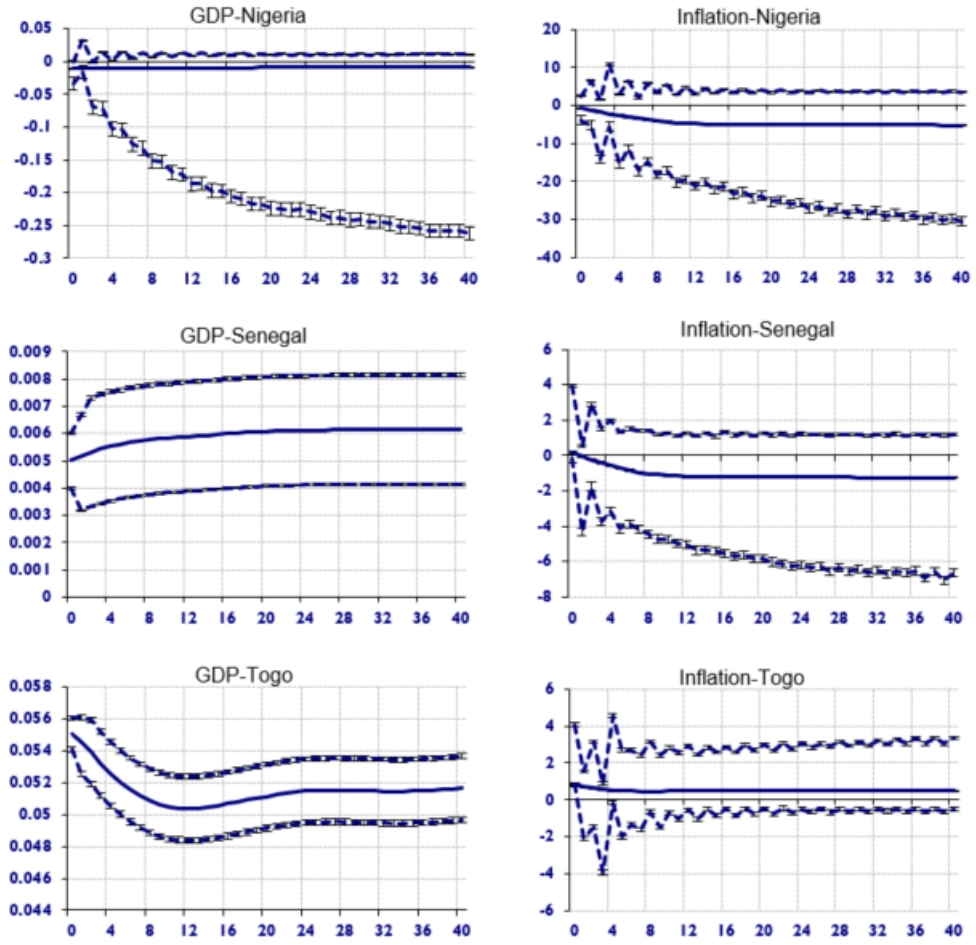
The dashed lines represent 90% bootstrap confidence interval.

Figure 3.3: **Impulse responses of country-specific negative spending shock affecting Nigeria (cont.)**



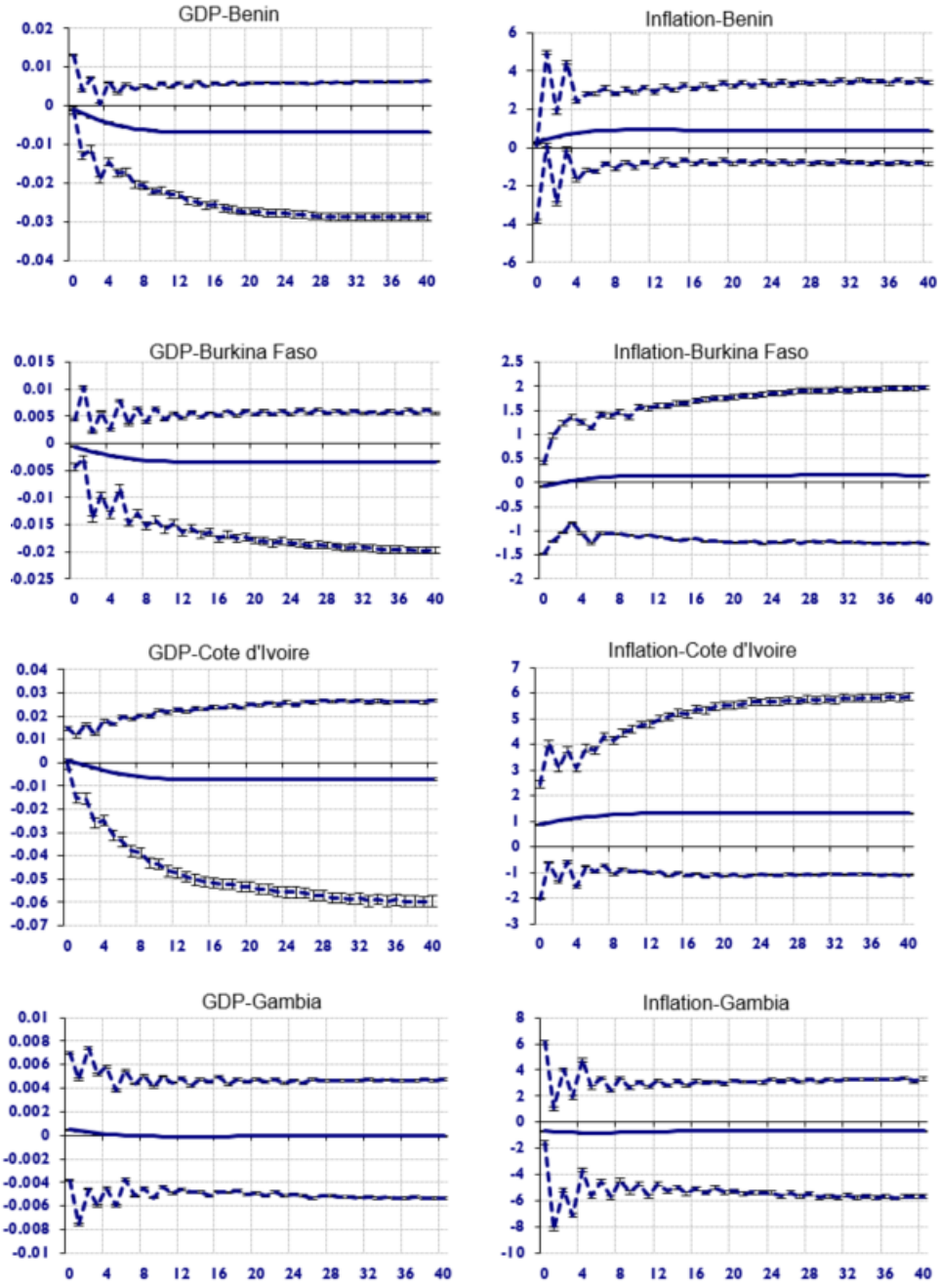
The dashed lines represent 90% bootstrap confidence interval.

Figure 3.4: **Impulse responses of country-specific negative spending shock affecting Nigeria (cont.)**



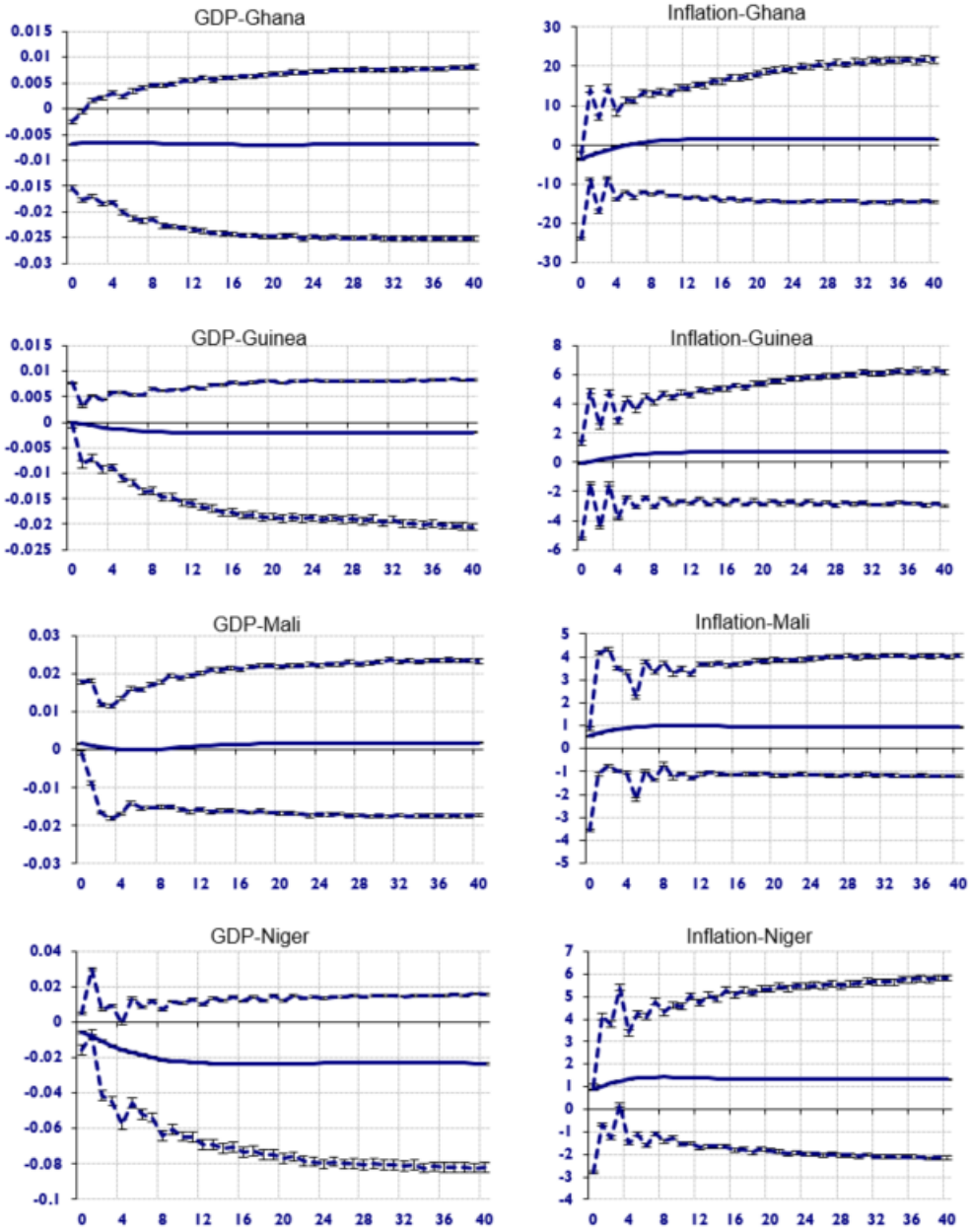
The dashed lines represent 90% bootstrap confidence interval.

Figure 3.5: **Impulse responses of country-specific negative tax revenue shock affecting Nigeria**



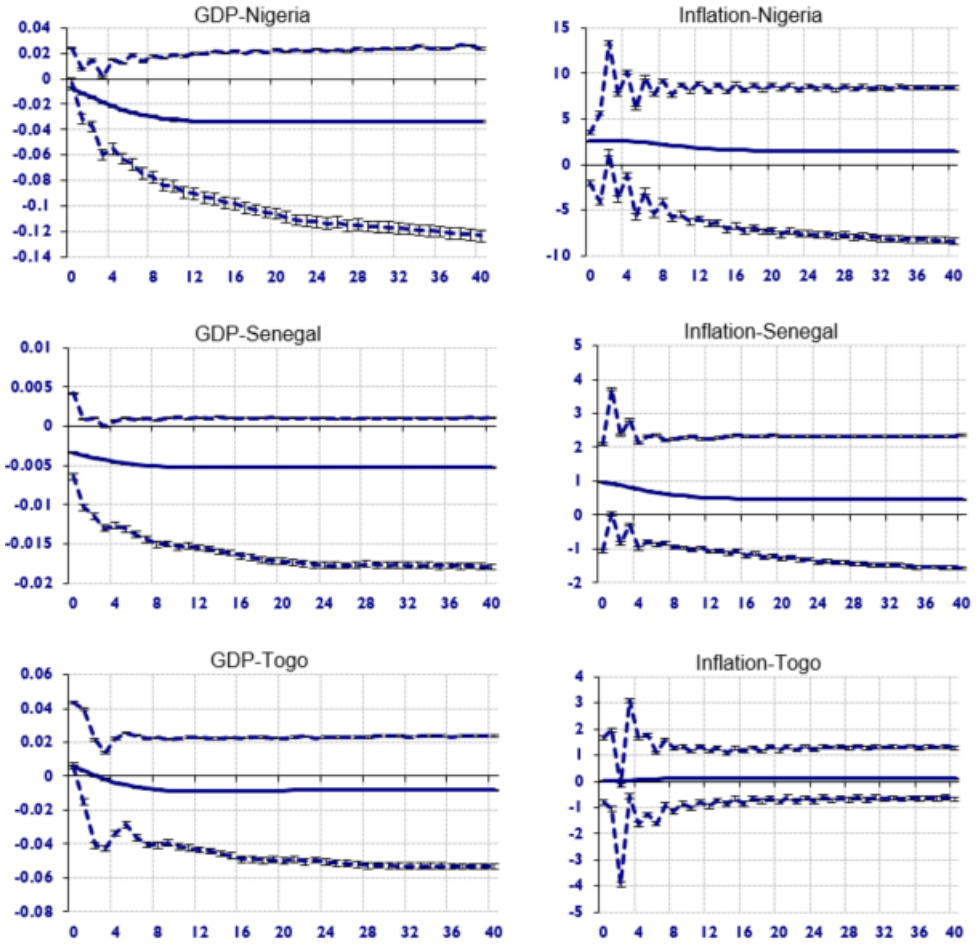
The dashed lines represent 90% bootstrap confidence interval.

Figure 3.6: **Impulse responses of country-specific negative tax revenue shock affecting Nigeria (cont.)**



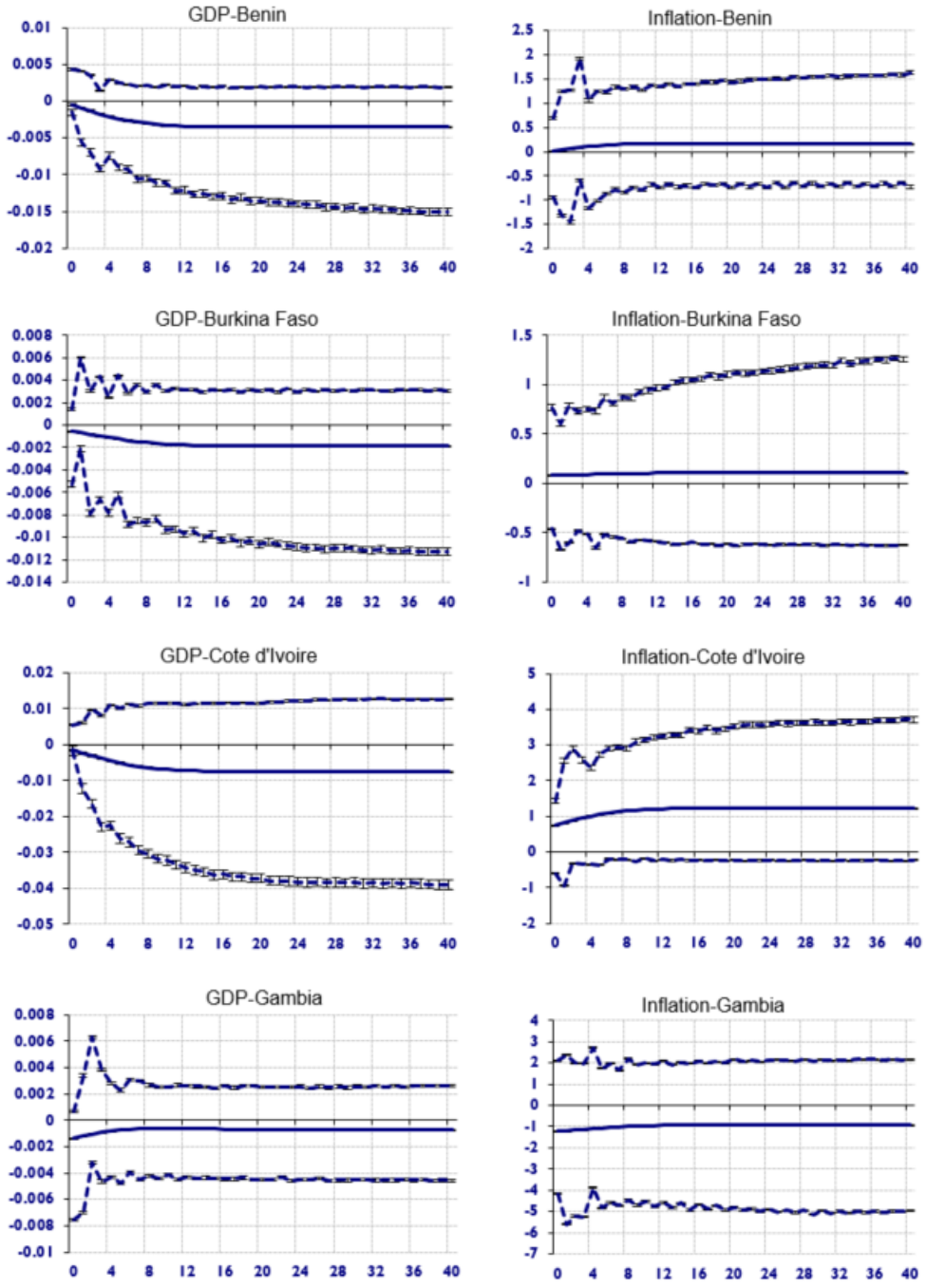
The dashed lines represent 90% bootstrap confidence interval.

Figure 3.7: **Impulse responses of country-specific negative tax revenue shock affecting Nigeria (cont.)**



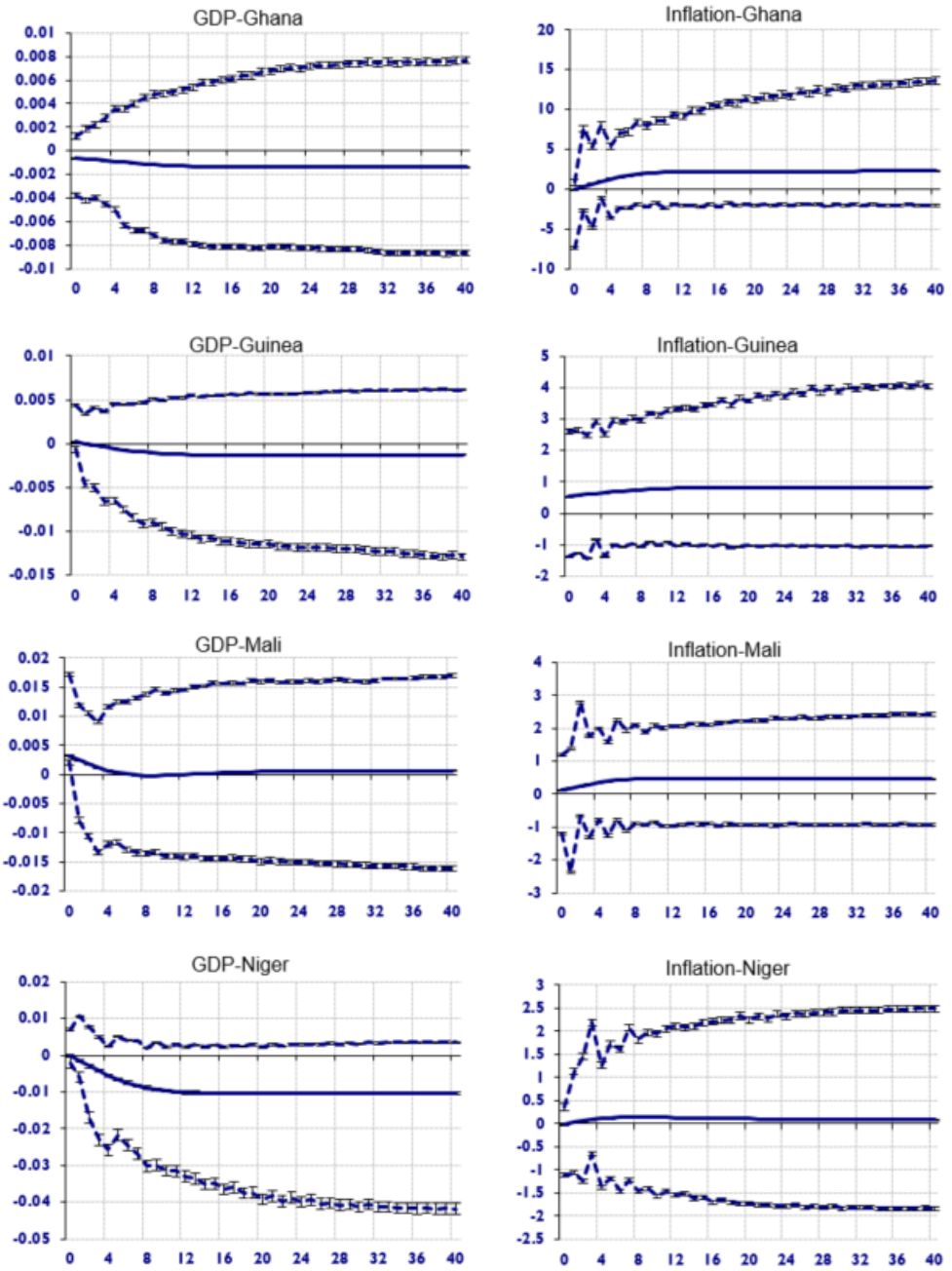
The dashed lines represent 90% bootstrap confidence interval.

Figure 3.8: **Impulse responses of regional negative spending shock affecting WAEMU**



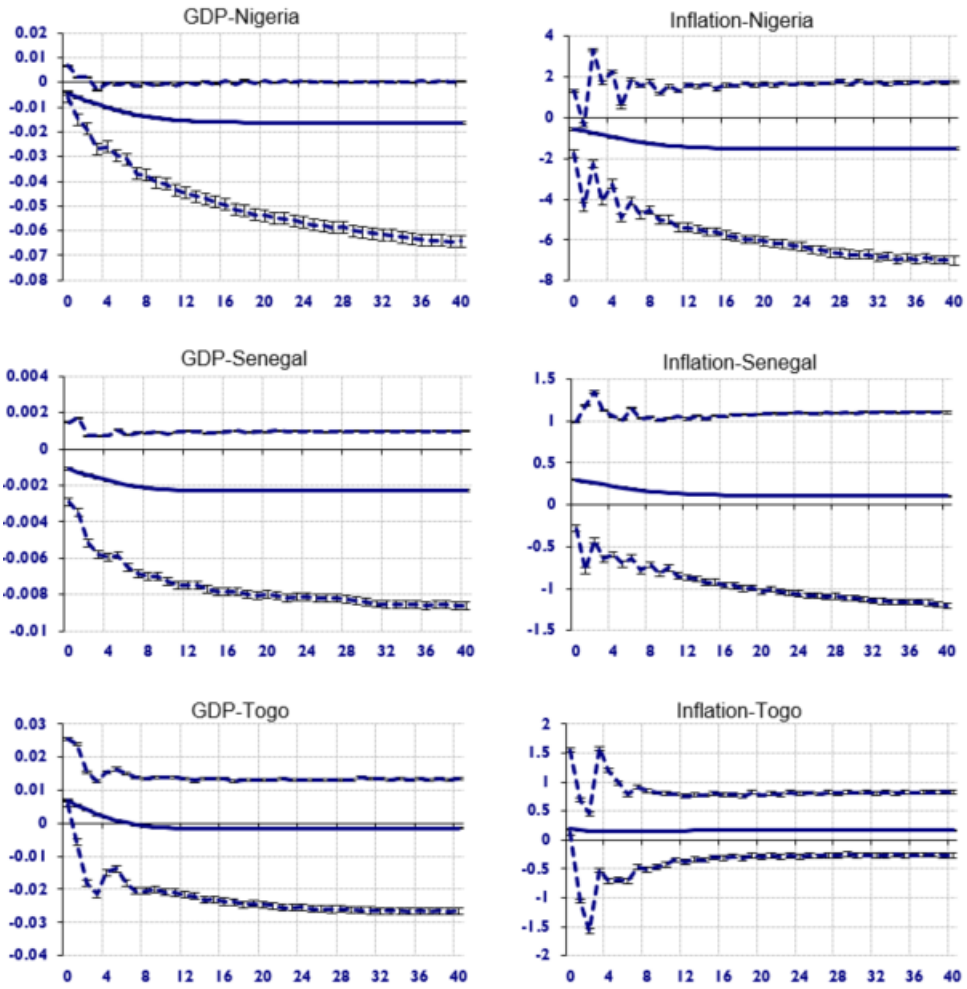
The dashed lines represent 90% bootstrap confidence interval.

Figure 3.9: **Impulse responses of regional negative spending shock affecting WAEMU (cont.)**



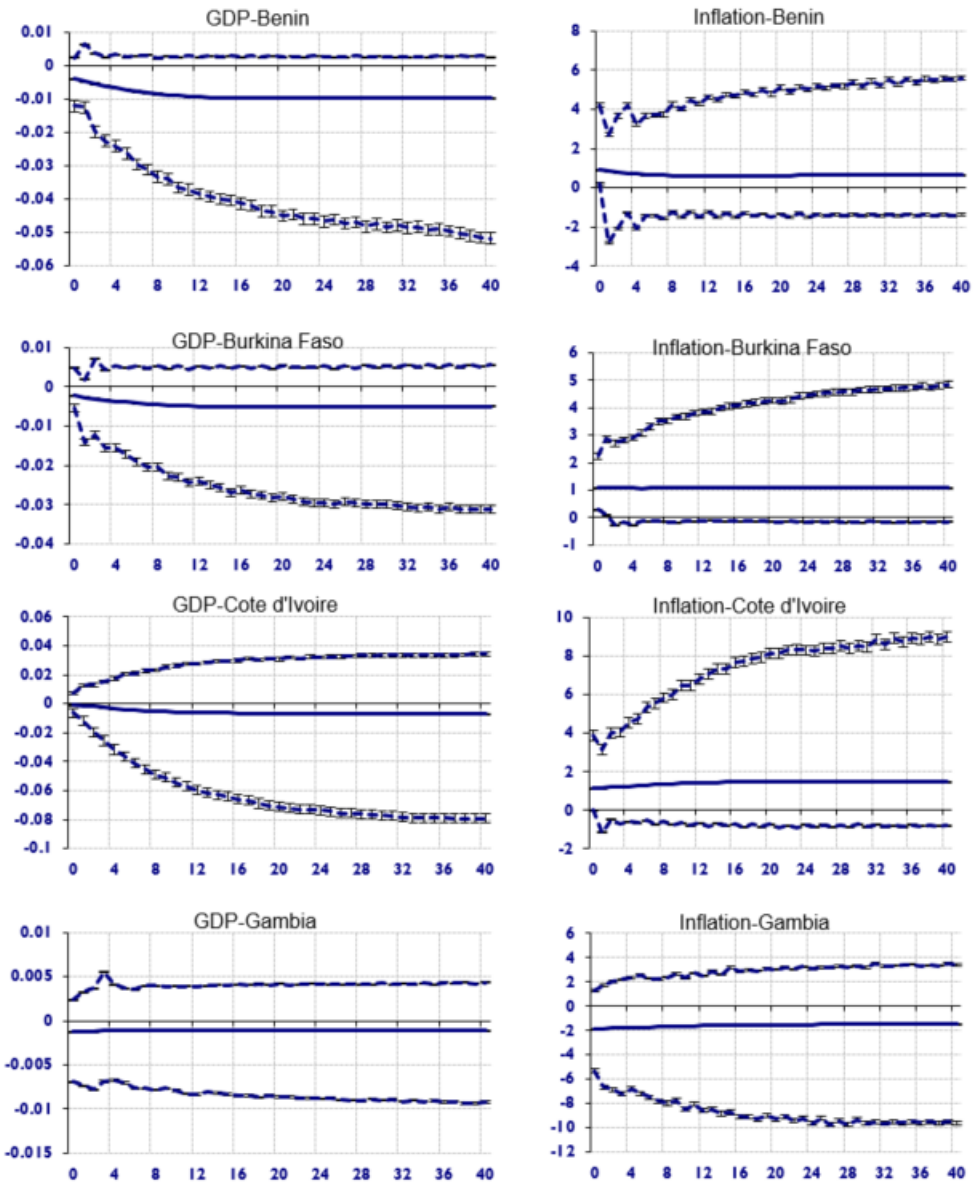
The dashed lines represent 90% bootstrap confidence interval.

Figure 3.10: **Impulse responses of regional negative spending shock affecting WAEMU (cont.)**



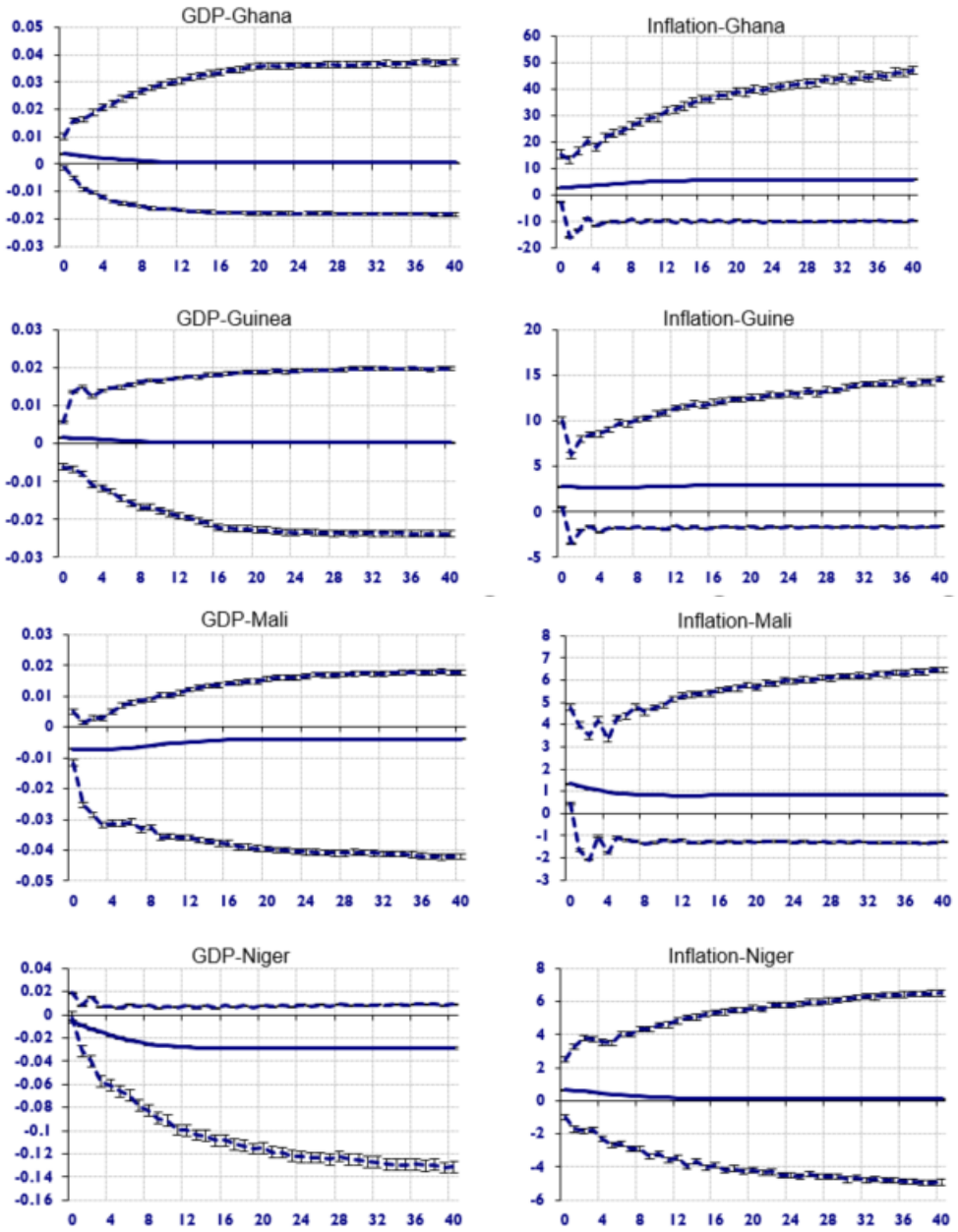
The dashed lines represent 90% bootstrap confidence interval.

Figure 3.11: **Impulse responses of regional negative tax revenue shock affecting RECOWAS**



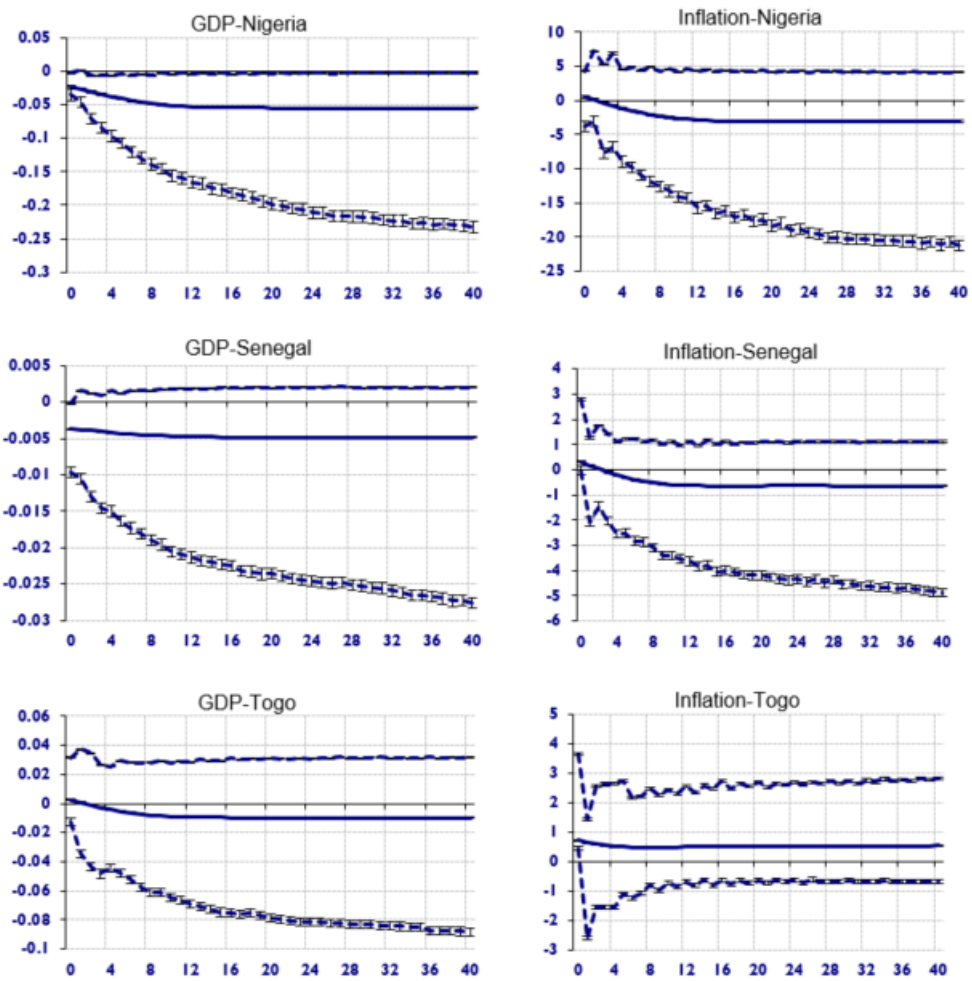
The dashed lines represent 90% bootstrap confidence interval.

Figure 3.12: **Impulse responses of regional negative tax revenue shock affecting RECOWAS (cont.)**



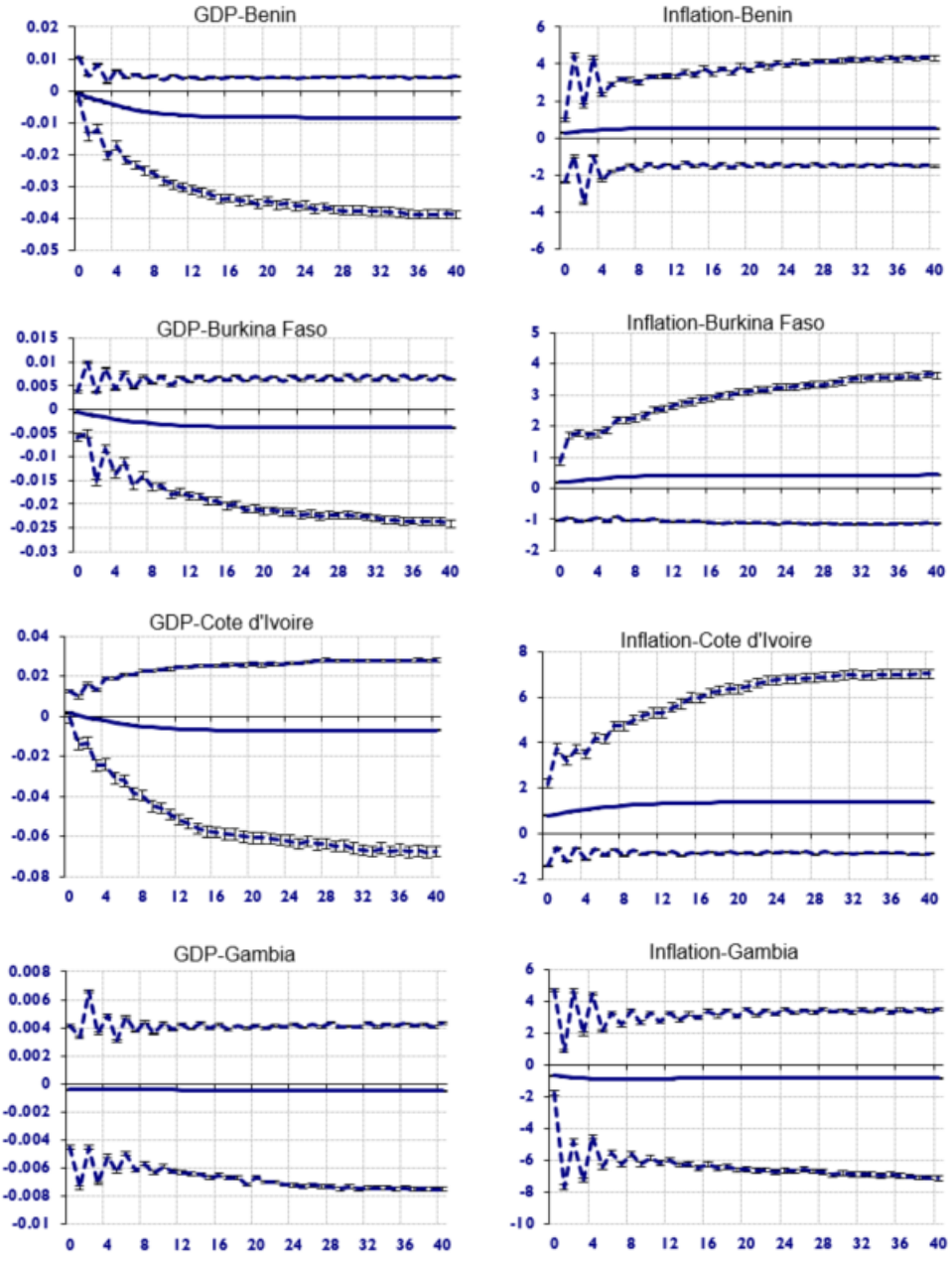
The dashed lines represent 90% bootstrap confidence interval.

Figure 3.13: **Impulse responses of regional negative tax revenue shock affecting RECOWAS (cont.)**



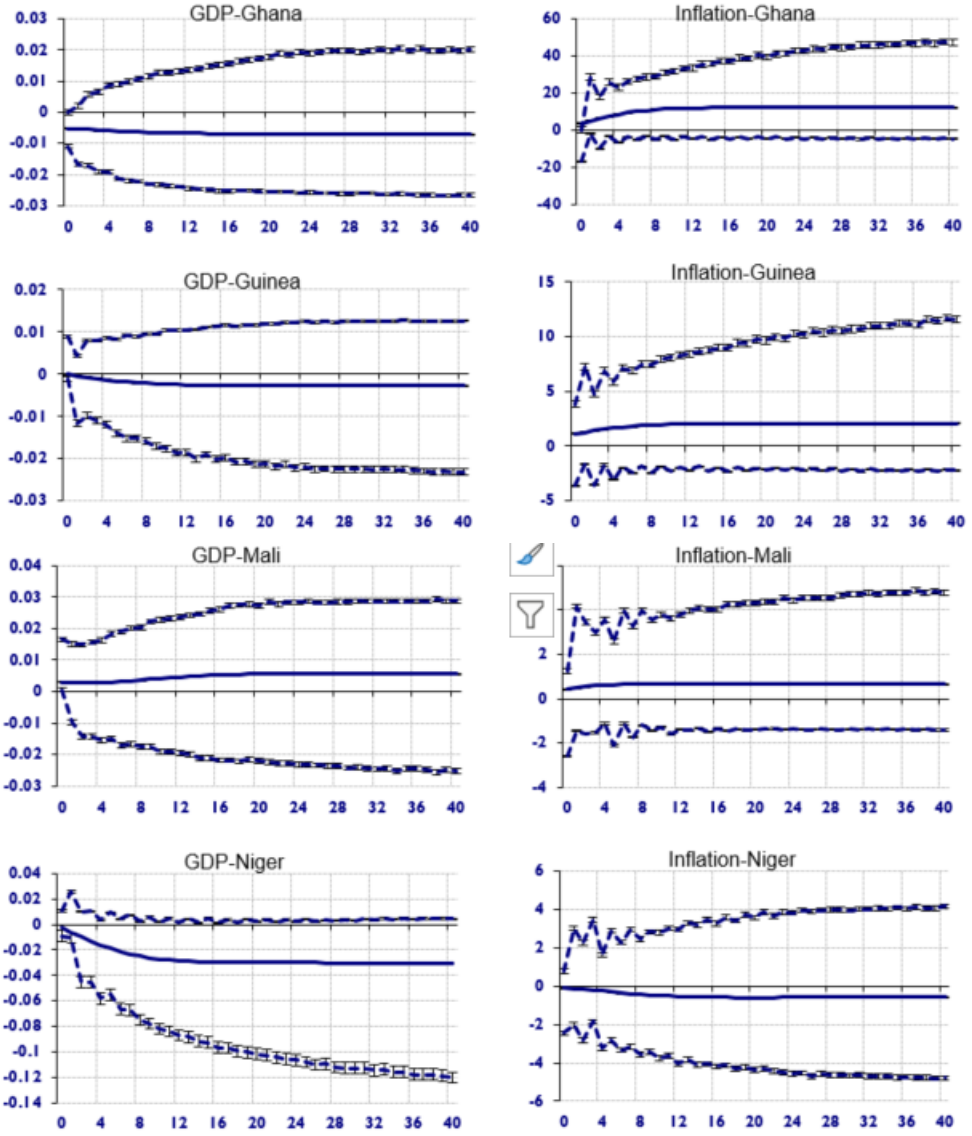
The dashed lines represent 90% bootstrap confidence interval.

Figure 3.14: **Impulse responses of regional negative spending shock affecting RECOWAS**



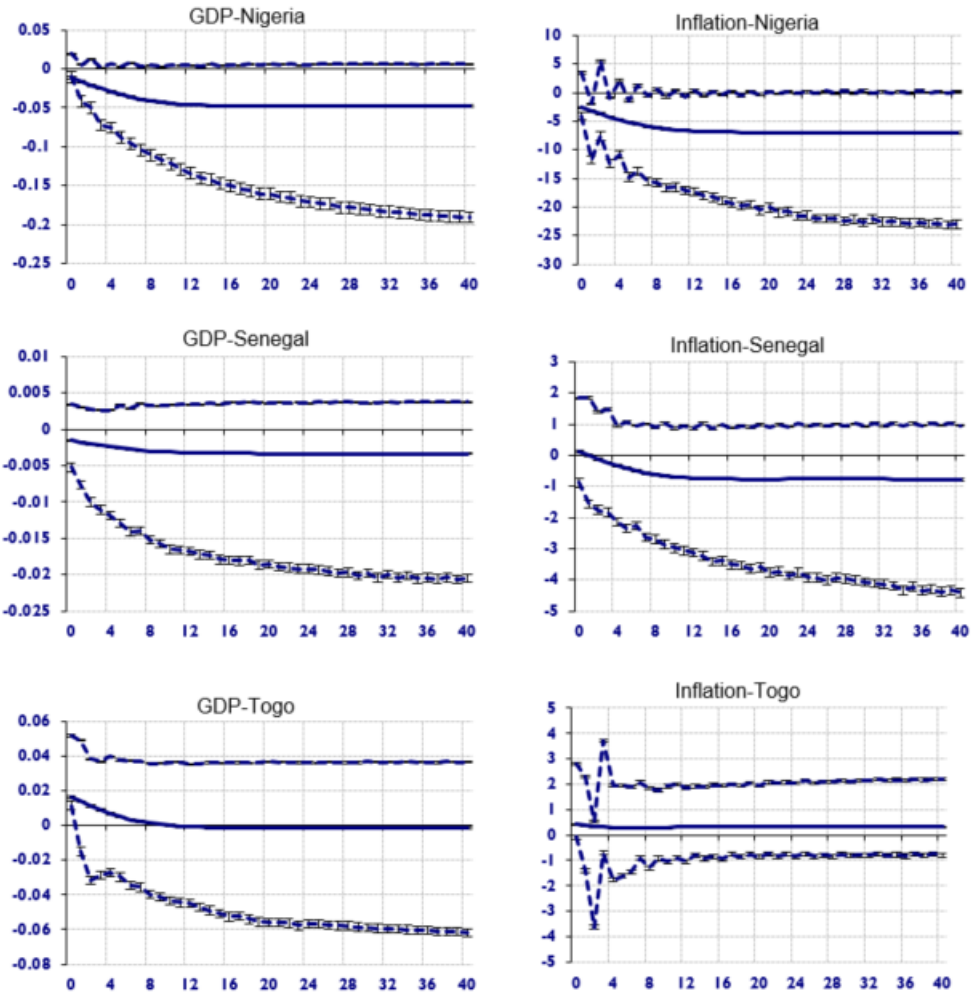
The dashed lines represent 90% bootstrap confidence interval.

Figure 3.15: **Impulse responses of regional negative spending shock affecting RECOWAS (cont.)**



The dashed lines represent 90% bootstrap confidence interval.

Figure 3.16: **Impulse responses of regional negative spending shock affecting RECOWAS (cont.)**



The dashed lines represent 90% bootstrap confidence interval.

General Conclusion

This thesis is composed of three stand-alone but interconnected chapters in which we use a set of macroeconomic models to assess the effectiveness and the feasibility of the project of creating a monetary union in the Economic Community of West African States (ECOWAS). The creation of this monetary union is crucial for strong economic integration in the ECOWAS region; however, it could have significant effects on the economies of the participating countries. Hence, a thorough analysis is needed to shed light on the readiness of these countries. In this thesis, we have focused on the macroeconomic implications of this project, focusing on three aspects. First, we have studied the propagation mechanisms of idiosyncratic macroeconomic shocks across the region since asymmetric shocks are one of the main reasons why joining a monetary union could be costly. Second, we have assessed the role of fiscal transfers in the stabilization of business cycle fluctuations in the monetary union; and third, we have examined the role of fiscal policy in the smooth transition to this monetary union as well as the welfare implications of the creation of this monetary union for the participating countries.

The first chapter has provided an understanding of the propagation mechanisms of idiosyncratic shocks in the ECOWAS countries when there are inside a monetary union compared to outside. We have compared the dynamics over time of a series of macroeconomic indicators in the presence of idiosyncratic productivity and terms-of-trade shocks in the ECOWAS region. Based on the analysis, we have shown that the effects of idiosyncratic shocks in the ECOWAS countries are magnified in monetary union compared to the independent monetary regime. Also, notable differences have been observed in terms of the cross-country effects of the shocks. Our results suggest that macroeconomic adjustment is needed to cope efficiently with idiosyncratic shocks if the ECOWAS countries were to form a monetary union.

Based on the results of the first chapter, we have considered in the second chapter intergovernmental fiscal transfers as an adjustment tool and assess how they could be used to stabilize business cycle fluctuations in the union. Even though the intergovernmental transfer mechanism requires strong political will and fiscal discipline that is relatively nonexistent in the ECOWAS countries, the renewed interest for fiscal transfers within the European Monetary Union suggests that the analysis of the functioning of such arrangements in the ECOWAS region is relevant. Our study results suggest that the transfer system has some relevant stabilization properties and can potentially be considered in the context of the ECOWAS monetary union. However, the optimal design of the fiscal transfer mechanism plays a critical role in its ability to stabilize business cycle fluctuations in the region. Using the model developed in the first two chapters of the thesis, we have derived the welfare implications of

the creation of the monetary union in the presence of idiosyncratic shocks. We have shown that the creation of the ECOWAS monetary union could be welfare improving for all the participating countries with some cross-country divergence in the magnitude of the welfare gain.

Finally, in the third chapter, we have investigated the cross-border spillovers effect of fiscal shocks in the ECOWAS region. Our results suggest the existence of small fiscal interlinkages within the ECOWAS countries. We also provide evidence of cross-country heterogeneity in fiscal spillovers in the region. The spillover effects are relatively high for fiscal shocks affecting Nigeria, but small for shocks affecting the other countries in the area.

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