Quantitative Exploration of Fiscal Rules for WAEMU Countries

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Motivation

- I document that WAEMU countries are heteregeneous in mean and volatility of government spendings, revenues, debts, budget balance

- Despite their heterogeneity they are subjected to the same fiscal rule (below 3% of deficit limit)

Questions

1. *Evaluation of current fiscal rule:* Is the current homogeneous fiscal rule of 3% of deficit limit is Pareto improving over no rule ?

2. *Potential reform:* Is there an optimal fiscal rule that is Pareto improving over current rule?

    i. The interest rate is exogenous $\equiv$ Individually design the fiscal rule

    ii. The interest rate is endogenous $\equiv$ Jointly design the fiscal rule

Contributions

- I quantitatively evaluate the optimal rule using a model of fiscal policy with two ingredients:
  1. Present-biased government: need for discipline
  2. Shocks to fiscal revenues: need for flexibility
- I perform the welfare analysis of the fiscal rules

Findings:

- *Evaluation of current fiscal rule:* All the countries benefit from 3% deficit limit over no rule
- *Potential reform I:* When each country individually designs their rule, the tighter deficit limit is 0.6% and the looser deficit limit is 3.9%
- *Potential reform II:* When the countries jointly design the rule, the tighter maximum deficit is 2% and the slacker deficit limit is 12%

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Fiscal rule in WAEMU countries: Uniform fiscal rule

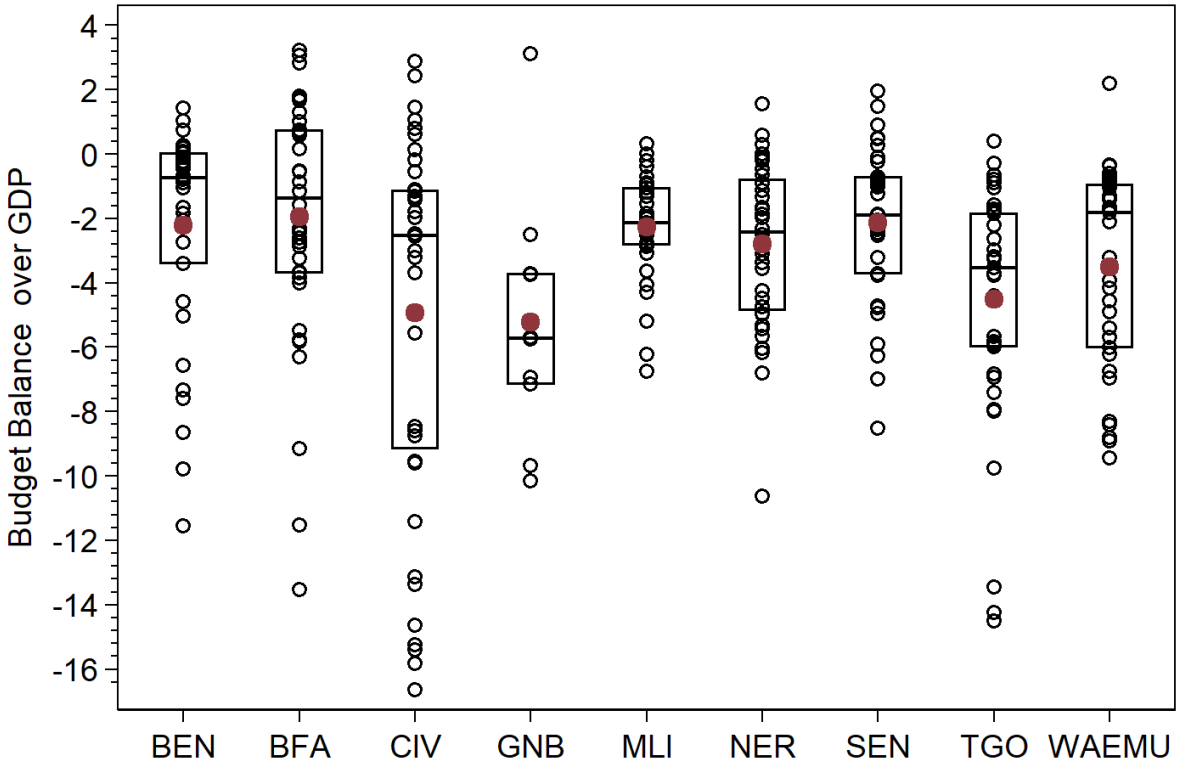
- In 2000, WAEMU countries adopt a supranational rules refer as fiscal convergence criteria including:
  - Balanced budget rule (excluding budget grants and foreign-financed capital expenditures)
- Since 2015, a maximum of 3% deficit rule has been adopted

Fiscal rule in WAEMU countries: Heterogeneity

Data

- Data source: ”La Base des Données Economiques et Financières” de la BCEAO
- I extract data on government expenditures, revenues, debts for the eight WAEMU countries
- Annual time series data from 1960 to 2018

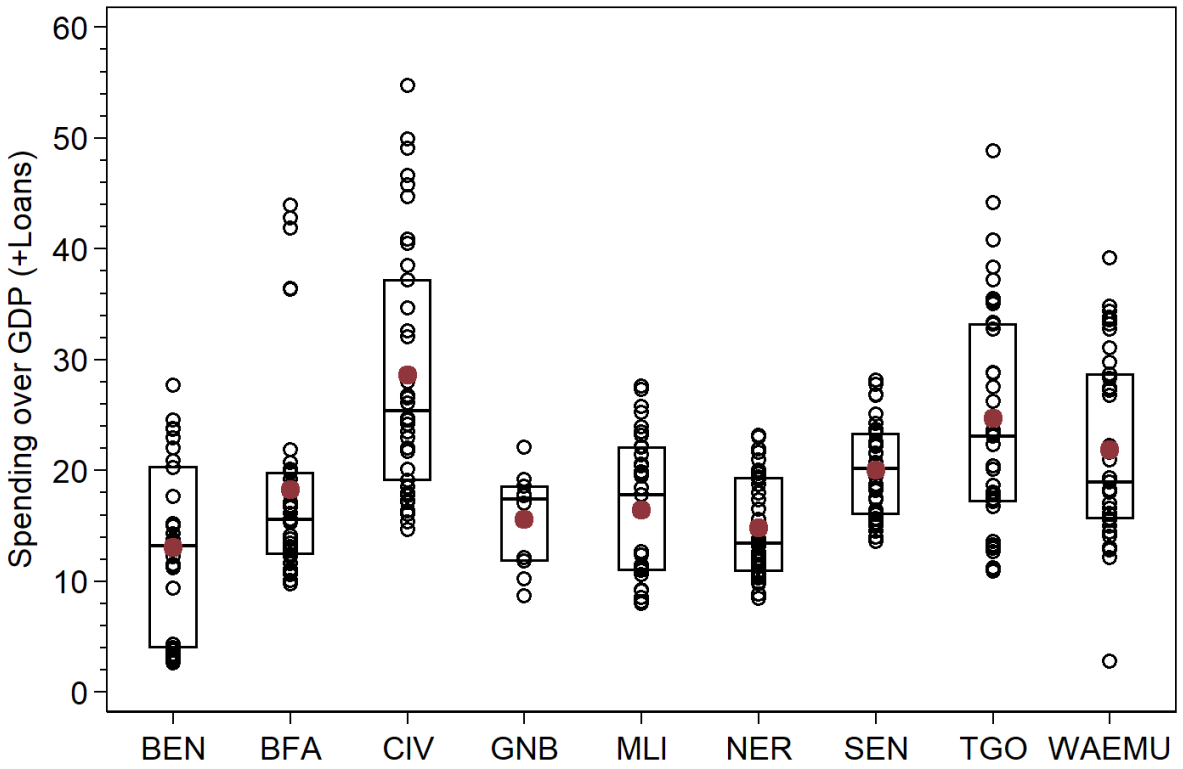
Fiscal rule in WAEMU countries: Heterogeneity



The height of each box is the interquartile intervalle (measure of volatility)
The red dot represents the average point

- Government Budget Balance over GDP
- Government Spending over GDP
- Government Revenue over GDP
- Government Debt over GDP

Fiscal rule in WAEMU countries: Heterogeneity



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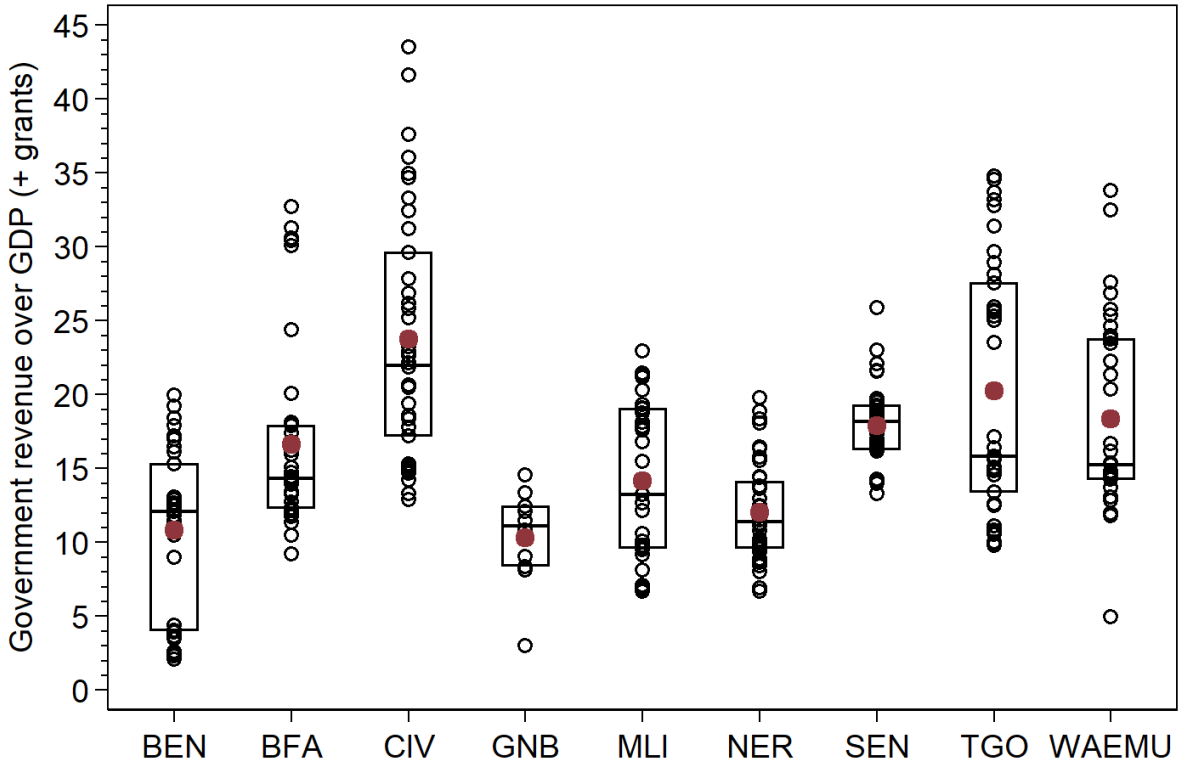

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- Government Budget Balance over GDP
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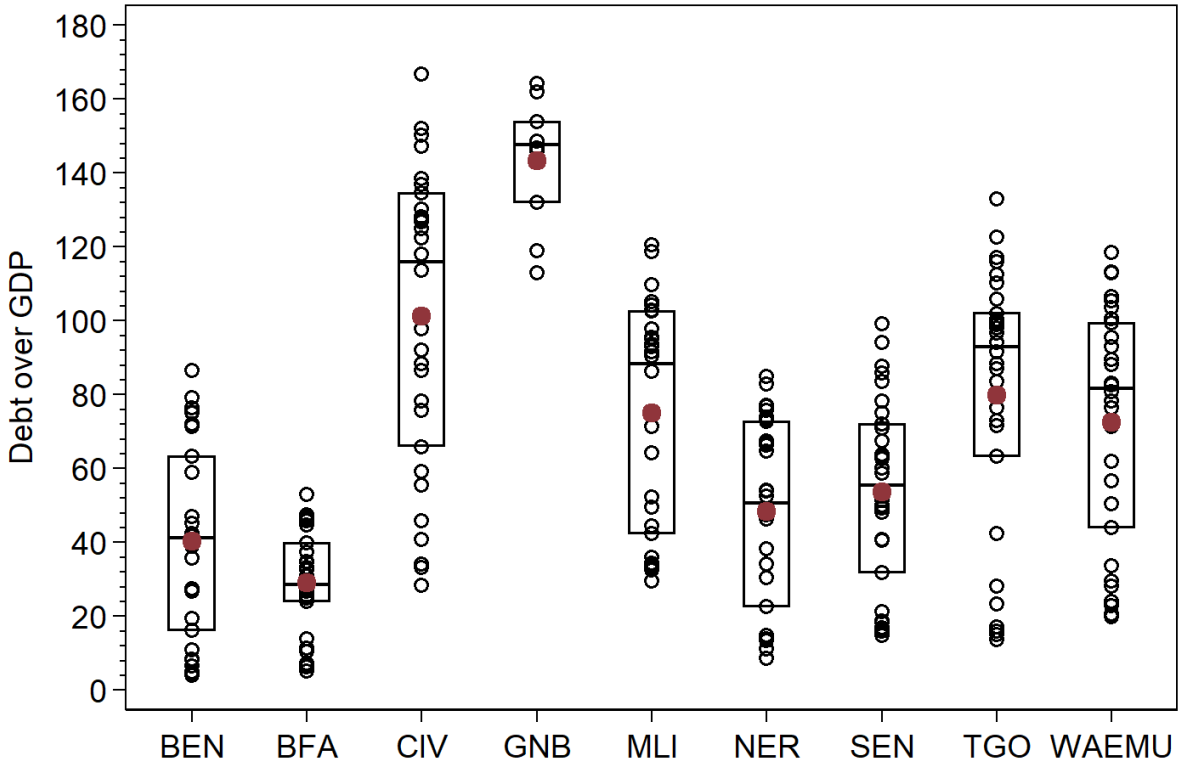

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- Government Spending over GDP
- Government Revenue over GDP
- Government Debt over GDP

Economic environment

- Model of fiscal policy of N governments where each makes decisions on spending and borrowing $i = 1, 2, ..., N$
- Two periods model: each government chooses first-period public spending and second-period asset
- Governments are heterogeneous in two ways:
  - They experience each a preference shocks $\theta_i \in \theta_i \equiv [\underline{\theta_i}, \bar{\theta_i}]$; $\theta_i > 0$ with cdf $F_i(\theta_i)$;
  - They are each present-biased : δ_i

$$\{t, t+1, t+2, t+3, ...\} \quad \{1, \delta_i\beta, \delta_i\beta^2, \delta_i\beta^3, ...\}$$

- For each government $i = 1, 2, ...N$ we have
  - Social welfare:

$$\mathbb{E}\left[\theta_i U(g_i, \theta_i) + \beta W(x_i)\right], \quad \beta \in (0, 1) \tag{1}$$

  - Government objective:

$$\theta_i U(g_i, \theta_i) + \delta_i \beta W(x_i), \quad \delta_i \in (0, 1] \tag{2}$$

Model implications for government i

- Unless $\delta_i = 1$, there is a trade-off between **commitment** and **flexibility**
  - Rules provide commitment (limit distorted incentives)
  - Some discretion may be optimal (flexibility to react to shocks)

- Fiscal rule: Spending cap $\equiv$ Threshold on $\theta_i^* \in [\underline{\theta}_i, \bar{\theta}_i]$ Plot1

$$(g_i^{fr}(\theta_i, R), x_i^{fr}(\theta_i, R)) \equiv \begin{cases} (g_i^f(\theta_i, R), x_i^f(\theta_i, R)), & \text{if } \theta_i \leq \theta_i^* \\ (g_i^f(\theta_i^*, R), x_i^f(\theta_i^*, R)), & \text{if } \theta_i > \theta_i^* \end{cases} \tag{3}$$

Where
$(g_i^f(\theta_i, R), x_i^f(\theta_i, R)) = \underset{g_i, x_i}{\operatorname{argmax}} \left(\theta_i U(g_i, \theta_i) + \delta_i \beta W(x_i, \theta_i) \quad st \quad g_i + \frac{x_i}{R} = \tau_i \right)$ is the government choice of allocations in absence of fiscal rule

- Assuming a constant revenue, the fiscal rule can be implemented by a maximum deficit limit rule

Calibration

- Functional forms: $U(g) = 1 - e^{(-\alpha g)}$; $W(x) = 1 - e^{-\alpha(\tau + x)}$; $\theta \equiv$ Shock on government revenue

Parameters picked from literature and identical for all countries

- Discount factor $\beta = 0.9524$

- Net interest rate $r = 5\%$

Parameters calibrated to match mean and variance of budget balance from 1960-1999

Table 1: Calibration

	BEN	*BFA*	*CIV*	*GNB*	*MLI*	*NER*	*SEN*	*TGO*
α	**0.365**	**0.121**	**0.621**	**0.654**	**0.178**	**0.482**	**0.533**	**0.569**
δ	**0.954**	**0.966**	**0.896**	**0.901**	**0.981**	**0.951**	**0.958**	**0.918**

Spending Equivalent variation of welfare

Spending Equivalent variation of welfare for Benin with $\delta = 0.954$

- Let $g^f(\theta, R)$ be the government spending rule before the year 2000
- Let $g^{fr}(\theta, R)$ be the government spending rule under the maximum deficit rule of 3% of GDP
- Λ, the spending equivalent of welfare variation, satisfies:

$$\mathbb{E}[\theta U(g^f(\theta, R)(1+\Lambda)) + \beta W(x^f(\theta, R))] = \mathbb{E}[\theta U(g^{fr}(\theta, R)) + \beta W(x^{fr}(\theta, R))] \quad (4)$$

- $\Lambda = 0.51\%$

Spending Equivalent variation of welfare

Spending Equivalent of welfare variation for WAEMU countries

Table 2

	From no rule to 3% deficit limit in %							
	BEN	*BFA*	*CIV*	*GNB*	*MLI*	*NER*	*SEN*	*TGO*
δ	**0.954**	**0.966**	**0.896**	**0.901**	**0.981**	**0.951**	**0.958**	**0.918**
Λ (in%)	**0.51**	**0.71**	**0.69**	**1.77**	**0.11**	**0.38**	**0.16**	**0.61**

Proposition

There exist δ_i^* for each country such that if $\delta_i < \delta_i^*$ the 3% rule improves government i welfare over no rule

Present-bias parameters for indifference between no rule and current rule

Table 3: δ and δ^*

	BEN	*BFA*	*CIV*	*GNB*	*MLI*	*NER*	*SEN*	*TGO*
δ	**0.954**	**0.966**	**0.896**	**0.901**	**0.981**	**0.951**	**0.958**	**0.918**
δ^*	**0.976**	**0.987**	**0.929**	**0.943**	**0.988**	**0.970**	**0.975**	**0.945**

Uncoordinated Fiscal Rule Design

- Government i chooses its fiscal rule independently

- Program solve by this government: Plot 2

$$\max_{\theta_i^* \in [\underline{\theta_i}, \bar{\theta_i}]} \int_{\underline{\theta_i}}^{\theta_i^*} \left(\theta_i U(g_i(\theta_i, R)) + \beta W(x_i(\theta_i, R))\right) f(\theta_i) d\theta_i + \int_{\theta_i^*}^{\bar{\theta_i}} \left(\theta_i U(g_i(\theta_i^*, R)) + \beta W(x_i(\theta_i^*, R))\right) f(\theta_i) d\theta_i \tag{5}$$

s.t.

$$(g_i(\theta_i, R), x_i(\theta_i, R)) \in \underset{g_i, x_i}{\operatorname{argmax}} \left(\theta_i U(g_i, \theta_i) + \delta_i \beta W(x_i, \theta_i) \quad s.t. \quad g_i + \frac{x_i}{R} = \tau_i\right)$$

- Given R, the optimal uncoordinated fiscal rule is a cutoff θ_{iu}^* satisfying:

$$\frac{\mathbb{E}\left[\theta_i | \theta_i \geq \theta_{iu}^*\right]}{\theta_{iu}^*} = \frac{1}{\delta_i} \tag{6}$$

Quantitative uncoordinated fiscal rule for Benin

- Shock threshold as fiscal rule: $\theta^* = 0.959$
- Government spending cap as fiscal rule: $gcap = 11.49\%$ of GDP
- Optimal deficit limit as fiscal rule: $deficit = 0.64\%$ of GDP
- Spending welfare variation equivalent from 3% deficit limit to 0.64% deficit limit: $\Lambda = 0.13\%$

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Evaluation of optimal uncoordinated fiscal rule for WAEMU countries

Optimal deficit limit rule and welfare variation for WAEMU countries

Table 4

Optimal deficit limit (DL) and Λ from 3% to optimal rule in %								
	BEN	*BFA*	*CIV*	*GNB*	*MLI*	*NER*	*SEN*	*TGO*
δ	**0.954**	**0.966**	**0.896**	**0.901**	**0.981**	**0.951**	**0.958**	**0.918**
DL (in%)	**0.64**	**3.91**	**1.79**	**3.50**	**2.06**	**1.80**	**1.06**	**2.17**
Λ (in%)	**0.125**	**0.000**	**0.019**	**0.013**	**0.006**	**0.025**	**0.038**	**0.013**

Constraint Uniform fiscal rule Design

- The assumptions for this case are: common preference shocks θ, common governments' present bias δ for all countries

- Program solve by the Central Bank:

$$\max_{\theta^* \in [\underline{\theta}, \bar{\theta}]} \int_{\underline{\theta}}^{\theta^*} \left(\theta U(g(\theta, R)) + \beta W(x_i(\theta_i, R))\right) f(\theta) d\theta + \int_{\theta^*}^{\bar{\theta}} \left(\theta U(g(\theta^*, R)) + \beta W(x(\theta^*, R))\right) f(\theta) d\theta \tag{7}$$

s.t.
$$(g(\theta, R), x(\theta, R)) \in \underset{g,x}{\operatorname{argmax}} \left(\theta U(g, \theta) + \delta\beta W(x, \theta) \quad s.t. \quad g + \frac{x}{R} = \tau\right)$$

- Given R, the optimal constraint uniform fiscal rule is a cutoff θ^*_{uc} satisfying:

$$\frac{\mathbb{E}\left[\theta | \theta \geq \theta^*_{uc}\right]}{\theta^*_{uc}} = \frac{1}{\delta} \tag{8}$$

Evaluation of constraint uniform fiscal rule for WAEMU

- Model parameters: $\alpha = 0.65$ and $\delta = 0.93$
- Shock threshold as fiscal rule: $\theta^* = 0.939$
- Government spending cap as fiscal rule: $gcap = 19.09\%$ of GDP
- Optimal deficit limit as fiscal rule: $deficit = 0.73\%$ of GDP
- Spending welfare variation equivalent from 3% deficit limit to 0.73% deficit limit: $\Lambda = 0.088\%$

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Coordinated Fiscal Rule Design

- The Central Bank designs jointly the rules for each country in the Union such that:

$$\max_{\otimes_{i=1}^{n}\theta_i^* \in \otimes_{i=1}^{n}[\underline{\theta_i},\bar{\theta_i}]} \sum_{i}^{n} \upsilon_i [\int_{\underline{\theta_i}}^{\theta_i^*} \left(\theta_i U(g_i^f(\theta_i, R(\theta^*))) + \beta W(x_i^f(\theta_i, R(\theta^*))\right) f_i(\theta_i) d\theta_i \tag{9}$$

$$+ \int_{\theta_i^*}^{\bar{\theta_i}} \left(\theta_i U(g_i^f(\theta_i^*, R(\theta^*))) + \beta W(x_i^f(\theta_i^*, R(\theta^*))\right) f_i(\theta_i) d\theta]$$

subject to

$$\sum_{i}^{n} \upsilon_i \int_{\underline{\theta_i}}^{\bar{\theta_i}} \left((g_i^f(\theta_i, R)\right) f_i(\theta_i) d\theta_i = \sum_{i}^{n} \upsilon_i \int_{\underline{\theta_i}}^{\bar{\theta_i}} \tau_i f_i(\theta_i) d\theta_i \tag{10}$$

Where $\theta^* = (\otimes_{i=1}^{n} \theta_i^*)$

- The solution of this program involves a system of equations;

Solution of the program

- The optimal coordinated fiscal rule is a cutoff θ^* and its associated interest rate $R = R(\theta^*)$ satisfying, $\forall \theta^* < \bar{\theta}$ and $\forall i \in 1, 2, ..., N$:

$$\begin{cases} \dfrac{\mathbb{E}\left[\theta_i | \theta_i \geq \theta_i^*\right]}{\theta_i^*} = \dfrac{1}{\delta_i} + \dfrac{R'(\theta_i^*)}{(1 - F(\theta_i^*))\theta_i^* U'(g_i^f(\theta_i^*, R)) \frac{\partial g_i^f(\theta_i^*, R)}{\partial \theta_i^*}} (\rho_i + \lambda_i) \\ \sum_i^n \upsilon_i \int_{\underline{\theta_i}}^{\bar{\theta_i}} \left(g_i^f(\theta_i, R)\right) f_i(\theta_i) d\theta_i = \sum_i^n \upsilon_i \int_{\underline{\theta_i}}^{\bar{\theta_i}} \tau_i f_i(\theta_i) d\theta_i \end{cases} \tag{11}$$

Where $\rho_i \equiv$ redistributive effect and $\lambda_i \equiv$ Discipline effect;

$$\rho_i = -\frac{1}{R}\left[\int_{\underline{\theta_i}}^{\theta_i^*} W'(x_i^f(\theta_i, R)) x_i^f(\theta_i, R) f_i(\theta_i) d\theta_i + \int_{\theta_i^*}^{\bar{\theta_i}} W'(x_i^f(\theta_i^*, R)) x_i^f(\theta_i^*, R) f_i(\theta_i) d\theta_i\right]$$

$$\begin{aligned} \lambda_i = -(& \int_{\underline{\theta_i}}^{\theta_i^*} \left(\theta_i U'(g_i^f(\theta_i, R)) - R W'(x_i^f(\theta_i, R))\right) \frac{dg_i^f(\theta_i, R)}{dR} f_i(\theta_i) d\theta_i + \\ & \int_{\theta_i^*}^{\bar{\theta_i}} \left(\theta_i U'(g_i^f(\theta_i^*, R)) - R W'(x_i^f(\theta_i^*, R))\right) \frac{dg_i^f(\theta_i^*, R)}{dR} f_i(\theta_i) d\theta_i) \end{aligned}$$

Quantitative coordinated fiscal rule

- The optimal deficit limit for each country is:

Table 5: Joint Fiscal Rule

	Optimal deficit limit (DL)							
	BEN	*BFA*	*CIV*	*GNB*	*MLI*	*NER*	*SEN*	*TGO*
delta	**0.954**	**0.966**	**0.896**	**0.901**	**0.981**	**0.951**	**0.958**	**0.918**
DL (in%)	**12.40**	**2.11**	**3.21**	**2.98**	**9.79**	**4.19**	**5.22**	**3.33**

- The equilibrium net interest associated is: 6.8%

Quantitative coordinated fiscal rule

- The welfare equivalent variation from no rule to optimal joint rule is:

Table 6: Welfare variation

Λ *from no rule to optimal rule in %*								
	BEN	*BFA*	*CIV*	*GNB*	*MLI*	*NER*	*SEN*	*TGO*
delta	**0.954**	**0.966**	**0.896**	**0.901**	**0.981**	**0.951**	**0.958**	**0.918**
Λ (in%)	**0.019**	**0.581**	**0.656**	**1.875**	**0.000**	**0.263**	**0.050**	**0.575**

Program solved

- In this setting while the countries are heterogeneous, central authority chooses the same spending limit for all the countries
- The program solved is the following:

$$\max_{\theta^* \in [\underline{\theta}, \bar{\theta}]} \sum_i^N \upsilon_i [\int_{\underline{\theta}}^{\theta^*} \left(\theta U(g^f(\theta, R(\theta^*))) + \beta W(x^f(\theta, R(\theta^*)) \right) f_i(\theta) d\theta + \tag{12}$$

$$\int_{\theta^*}^{\bar{\theta}} \left(\theta U(g^f(\theta^*, R(\theta^*))) + \beta W(x^f(\theta^*, R(\theta^*)) \right) f_i(\theta) d\theta]$$

subject to

$$\sum_i^N \upsilon_i \int_{\underline{\theta}}^{\bar{\theta}} \left(g^f(\theta, R) \right) f_i(\theta) d\theta = \sum_i^N \upsilon_i \int_{\underline{\theta}}^{\bar{\theta}} \tau_i f_i(\theta) d\theta \tag{13}$$

Where $\theta = h(\theta_i) \qquad \forall i = 1, 2, ..., N$

Specific case of $\delta_i = \delta$

- The optimal uniform coordinated fiscal rule is a cutoff θ^* and its associate interest rate $R = R(\theta^*)$ satisfying, $\forall \theta_c^* < \bar{\theta}$: $f(\theta) = \sum_i^n \upsilon_i f_i(\theta)$

$$\begin{cases} \dfrac{\mathbb{E}\left[\theta | \theta \geq \theta^*\right]}{\theta^*} = \dfrac{1}{\delta} + \dfrac{R'(\theta^*)}{(1 - F(\theta^*))\theta^* U'(g^f(\theta^*, R)) \frac{\partial g^f(\theta^*, R)}{\partial \theta^*}} (\rho + \lambda) \\ \displaystyle\int_{\underline{\theta}}^{\bar{\theta}} \left(g^f(\theta, R)\right) f(\theta) d\theta = \int_{\underline{\theta}}^{\bar{\theta}} (\sum_i^N \upsilon_i \tau_i f_i(\theta)) d\theta \end{cases} \tag{14}$$

Where $\rho \equiv$ redistributive effect and $\lambda \equiv$Discipline effect;

$$\rho = -\frac{1}{R}\left[\int_{\underline{\theta}}^{\theta^*} W'(x^f(\theta, R) x^f(\theta, R) f(\theta) d\theta + \int_{\theta^*}^{\bar{\theta}} W'(x^f(\theta^*, R) x^f(\theta^*, R) f(\theta) d\theta\right]$$

$$\lambda = -(\int_{\underline{\theta}}^{\theta^*} \left(\theta U'(g^f(\theta, R)) - R W'(x^f(\theta, R)\right) \frac{dg^f(\theta, R)}{dR} f(\theta) d\theta +$$
$$\int_{\theta^*}^{\bar{\theta}} \left(\theta U'(g^f(\theta^*, R)) - R W'(x^f(\theta^*, R)\right) \frac{dg^f(\theta^*, R)}{dR} f(\theta) d\theta)$$

Quantitative uniform coordinated fiscal rule

- **Parameters**: $\alpha = 0.44$; $\delta = 0.94$
- Fiscal Rule as spending limit: $gcap = 36.42\%$
- Corresponding net interest rate: 4.34%
- Fiscal Rule as uniform deficit limit : 21.8%
- Fiscal Rule as deficit limit for each country:

Table 7

Optimal deficit limit (DL)								
	BEN	*BFA*	*CIV*	*GNB*	*MLI*	*NER*	*SEN*	*TGO*
DL (in%)	**26.96**	**21.16**	**11.86**	**27.48**	**23.64**	**25.78**	**19.93**	**17.58**

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Summary

- I show that WAEMU countries are very heterogeneity in the volatility of their revenues, expenditure and debts and balanced budget;
- I design an optimal quantitative fiscal rule for each country of the union base on a model that uses each country preference shocks;
- Some countries benefit from 3% deficit limit rule in place in WAEMU while others don't.
- The joint optimal deficit limit design shows that we may strengthen the rule for BFA, while loosen it for BEN, MLI, NER, SEN and leave it unchangeable for CIV, GNB and TGO.

Thank You!

Literature Review

Hyperbolic discount literature

Amador, Manuel, Iván Werning, and George Marios Angeletos. ”Commitment vs. flexibility.” Econometrica 74, no. 2 (2006): 365-396.

Uncoordinated and coordinated fiscal rule

Halac, Marina, and Pierre Yared. ”Fiscal Rules and Discretion in a World Economy.” The American Economic Review 108, no. 8 (2018): 2305-2334.

Presentation 1

Figure 1: Fiscal Policy

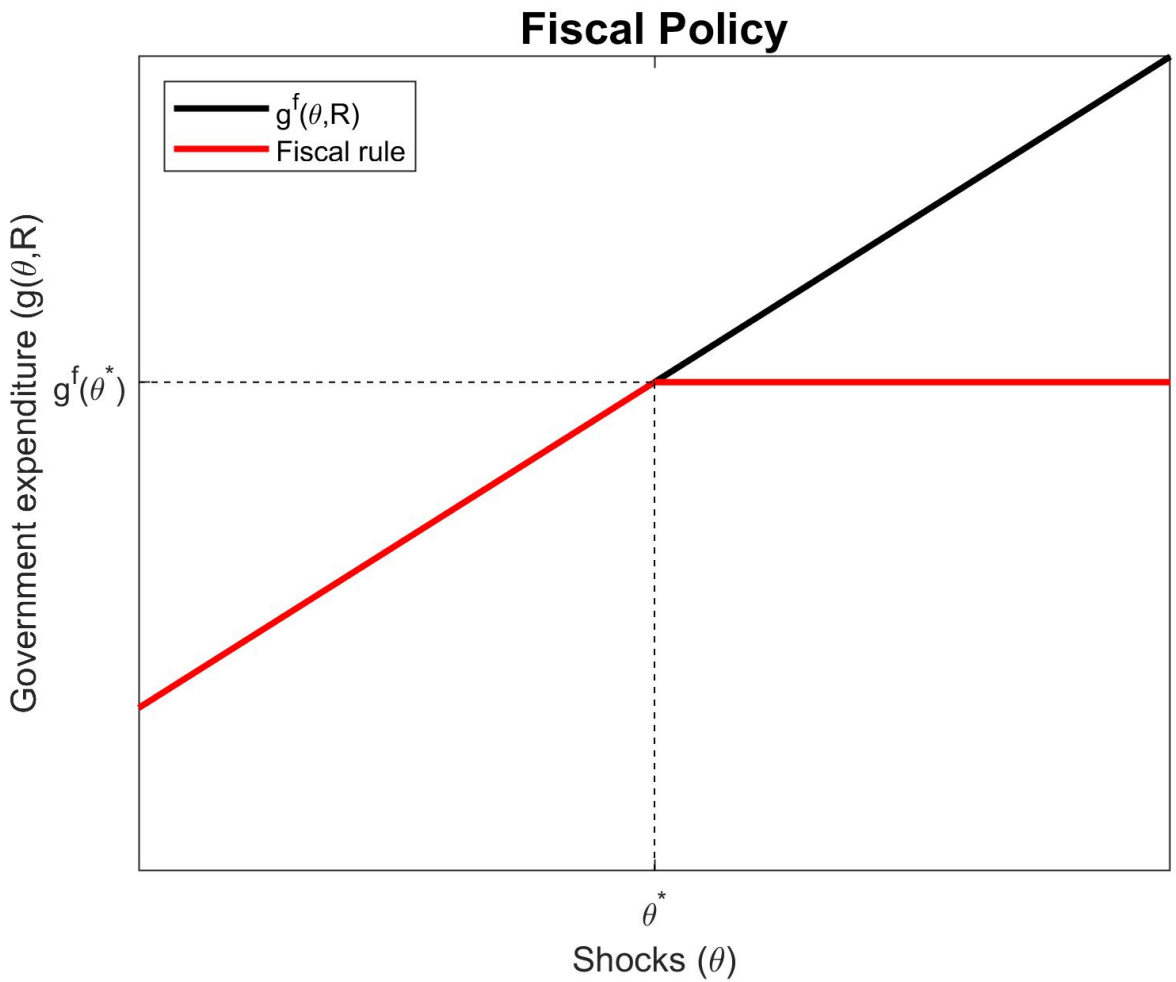
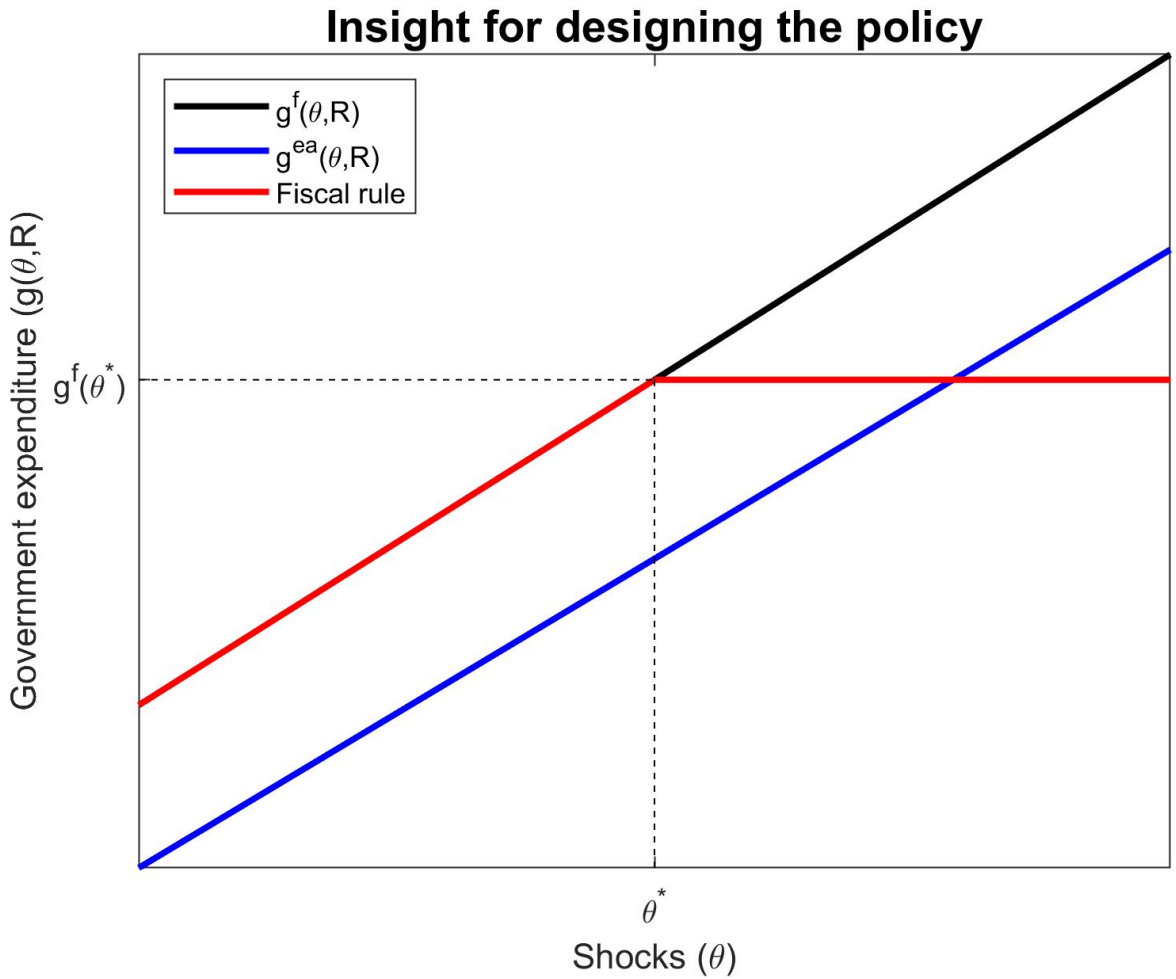


Figure 2: Fiscal Policy Designing



Presentation 2

Table 8

Homogeneity tests between WAEMU countries 1960-1999		*Fstat*	*p-values*
Revenue	H0: Mean equality	***19.023***	***0.000***
	H0: Variance equality	***12.256***	***0.000***
Spendings	H0: Mean equality	***16.359***	***0.000***
	H0: Variance equality	***9.942***	***0.000***
Budget Balance	H0: Mean equality	***4.484***	***0.000***
	H0: Variance equality	***9.111***	***0.000***
Debts	H0: Mean equality	***30.454***	***0.000***
	H0: Variance equality	***7.817***	***0.000***

Levene's test for equality of variances is used for test of variances homogeneity

▸ Plot Heterogeneity

Another interpretation of preference shock

- With utility function $U(g) = -e^{-\alpha g}$, preference shock (θ) can be interpreted as shock on government revenue (ϵ);
  - Maximization problem (15) and (16 are equivalents.

$$\max_{g,x}\{\theta U(g) + \delta\beta W(x)\} \tag{15}$$
$$st \quad g + \frac{x}{R} = \tau$$

$$\max_{g,x}\{U(g) + \delta\beta W(x)\} \tag{16}$$
$$st \quad g + \frac{x}{R} = (\tau + \epsilon)$$