Université de Montréal

Essays in International Macroeconomics

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Résumé

Au cours des dernières décennies, la mondialisation a joué un rôle crucial dans l'évolution de l'économie mondiale et du mode de vie des populations. Elle a largement contribué à la croissance économique de nombreux pays grâce à l'essor des échanges commerciaux, des investissements et de la création d'emplois , entre autres. Cependant, si la mondialisation a apporté de nombreux avantages, elle a également rendu les pays plus vulnérables aux crises. Elle a aussi soulevé des défis en matière de coordinations de politiques économiques des groupes de pays souverains. Cette thèse, composée de trois chapitres, se penche sur certaines questions macroéconomiques liées à l'économie internationale. Le premier chapitre présente une méthode permettant d'analyser les canaux de propagation du cycle économique au sein d'une économie et entre les pays. Le deuxième chapitre aborde la conception de règles budgétaires pour les économies intégrées au sein d'une union économique et monétaire. Enfin, le dernier chapitre évalue l'impact des obstacles routiers tels que les barrages, les retards et la corruption sur l'intégration commerciale régionale en Afrique de l'Ouest.

Dans le premier chapitre, j'ai développé une méthode visant à orienter les chercheurs dans la spécification améliorée de leurs modèles quantitatifs lors de l'étude du cycle économique international. Les orientations découlent de l'application de la comptabilité des cycles économiques, en se basant sur un modèle prototype. Ce modèle prototype est construit à partir d'un modèle de croissance internationale auquel sont intégrés des «wedges» qui captent les frictions et distorsions présentes dans l'économie. Pour chaque pays, j'ai pris en compte les «wedges» suivants : l'efficacité technologique, les distorsions sur le marché du travail, l'investissement, les dépenses gouvernementales, les préférences et les échanges d'actifs étrangers. J'ai ensuite illustré cette méthode en l'appliquant aux États-Unis et au Canada pendant la grande récession de 2007-2008. Mes résultats indiquent que les ralentissements économiques observés dans les deux pays au cours de cette période étaient principalement dus aux distorsions de l'investissement, aux distorsions sur le marché du travail et à celles de l'efficacité technologique aux États-Unis, tandis

que les distorsions de l'investissement au Canada ne jouaient qu'un rôle secondaire. Ces résultats suggèrent que la crise est partie des États-Unis pour se propager ensuite au Canada.

Le deuxième chapitre se concentre sur la conception de la règle budgétaire au sein d'une union économique, avec une application à l'Union économique et monétaire ouest-africaine (UEMOA), qui possède un marché des capitaux intégré et une règle budgétaire commune. Je présente des faits sur l'existence d'une hétérogénéité significative des recettes, des dépenses et de la dette publiques parmi les pays de l'UEMOA. Dans ce chapitre, j'effectue une analyse quantitative de la règle budgétaire au sein de l'UEMOA et propose une réforme optimale en utilisant un cadre théorique qui modélise la politique fiscale des gouvernements confrontés à des chocs et ayant des préférences temporelles biaisées vers le présent. Le modèle met en évidence un compromis entre la flexibilité du gouvernement pour faire face aux chocs et l'engagement à limiter les incitations à un endettement excessif. Les résultats montrent que la règle actuelle de limitation du déficit à 3 %, appliquée uniformément à tous les pays de l'UEMOA, améliore le bien-être des citoyens par rapport à un scénario sans règle budgétaire. Cependant, l'adoption de règles budgétaires spécifiques à chaque pays conduirait à une amélioration au sens de Pareto par rapport à la règle uniforme actuelle. La limite optimale du déficit pour chaque pays dépendrait de la volatilité des chocs affectant ses besoins de dépenses ainsi que des frictions politico-économiques et monétaires propres à son gouvernement. En outre, en imposant une règle budgétaire uniforme à tous ses membres, l'UEMOA renonce à 24 % des gains de bien-être qui pourraient être obtenus grâce à l'adoption de règles budgétaires spécifiques à chaque pays. En résumé, mes résultats démontrent que bien que l'UEMOA bénéficie d'une règle budgétaire commune, une règle sur mesure tenant compte des caractéristiques spécifiques de chaque pays membre améliorerait encore davantage le bien-être général.

Le troisième chapitre (*co-écrit avec Idossou Marius Adom*) examine les effets des barrages routiers, des retards et de la corruption le long des routes interétatiques sur l'intégration commerciale régionale en Afrique de l'Ouest. Il est bien connu que le commerce régional en Afrique est relativement faible par rapport à d'autres régions du monde. Dans cet article, nous utilisons les rapports sur «l'amélioration de la gouvernance des transports routiers» (IRTG) pour construire une nouvelle base de données mesurant les barrages routiers, les retards et les pots-de-vin liés au commerce sur huit routes interétatiques en Afrique de l'Ouest entre 2006 et 2013. Notre objectif est d'étudier leurs effets sur le commerce bilatéral dans la région. Ces routes interétatiques relient trois pays enclavés – le Burkina

Faso, le Niger et le Mali – à d'autres pays côtiers. Nos résultats montrent que les barrages routiers, les retards et la corruption sont des problèmes récurrents sur ces routes. Pendant le transport des marchandises, les camions sont soumis à plus de 25 contrôles, subissent des retards de plus de 5 heures et sont contraints de verser des pots-de-vin allant de 45 à 115 dollars américains. Nos analyses empiriques révèlent que les retards entravent considérablement le commerce bilatéral entre les pays connectés, tandis que l'effet positif de la corruption semble correspondre à celui de la théorie du «grease the wheels».

Mots-clés : Cycle économique international, Comptabilité des cycles économiques, Règle budgétaire, Union économique et monétaire, Règle coordonnée, Retards routiers, Corruption routière, Commerce bilatéral.

Abstract

Globalization has been an important force in shaping the world economy and the way people live their lives in the past few decades. It has had sizable importance in the economic growth of many countries through the increase in trade, investment, new job creation, etc. While globalization has brought many benefits, it has also created many challenges such as the increase of the vulnerability of countries to crises, and the challenges of policy management of groups of sovereign countries. This dissertation, composed of three chapters, investigates some macroeconomic issues of the international economy. The first chapter proposes a method to access the channel through which the business cycle propagates to an economy and across countries. The second chapter investigates the fiscal rule design for integrated economies constituted in an economic and monetary union. The last chapter evaluates the effect of roadblocks, time delays, and bribes on interstate roads on regional trade integration in West Africa.

In the first chapter, I have developed a method that can provide insights to researchers to better specify their quantitative models in international business cycle studies. The guidance comes from the application of an accounting procedure based on a prototype model of international growth that includes wedges capturing all the potential frictions and distortions of markets. For each country, I include an efficiency wedge, labor wedge, investment wedge, government wedge, preference wedge, and foreign asset wedge. I then demonstrate the method by applying it to the US and Canada during the Great Recession (2007-2008). I found that the economic downturns in both countries during this period were primarily due to the US investment wedge, US labor wedge, and US efficiency wedge, with the Canada investment wedge playing a secondary role. These results suggest that the crisis originated in the US and was propagated to Canada.

The second chapter investigates the fiscal rule design for an economic union with an application to the West African Economic and Monetary Union (WAEMU) which has an integrated capital market and a common fiscal rule. I document a sig-

nificant heterogeneity in government revenue, spending, and debt across WAEMU countries. Then, in this chapter, I present a quantitative analysis of the fiscal rule in WAEMU and propose an optimal reform using a theoretical framework that models fiscal policy under present-biased governments facing shocks to their fiscal needs. The model highlights a trade-off between government flexibility in responding to shocks and a commitment to limit the incentive to overborrow. I find that the current 3% deficit limit rule, which is uniform across all WAEMU countries, improves welfare for the citizens of all countries compared to a scenario with no fiscal rule. However, country-specific fiscal rules would lead to a Pareto improvement over the current uniform rule. The optimal deficit limit for each country would depend on the volatility of the shocks to its spending needs and the strength of the political-economic and monetary-economic frictions of its government. In addition, by imposing a uniform fiscal rule on all members, WAEMU foregoes 24% of the welfare gains that could be achieved with a country-specific fiscal rule. In summary, I show that while WAEMU countries benefit from having a common fiscal rule, a tailored approach that considers the specific characteristics of each member country would enhance welfare even further.

The third chapter (*co-authored with Idossou Marius Adom*) explores the effects of roadblocks, time delays, and bribes along interstate roads on the regional trade integration in West Africa. Indeed, it is a well-known fact that regional trade within Africa is low compared to other regions in the world. In this paper, we rely on the Improved Road-Transport Governance reports to construct a novel data set that measures trade-related roadblocks, time delays, and bribes on eight interstate roads in Western Africa between 2006 and 2013 to investigate their effects on bilateral trade in the region. These interstate roads connect three landlocked countries – Burkina Faso, Niger, and Mali – to other coastal countries. We document that roadblocks, delays, and bribes are pervasive on the roads. During goods transportation, trucks experience up to more than 25 controls, are delayed by up to more than 5 hours, and pay between 45 and 115 US dollars bribe. Our empirical analyses show that the delays seriously impede bilateral trade between the connected countries while corruption tends to match the "grease the wheels" theory.

Keywords: International business cycle, Business cycle accounting, Fiscal Rule, Economic and Monetary Union, Coordinated rule, Road time delays, Road bribes, Bilateral trade.

Chapter 1

International Business Cycle Accounting*

1.1 Introduction

The synchronization of business cycles across countries is a well-known fact. However, the literature on international business cycles has shown that standard models used to study international macroeconomic issues hardly replicate this fact. It has then been documented in international macroeconomics a lot of puzzles[2]. To solve these puzzles, economics researchers build detailed models in which they add frictions to replicate economic fluctuations observed in data. However, they face significant difficulties with which frictions and where to introduce them in the model. In this study, I propose a method that could facilitate those choices, and I apply the method to the US and Canada during the Great Recession.

My method is an extension to the open economy of the *business cycle accounting* method proposed by Chari, Kehoe, and McGrattan (2007). The method has two components: a theoretical result and an accounting procedure. The theoretical result consists of building a prototype model in which we include time-varying wedges that distort the equilibrium of the economy (otherwise in perfectly competitive markets). This prototype model generalizes a large class of detailed models with frictions. In other words, each detailed model would be equivalent to the

*I'm indebted to my advisor, Guillaume Sublet for his invaluable guidance and support. I would like to thank my colleagues in the workshop group, organized by my advisor Guillaume Sublet at the University of Montreal, for their comments.

[2]Anomalies that occur when model predictions or results differ from the facts observed in data. (Obstfeld and Rogoff, 2000) have identified six puzzles.

prototype model with some specific business cycle wedges. My prototype model is built on a canonical two-countries model (as in Backus, Kehoe, and Kydland (1992)) in which I include some wedges. I consider six wedges for each country in my framework and label them *efficiency wedge*, *labor wedge*, *investment wedge*, *government wedge*, *preference wedge*, and *foreign asset wedge*. Those wedges intend to capture the frictions in each country as well as those resulting from the exchange relation between the countries. Thus the labor market frictions, the financial market frictions, the trade frictions, etc. are captured by one or a combination of those wedges in the model.

The accounting procedure consists of measuring, first of all, the wedges. Those wedges capture how much the realized allocations are distorted from the competitive equilibrium allocations. For that purpose, we use the data and the equilibrium conditions of the prototype model. To express those wedges in a meaningful way, in the second step, we evaluate the contribution of the wedges. This means that we feed the values of the wedges, one at a time or by combination, to the model. These experiments help assess how much the fluctuations of output, investment, consumption, and labor are due to wedges considered separately or in combination. For example, if we want to assess the role of the labor wedge in the fluctuation of aggregate variables we feedback in the model that wedge and keep constant all the remaining wedges.

I use the method developed to study the business cycle relation between the US and Canada during the Great Recession of 2007-2008. My goal from this exercise is to assess the channel through which the two economies were related during this crisis. I find that the US labor wedge, US efficiency wedge, and US investment wedge explain the major fall in output and labor in Canada during the recession. The decline in investment in Canada, on the other hand, was caused by the investment wedge of Canada. The US economic downturns during the recession were caused mainly by the US wedges. More specifically, the decline in US output and investment was due to the US labor wedge, and the US investment wedge. On the other hand, the decline in US employment was induced by the investment wedge of Canada combined with the US investment wedge. Those results can be compared to business accounting in the closed economy as performed by Brinca, Chari, Kehoe, and McGrattan (2016). While in a closed economy, all the aggregate fluctuations are attributed to frictions in the home country, my approach shows that the main causes could come from abroad. That is the case from the fact that the main wedges that explain the decline of Canada's output, during the recession, were the US efficiency wedge and the US labor wedge.

It was documented that the 2007-2008 Great Recession was a financial crisis[3]. My findings suggest then that the financial frictions manifest themselves not only as investment wedges but also as efficiency wedges and labor wedges. The US investment wedge, US labor wedge, and the US efficiency wedge account mainly for the downturns in both US and Canada. As my findings indicate that the frictions in the US economy explain the fluctuations in Canada's aggregate variables I infer that the Great Recession originate in the US and then propagate to Canada. The trade relationship as well as the financial transactions between the two countries are the channels of this transmission of the business cycle. Indeed, the prominent role of the US investment wedge in the decline of Canadian investment during this period suggests that the financial shock that occurred in the US has created some investment distortions in Canada.

The International Business Cycle Accounting method can help address different questions involving the relationship between countries. For instance, it can provide insights into the extent to which shocks to the US labor market or the US financial market can affect the economic condition in Canada or vice-versa. This paper is then related to the literature on the causes of business cycle synchronization across countries. The first driven source of the business cycle synchronization explored was the productivity shocks (Backus et al. (1992), Heathcote and Perri (2002)). Then some authors contribute to the literature by combining technology and non-technology shocks to explain the international business cycle (Stockman and Tesar (1995), Wen (2007), Levchenko and Pandalai-Nayar (2020)). Other authors have investigated the role of input linkages and production networks in international business cycle synchronization (e.g. Kose and Yi (2006), Bems, Johnson, and Yi (2010), Johnson (2014), Eaton, Kortum, Neiman, and Romalis (2016) and Huo, Levchenko, and Pandalai-Nayar (2023)). Devereux and Yetman (2010) investigate the role of financial markets in the propagation of the business cycle across countries.

Nevertheless, the identified source included in those models explained a fraction of the business cycle across countries and/or generated predictions inconsistent with the data known as *puzzles*. Many papers have investigated such anomalies in international macroeconomics such as Obstfeld and Rogoff (2000), Kose and Yi (2001), Kose, Otrok, and Whiteman (2003) and Ambler, Cardia, and Zimmermann (2004)). My paper, instead of considering a particular drive source, contributes to this literature by investigating all the possible sources that explain the international comovement observed in data. Thus, all the frictions together in the

[3]Bordo (2012) shows that it is the financial crisis that lead to the recession

model will explain, by construction, the 100% of the business cycle synchronization. Therefore, my methodology intends to shed light on the source of friction that explain business cycle synchronization across countries. It is a diagnostic tool for the business cycles of a particular economy in its relationship with other countries. It distinguishes not only the shocks that affect the fluctuations of the aggregate variables but also the origins of those shocks (in terms of home shocks or foreign shocks).

Regarding methodology, the most closely related work is the seminal paper of Chari et al. (2007). A number of papers were dedicated to applying the methodology to study business cycles for many countries such as OECD[4] countries, China, Japan, and some developing countries (e.g. Kobayashi and Inaba (2006), Lama (2005), Chari et al. (2007), Gao (2007), and Brinca et al. (2016)). Whereas the methodology in those papers is designed for a closed economy, I extend it to open two countries. Thus, I allow a description and a quantification of the relations between countries while (Chari et al., 2007)'s method summarize all the interactions of a country with the rest of the world into the government wedge. Rouillard (2013) and Otsu (2009) have also developed a version of international business cycle accounting. Otsu (2009) has applied its methodology to study the business cycle correlation between Japan and the US during the 1980-2008 period. Rouillard (2013) in the last chapter of his thesis introduced an *international wedge*, capturing the international risking sharing, to Chari et al.'s method to investigate the *Backus-Smith puzzle*.

The limitations of the Business Cycle Accounting method raised in the literature could also be raised in the context of my method. For instance, Buera and Moll (2015) show that the form of the underlying heterogeneity explains the variant of the simple aggregate wedges model obtained. More specifically, they find that a credit crunch can show up in three variants model with specific wedges: efficiency, investment, and labor wedges. In my methodology as well, the underlying heterogeneity source can determine the mapping to a simple international aggregate wedges model.

After the current introductory section 1.1, the rest of the paper is organized as follows. In section 1.2, I present the benchmark prototype model. In section 1.3 I describe the accounting procedure of my method. The section 1.4 is dedicated to the description of the application of the method and the findings. After that, I make a discussion around the results found in section 1.5. The section 1.6 summarizes my findings and suggests some directions for further work.

[4]The Organization for Economic Cooperation and Development

1.2 Description of the Benchmark Prototype Model

The model is a competitive version of a two-country business cycle model as in Backus et al. (1992) except that each country produces a single specific tradable final good. I introduce wedges in relevant markets that represent distortionary shocks. Each country i consists of a representative household, firm, and government. The model is set up as follows.

Final Good Firms.– The representative firm in each country produces the aggregate output $y_t^i(s^t)$ from local capital stock $k_t^i(s^t)$ and local labor $l_t^i(s^t)$ using the production technology $F(.)$. s^t represents the current state of nature. As all the variables in the model depend on the state variable s^t, for convenience I can omit them. The production relation is defined as followed:

$$y_t^i = A_t^i F(k_t^i, (1+\gamma)^t l_t^i), \tag{1.1}$$

where the aggregate TFP is composed of labor-augmented technical progress captured by the rate $1+\gamma$ (assumed constant) and the stationary component A_t^i.

The final good is specific to each country. Thus, in the country i, the aggregate output serves for the home household consumption, foreign household consumption, home investment, and home government consumption.

Finally, the profit maximization problem for the final good firm can be written as

$$\max_{k_t^i, l_t^i} \left(p_t^i A_t^i F(k_t^i, (1+\gamma)^t l_t^i) - w_t^i l_t^i - r_t^i k_t^i \right), \tag{1.2}$$

where p_t^i, w_t^i, and r_t^i are respectively the price of the goods, the wage rate, and the rental rate on local capital.

Households.– The households in each country maximize their expected lifetime utility (equation '1.3)) over per capita home consumption good $c_{ht}^i(s^t)$, per capita foreign consumption good $c_{ft}^i(s^t)$ and per capita labor supply $l_t^i(s^t)$. Let E_t be the expectation operator relative to the probability that each state event occurs.

$$E_t \left[\sum_{t=0}^{\infty} \tilde{\beta}_i^t U(c_{ht}^i, c_{ft}^i, 1 - l_t^i) N_t^i \right], \tag{1.3}$$

where $\tilde{\beta}_i$ is the discount factor, and N_t^i is the population with a growth rate denoted $(1+\gamma_n^i)$.

The maximization problem of the households is subjected to the budget constraints

$$\begin{aligned} & p_t^i c_{ht}^i + p_t^j (1+\tau_{ct}^i) c_{jt}^i + (1+\tau_{xt}^i) p_t^i x_t^i + \frac{N_{t+1}^i}{N_t^i} b_{t+1}^i \\ =& (1-\tau_{lt}^i) w_t^i l_t^i + r_t^i k_t^i + (1 + r_t^*(1-\tau_{bt}^i)) b_t^i + T r_t^i, \end{aligned} \tag{1.4}$$

where for a variable Z_j^i the subscript j is the origin country and the subscript i is the destination country. x_t^i is per capita investment, b_t^i per capita non-contingent international claim [5], r_t^* is the world rate return on risk-free securities, and Tr_t^i is per capita lump sum transfer from the government. τ_{ct}^i, τ_{xt}^i, τ_{lt}^i, and τ_{bt}^i represent distortionary taxes on household foreign consumption goods, investment, labor income, and foreign asset respectively.

Investment is assumed to follow the capital law of motion:

$$\frac{N_{t+1}^i}{N_t^i} k_{t+1}^i = ((1-\delta) k_t^i + x_t^i), \tag{1.5}$$

where δ is the depreciation rate of capital.

International Asset Market.– The households of each country trade on the foreign asset market a one-period non-contingent asset. At period t a household can contract an asset b_{t+1} (maturing at period $(t+1)$) and pay back the existing asset b_t issued at period $(t-1)$ including the interest at the world interest rate r_t^*.

As the world economy is constituted of the two countries, in each period, since the asset is zero net supply at the world level, the international asset market clearance condition is

$$N_t^h b_t^h + N_t^f b_t^f = 0 \text{[6]} \tag{1.6}$$

Definition of the wedges.– The set-up of the model includes six wedges for each country capturing all the disturbances in the economy. For each country the six wedges are defined as follows:

1. The *efficiency wedge* $\Delta_{at} = A_t$ resembles a time-varying technology shock; they are equivalent to total factor productivity.

[5] It is an asset that is due to the foreign country, or invest in foreign country

[6] The method can easily accommodate for a net balance with the rest of the world

2. The *labor wedge* $\Delta_{lt} = (1 - \tau_{lt})$ captures all the disturbances in the labor market as well as the distortions in other sectors that have an impact on the labor market. It captures the discrepancy between the intra-temporal marginal rate of substitution of leisure to consumption and the marginal product of labor.

3. The *investment wedge* $\Delta_{xt} = (1/(1 + \tau_{xt}))$ captures the distortions in the capital market. They represent the discrepancy between the inter-temporal marginal rate of substitution and the return on investment.

4. The *government wedge* $\Delta_{gt} = g_t$ is the distortions in the resource constraint and corresponds to the government purchases in the data.

5. The *preference wedge* $\Delta_{ct} = (1/(1 + \tau_{ct}))$ captures the discrepancy between the intra-temporal marginal rate of substitution of home consumption to foreign consumption and the relative price of those goods.

6. The *asset wedge* $\Delta_{bt} = (1-\tau_{bt})$ captures the distortions in the Euler equation and represents the discrepancy between the inter-temporal marginal rate of substitution and the return on foreign asset.

Notice that one could consider other models where we change the location of the wedges. But, if all the possibilities are considered, those models would capture the same features present in the model I previously described. For example, we could add a wedge on capital, but this would capture the same distortion as the investment wedge.

Definition of the equilibrium.– A competitive equilibrium of the prototype economy consists of wedges $\{A_t,\ \tau_{lt},\ \tau_{xt},\ g_t,\ \tau_{ct},\ \tau_{bt}\}$, allocation $\{c_{ht}, c_{ft}, l_t, k_t, b_t\}$, and prices $\{r_t, r_t^*, w_t, p_t\}$, for each country, such as:

i- Given the wedge A_t and the prices $\{r_t, w_t, p_t\}$, the firm of each country maximizes its profits,

ii- Given the wedges $\{\tau_{lt},\ \tau_{xt},\ \tau_{ct},\ \tau_{bt}\}$ and the prices $\{r_t, r_t^*, w_t, p_t\}$, the household of each country maximizes its life-time utility,

iii- The resource constraint for each country holds,

$$c_{ht}^i + c_{ft}^j + x_t^i + g_t^i = y_t^i \tag{1.7}$$

iv- The international asset market clears (equation (1.6)).

Remark 1. *From the description of the household environment, the consumers of country i can invest in local capital with a net rate of return r^i or/and participate in the international financial market with a return of r^*. We expect, without non-arbitrage conditions, that the household invests only in the asset with the higher return such that the local investment and the foreign asset are redundant. However, the two assets are not redundant in my setting. They play different roles. The local investment ensures the building up of the capital necessary for the final good production in each country. Thus, as an investment in capital comes only from the home household, it cannot be null every period. Foreign asset plays the role of international finance as a financial counterpart of the trade in good. Then, if a country faces a bad shock, it can borrow from abroad, and in good times, it can pay back the debt; it is international insurance. The proposition 1 describes the role of foreign assets in our prototype economy.*

Remark 2. *The non-arbitrage condition implies that the net return on foreign assets equals the net return on the investment in local capital for each country. Considering that the government taxes both capital investment and investment in foreign assets in addition to the depreciation of the capital, the non-arbitrage condition is stated in equation (A.2).*

Proposition 1. *When the foreign asset market is nonexistent, i.e., $b_t^h = b_t^f = 0$, in equilibrium, trade is balanced each period, and there is a lack of international finance. In our framework, there exists a period during which a country incurs debt from abroad.*

Proof.– (See Appendix A.4.1) It comes out from the proof that without the international financial market, the net export of each country is zero every period. The rationale behind the proposition is that, as the two economies are not identical in terms of the size of the population, the production process, and preference for foreign goods, it is unusual that the exports offset each period the imports. Thus, the international financial market exists.

1.3 The accounting procedure

The accounting procedure consists first in measuring the different wedges, and second in evaluating the contribution of those wedges (one at a time or in combination).

Measuring the wedges.– For this step, we use data on aggregate variables and compute the different wedges using the equations derived from the prototype equilibrium conditions. The wedges are then measured using the following equations from the equilibrium conditions $\forall i = h, f$:

$$c^i_{ht} + c^j_{ft} + x^i_t + g^i_t = y^i_t \tag{1.8}$$

$$y^i_t = A^i_t F(k^i_t, (1+\gamma)^t l^i_t) \tag{1.9}$$

$$u^i_{c_f t}(.) = u^i_{c_h t}(.)(1+\tau^i_{ct})\frac{p^j_t}{p^i_t} \tag{1.10}$$

$$u^i_{lt}(.) = -u^i_{c_h t}(.)(1-\tau^i_{lt})(1+\gamma)^t F^i_{lt} \tag{1.11}$$

$$u^i_{c_h t}(.)(1+\tau^i_{xt}) = \beta^i E_t\left[u^i_{c_h t+1}(.)(F^i_{kt+1} + (1-\delta)(1+\tau^i_{xt+1}))\right] \tag{1.12}$$

$$E_t\left[1 + (1-\tau^i_{bt+1})r^*_{t+1}\right] = \frac{1}{1+\tau^i_{xt}} E_t\left[\frac{p^i_{t+1}}{p^i_t}\left(F_{1t+1} + (1-\delta)(1+\tau^i_{xt+1})\right)\right], \tag{1.13}$$

where H_{zt} denotes the derivative of the function with respect to its argument z.

Measuring the contribution of wedges.– The measurement of the contribution of wedges consists in using my prototype model to perform some counterfactual analysis. For that purpose, I conduct different experiments to isolate the effect of wedges. In other words, I make some wedges fluctuate and shut down the fluctuation of the remaining wedges by setting their values to a constant. For example, to evaluate the contribution of the country i efficiency wedge, we make this wedge (A^i_t) fluctuate and set the other wedges to their steady-state values ($\forall t, \omega_t = \omega_1$, where ω stands for all of the other wedges in the model). After, the goal now is to solve the model to back up the aggregate variables (the allocation of the economy). Those variables represent then how the economy would have evolved if the only distortion in the economy were expressed as the total productivity shock. Notice that the allocation backup and the associated prices must satisfy the competitive equilibrium of the economy. The proposition states the conditions of an equilibrium allocation.

Proposition 2. *Given the wedges*$\{\tau^i_{ct}, \tau^i_{lt}, \tau^i_{bt}, \tau^i_{xt}\}, i = h, f$, *a competitive equilibrium allocation of the economy solves the following equation (1.14)–(1.21)*

$$u^i_{lt}(.) = -u^i_{c_h t}(.)(1-\tau^i_{lt})F^i_{c_f t}(.) \tag{1.14}$$

$$u^j_{lt}(.) = -u^j_{c_h t}(.)(1-\tau^j_{lt})F^j_{c_f t}(.) \tag{1.15}$$

$$\frac{u^i_{c_f t}(.)}{u^i_{c_h t}(.)(1+\tau^i_{ct})} = \frac{u^j_{c_h t}(.)(1+\tau^j_{ct})}{u^j_{c_f t}(.)} \tag{1.16}$$

$$c^i_{ht} + c^j_{ft} + k^i_{t+1} + g^i_t = F(k^i_t, z^i_t l^i_t) + (1-\delta)k^i_t \tag{1.17}$$

$$c^j_{ht} + c^i_{ft} + k^j_{t+1} + g^j_t = F(k^j_t, z^j_t l^j_t) + (1-\delta)k^j_t \tag{1.18}$$

$$u^i_{c_h t}(.)(1+\tau^i_{xt}) = \beta E_t\left[u^i_{c_h t+1}(.)\left(F^i_{c_h t+1}(.) + (1-\delta)(1+\tau^i_{xt+1})\right)\right] \tag{1.19}$$

$$u^j_{c_h t}(.)(1+\tau^j_{xt}) = \beta E_t\left[u^j_{c_h t+1}(.)\left(F^j_{c_h t+1}(.) + (1-\delta)(1+\tau^j_{xt+1})\right)\right] \tag{1.20}$$

$$E_t\left[\frac{1}{(1-\tau^i_{bt+1})}\frac{1}{1+\tau^i_{xt}}(F^i_{kt+1} + (1-\delta)(1+\tau^i_{xt+1})) - 1)\right] = E_t\Big\{\frac{1}{(1-\tau^j_{bt+1})} \tag{1.21}$$
$$(\frac{1}{1+\tau^j_{xt}}\frac{u^i_{c_f t+1}(.)}{u^i_{c_h t+1}(.)(1+\tau^i_{ct+1})}\frac{u^i_{c_h t}(.)(1+\tau^i_{ct})}{u^i_{c_f t}(.)}(F^j_{kt+1} + (1-\delta)(1+\tau^j_{xt+1})) - 1)\Big\}$$

Proof.– (See appendix A.4.2)
The procedure of the proof is to recover the prices from the allocation that satisfies the equation (1.14) to the equation (1.21). Then show that given those prices, households, and firms optimize in each country, the resource constraints are verified and all markets are cleared.

1.4 Quantitative Analysis: application of the accounting procedure to the US and Canada

This section provides the procedure of application of the international business cycle accounting to the US and Canada. The goal is to account for the business cycle of the US and Canada during the Great Recession of 2007-2008. The findings that I present in this section are based on the assumption that agents have perfect foresight. This implies that they have accurate and complete information about future economic conditions such that they face no uncertainty.

1.4.1 Calibration procedure

For the application, I use common functional forms in business cycle literature. I opt for a Cobb-Douglas form $F(k,l) = k^{\alpha}l^{1-\alpha}$ for the production function and for the utility function the form $U(c,l) = \log(c) + \psi\log(1-l)$ with an Armington aggregation for the consumption $\left(c_h^{\frac{\sigma-1}{\sigma}} + c_f^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$. The parameters I use are also familiar to business cycle literature. I choose the capital share α as one-third and the time allocation parameter $\psi = 2.5$. The Armington aggregator coefficient I use in the benchmark model is 2 for the two countries. I then vary those coefficients for the robustness check. I choose the depreciation rate δ and the discount factor β so that, on an annualized basis, depreciation is 5% and the rate of time preference 2.5%. I use the data to compute country-specific growth of population and the rate of labor-augmenting technical progress.

Only the aggregate data are needed for the application of the method. I collect those data for the US and Canada using the OECD database. We need, for each country, the output, the labor, the investment, the government consumption, the private consumption, the world import and export, and the bilateral import between the US and Canada. The model distinguishes home consumption from foreign consumption in opposite to what we have in data. To overcome this issue, I consider the total import from the partner country as the foreign consumption good. Then, the home consumption good is the aggregate consumption good minus the foreign consumption good. As the world economy consists of more than two countries and each country trades not only with each other, we let the government wedge be the net export of all other trade partners except Canada and the US in the data. Following the same rationale as Chari, Kehoe, and McGrattan (2004), the government wedges capture the relationship between, each country and the rest of the world. So the government wedges represent the net export with the rest of the world and the government spending. The data I use to measure the wedge and the counterfactual experiments are quarterly data for 2000:1 to 2014:4. As I mentioned, the data mainly come from the OECD database. However, in order to estimate the share of foreign consumption goods in the aggregate consumption goods, I use the import of the counterpart partner country from the DOTS (Direction Of Trade Statistics) database of the IMF (International Monetary Fund).

In order to reconcile the model and the data, I use per capita variables deflated by the GDP deflator. Indeed, the model is a representative agent model, thus using per capita variables in the model and data makes the approximation realistic.

1.4.2 Findings

In this section, I present the results of the accounting procedure performed for the US and Canada. I focus on describing the 2007-2008 crisis and the accounting of this business cycle.

Description of the crisis.– I begin by providing some descriptive statistics for the US and Canada during the period of the 2007-2008 crisis. The evolution of GDP, private consumption, investment, and hours worked for the US and Canada are described in Figures 1.1, 1.2, respectively. The decline of the aggregate variables during the recession started in the fourth quarter of 2007 and reached the through in the fourth quarter of 2009. In the US, the recession was characterized by a decline of output by about 4%, while investment and labor declined by about 21% and 9%, respectively, from the first quarter of 2008 to the third quarter of 2009 (see Table A.3.1). Concerning Canada, from the first quarter of 2008 to the third quarter of 2009, output fell by about 3%, investment fell by about 12%, and labor by about 6% (see Table A.3.1).

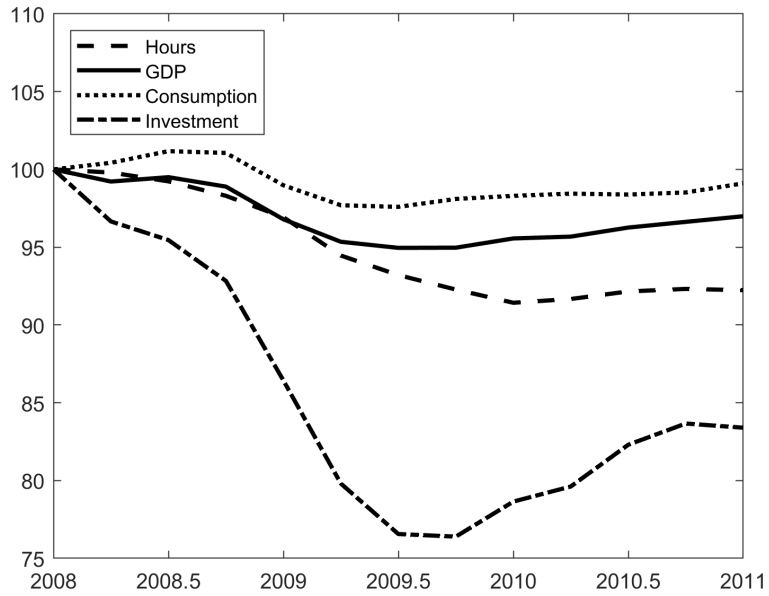


Figure 1.1: Description of the 2007-2008 crisis in the US

Notes.- The figure shows the evolution of hours worked, GDP, consumption, and investment for the US in percentages of their values in the first quarter of 2008. Source: OECD data and the author's calculations.

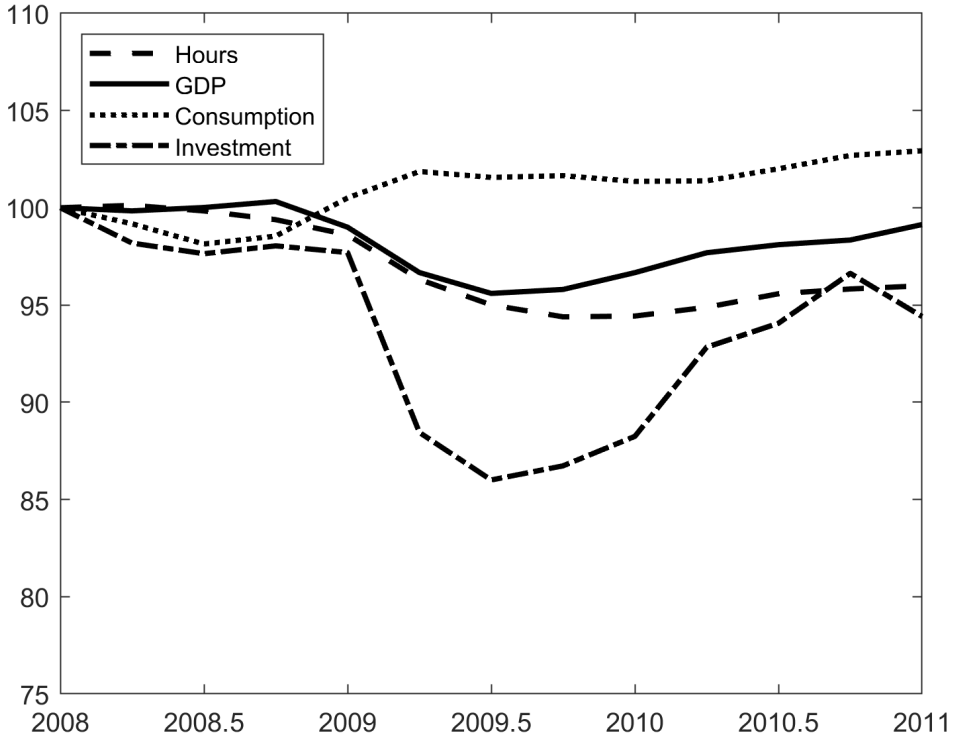


Figure 1.2: Description of the 2007-2008 crisis in Canada

Notes.- The figure shows the evolution of hours worked, GDP, consumption, and investment for Canada in percentages of their values in the first quarter of 2008. Source: OECD data and the author's calculations.

Wedges measurement.– I begin the analysis of the measured wedges by describing how they evolve during the period of the recession. Table 1.1 reports the percentage changes in the wedges between the first quarter of 2008 to the third quarter of 2009. For Canada, during this period, the investment wedge fell by about 7%, the labor wedge dropped by about 14%, and the foreign asset wedge dramatically declined by about 77%. At the same time the efficiency wedge, the preference wedge, and the government wedge have increased respectively by 0.3%, 14%, and 8%. In the US, they have been also a decrease in the preference wedge by about 4%, in the labor wedge by about 9%, in the investment wedge by about 15%, and in the foreign asset wedge by about 16%. We also registered an increase in the US efficiency wedge and government wedge by 2% and 8.8% respectively.

To further get insights on how the evolution of the wedges was associated with that of aggregate variables during the recession, for each country, I plot the wedges and some variables. Those graphs are presented in the appendix. They give broad information on the comovement of wedges and the considered aggregate variable. For example, from Figure A.1.1a we could expect that the efficiency and labor wedges of Canada play a role in the fluctuation of Canada's output during the recession. As not only the wedges in Canada, for example, can explain the fluctuations of aggregate variables in Canada we cannot surely draw a pattern from this analysis. I then, perform a counterfactual analysis to evaluate the contribution of some wedges.

Table 1.1: % variation of wedges from 2007:4 to 2009:4

	Δ_{at}	Δ_{lt}	Δ_{xt}	Δ_{gt}	Δ_{ct}	Δ_{bt}
Canada	0.32	-14.22	-7.24	8.01	14.38	-76.94
US	2.00	-9.11	-15.39	8.83	-3.79	-15.85

Notes.- The Table shows the variation of wedges in percentages for the US and Canada. Δ_{at} stands for efficiency wedge, Δ_{lt} labor wedge, Δ_{xt} investment wedge, Δ_{gt} government wedge, Δ_{ct} preference wedge, and Δ_{bt} foreign asset wedge. Source: The author's calculations.

Evaluation of wedges' contribution .– To better assess the role played by disturbances in each market, I evaluate the contribution of each wedge in the fluctuation of aggregate variables during the recession. Using the approach described in the third paragraph of the section 1.3, I assess how the aggregate variables would have fluctuated considering, once at a time, the fluctuation of each wedge. In other words, I determine how output would have fluctuated if the only distortion was the efficiency wedge. Considering the output, I do the same exercise, as for the efficiency wedge, with the remaining wedges in both countries. To summarize the contribution of each wedge, I rely on the ϕ statistic proposed by Brinca et al. (2016).

The ϕ statistic is the inverse of the mean-square error of each wedge. It captures how close a simulated variable (variable obtained from simulation when assumed that only some wedges fluctuate) is to its equivalent in the data. Let S_t be one of the aggregate variables in data, S_{mt} be the counterpart from the simulation of S_t

assuming that the only wedge that fluctuates is m. The ϕ_m^S statistic, measuring the contribution of the wedge m in the fluctuation of the variable S is:

$$\phi_m^S = \frac{1/\sum_t (S_t - S_{mt})^2}{\sum_j \left[1/\sum_t (S_t - S_{jt})^2\right]}, \tag{1.22}$$

where $(m, j) \in \left\{\Delta_{at}^i, \Delta_{lt}^i, \Delta_{xt}^i, \Delta_{gt}^i, \Delta_{pt}^i, \Delta_{bt}^i\right\}_{(i \in \{Ca,US\}}$.

The ϕ statistic lies in $[0, 1]$ and sums to 1 for all the twelve wedges in both countries for each variable. The more the statistic is close to one, the more the wedge contributes to the fluctuation of the variable. Thus, when the simulated output and its counterpart in data fit perfectly (meaning $y_t - y_{mt} = 0$ for all t), then $\phi_m^Y = 1$. When a wedge does not contribute to the fluctuation of a variable, the ϕ statistic is near zero.

Table 1.2 summarizes the ϕ statistics computed for both the US and Canada during the recession from the fourth quarter of 2007 to the fourth quarter of 2009. The results, shown in the table, concern the counterfactual analysis when we feedback the wedges one at a time to the model for the counterfactual experiments we conducted. Let's first focus on the analysis of the contribution of the wedges to the fluctuations of output in the US and Canada. The accounting procedure reveals that the output drop in Canada during the recession was caused mainly by discrepancies in the efficiency and labor wedges in the US. Those wedges account for about 26% and 14% respectively in the decline of the output in Canada. In other words, the distortions that caused disturbances in the labor wedge and the productivity in the US explain the main drop in the output of Canada. However, the drop in output in the US was mainly due to the discrepancies in the investment wedge and the labor wedge in the US. They respectively account for the 27% and 16% of the output drop in the US. The investment wedge and the preference wedge in Canada contribute by about 11% and 10% to the decline of the US output. To sum up, the output decline in the US and Canada during the recession was caused mainly by the efficiency wedge, the labor wedge, and the investment wedge in the US. A second role can be attributed to the investment wedge and preference wedge in Canada.

Concerning the decline of investment, in the US and Canada, during the crisis the primary role is attributed to the discrepancies in investment wedges both in the US and Canada. They account respectively by 20% and 40% for the decline of investment in Canada, and respectively by 29% and 9% in the decline of investment in the US. Compared with the business cycle accounting of the output, we notice

that the investment in the US and Canada are more affected by the shocks in both countries.

Finally, the employment business cycle accounting for the US and Canada reveals again that the main forces are the discrepancies in the efficiency wedge, labor wedge, and investment wedge in the US and the discrepancies in the investment wedge in Canada that explain mainly the drop of labor. With respectively 19% and 13% the efficiency wedge and labor wedge in the US explain the drop of employment in Canada. While the decline of employment in the US is due to about 27% of the discrepancies in the investment wedge in Canada and respectively 25% and 19% of discrepancies in the investment wedge and labor wedge in the US.

The takeaway of the counterfactual analysis is that the US and Canada were affected by the distortions in each other economies during the crisis. However, the disturbances in the US economy seem to have impacted more the economy of Canada. The labor wedge and efficiency wedge in the US played the most important role in Canada during the recession, with a non-negligible role for the US investment wedge and Canada investment wedge in the fluctuation of Canada's investment. Concerning the fluctuations in aggregate variables in the US, the most important role comes from the investment wedge, the labor wedge, and the efficiency wedge in the US. Nevertheless, the main role in the decline of labor in the US was due to the investment wedge in Canada.

1.5 Discussions

The quantitative results I presented suppose that the agents in the economy don't face future economic uncertainty. I assume a perfect foresight economy where the agents have complete and accurate information. We must have this assumption in mind when interpreting the quantitative results. Indeed, the assumption of perfect foresight impacts the decision of agents concerning the investment in capital and their participation in the international financial market. Thus the two Euler equations of the equilibrium would have been impacted in the quantitative experiments.

However, my results indicate that distortions in the US economy, especially in the labor wedge, the efficiency wedge, and the investment wedge in the US, have a significant impact on the Canadian economy. Similarly, distortions in the Canadian economy, specifically those affecting the investment wedge, have an impact on the US economy. According to the number of distorted markets in the US explaining the fluctuation of the aggregate variables in both countries, we may conclude that

the 2007-2008 crisis probably originated in the US and then spread to Canada.

In addition, as I mentioned in the introduction, Chari et al. demonstrated that an open economy is equivalent to a prototype closed economy with a government wedge. So what differentiates the Business Cycle Accounting proposed by Chari et al. (2007) for a closed economy from ours? To answer this question, I compare the ϕ statistics from my study and those obtained from Brinca et al. (2016) for output. The results presented in Table 1.3 indicate that a particular country's business cycle is mainly due to distortions in that country, and the impact of foreign countries is through the government wedge. For example, Chari et al.'s accounting procedure attributes most of the fluctuations of output in Canada to the efficiency wedge and the investment wedge in Canada, while my accounting procedure attributes the same output movements to the labor wedge and efficiency wedge in the US. Thus, ignoring the role of distortions to the US economy in the business cycle of Canada, and vice-versa, could misleading policies. This analysis shows that the International Business Cycle Accounting methodology highlights the interdependence between countries.

Table 1.2: ϕ statistics in % for 2007:4 to 2009:4

	Canda Wedges							**US Wedges**						
	Δ_{at}	Δ_{lt}	Δ_{xt}	Δ_{gt}	Δ_{ct}	Δ_{bt}	**Total**	Δ_{at}	Δ_{lt}	Δ_{xt}	Δ_{gt}	Δ_{ct}	Δ_{bt}	**Total**
Y Ca	0.14	0.72	4.98	0.71	6.37	1.57	12.92	13.92	26.37	8.25	23.25	6.52	7.20	85.51
Y US	1.52	4.87	10.50	1.70	10.28	5.42	28.87	2.97	15.69	27.02	5.80	4.82	9.41	65.72
X Ca	1.70	3.80	40.02	1.26	2.16	3.72	48.95	12.64	4.32	20.48	1.36	4.73	3.80	47.33
X US	6.79	8.94	8.36	9.17	5.73	5.97	38.99	4.09	2.30	28.96	1.57	9.42	8.70	55.03
L Ca	0.76	2.01	10.90	1.13	5.44	7.24	20.24	18.52	12.99	5.33	21.33	10.64	3.71	72.52
L US	2.70	0.34	26.50	1.89	0.46	8.48	31.89	1.80	18.79	25.58	4.00	5.09	4.38	59.63

Notes.- The Table shows the contribution in percentages of each wedge in the fluctuation of each country output Y, investment X, and labor L. Δ_{at} stands for efficiency wedge, Δ_{lt} labor wedge, Δ_{xt} investment wedge, Δ_{gt} government wedge, Δ_{ct} preference wedge, and Δ_{bt} foreign asset wedge. Source: The author's calculations.

Table 1.3: ϕ statistics comparison for IBCA and BCA

		Δ_{at}	Δ_{lt}	Δ_{xt}	Δ_{gt}	Δ_{ct}	Δ_{bt}	Δ_{at}	Δ_{lt}	Δ_{xt}	Δ_{gt}	Δ_{ct}	Δ_{bt}
IBCA	**Y Ca**	0.14	0.72	4.98	0.71	6.37	1.57	13.92	26.37	8.25	23.25	6.52	7.20
	Y US	1.52	4.87	10.50	1.70	10.28	5.42	2.97	15.69	27.02	5.80	4.82	9.41
BCA	**Y Ca**	49.00	13.00	18.00	20.00	-	-	-	-	-	-	-	-
	Y US	-	-	-	-	-	-	16.00	46.00	32.00	6.00	-	-

Notes.- The Table shows the contribution in percentages of each wedge in the fluctuation of each country output Y, investment X, and labor L. Δ_{at} stands for efficiency wedge, Δ_{lt} labor wedge, Δ_{xt} investment wedge, Δ_{gt} government wedge, Δ_{ct} preference wedge, and Δ_{bt} foreign asset wedge. IBCA is International Business Cycle Accounting Method and BCA is Business Cycle Accounting Method. Source: The author's calculations.

1.6 Conclusion and extensions

In this paper, I propose a method that can provide insights for researchers to better specify their quantitative models in international business cycle studies. The method focuses on an accounting procedure based on a prototype model of international growth that includes wedges to capture potential frictions and distortions in markets. For each country, I include an efficiency wedge, a labor wedge, an investment wedge, a government wedge, a preference wedge, and a foreign asset wedge. The evaluation of the contribution of the wedges to the fluctuations of aggregate variables provides insight into which frictions generate business cycles and the comovements observed in the data. Theoretically, business cycle co-movements across countries are allowed through the trade in goods and the international financial market present in this model.

To demonstrate the method, I apply it to study the synchronization of the business cycle during the Great Recession in the US and Canada. My results show, during this period, the primary role in the economic downturns in both countries is attributed to the disturbances in the labor market, investment, and in productivity in the US. However, the disturbances in investment in Canada play a secondary role in the fluctuations of aggregate variables in both countries. These results suggest that Canada and the US are linked. This is consistent with the high trade as well as the financial transactions between the two countries. The results suggest also that the 2007-2008 crisis probably originated in the US and then spread to Canada.

A further step for more accuracy of the results would be to add uncertainty in the agents' decisions in my quantitative analysis. Adding the uncertainty could affect the measurement of the wedges as well as the counterfactual analysis. Indeed, the uncertainty affects the agents through their investment decision in local capital and foreign assets. For that purpose, we need to determine a method to estimate the processes governing the twelve wedges in the state of nature s_t. The stochastic distribution of this state affects the expectations of the agents.

One direction for this work could be to explore the literature on other puzzles in international macroeconomics, such as the trade co-movement puzzle. To do this, we would need to apply our methodology by developing a detailed model based on the insights gleaned from the accounting procedure. Then, we can examine whether the model can help resolve the puzzle.

References

Ambler, S., E. Cardia, and C. Zimmermann (2004): "International business cycles: What are the facts?" *Journal of Monetary Economics*, 51, 257–276.

Backus, D. K., P. J. Kehoe, and F. E. Kydland (1992): "International real business cycles," *Journal of Political Economy*, 100, 745–775.

Bems, R., R. C. Johnson, and K.-M. Yi (2010): "Demand spillovers and the collapse of trade in the global recession," *IMF Economic Review*, 58, 295–326.

Bordo, M. D. (2012): "The Great Depression and the Great Recession: what have we learnt?" .

Brinca, P., V. Chari, P. Kehoe, and E. McGrattan (2016): "Accounting for Business Cycles," in *Handbook of Macroeconomics, 2016*, Elsevier BV, 1013–1063.

Buera, F. J. and B. Moll (2015): "Aggregate implications of a credit crunch: The importance of heterogeneity," *American Economic Journal: Macroeconomics*, 7, 1–42.

Chari, V. V., P. J. Kehoe, and E. McGrattan (2004): "Business Cycle Accounting," .

Chari, V. V., P. J. Kehoe, and E. R. McGrattan (2007): "Business cycle accounting," *Econometrica*, 75, 781–836.

Devereux, M. B. and J. Yetman (2010): "Leverage constraints and the international transmission of shocks," *Journal of Money, Credit and Banking*, 42, 71–105.

Eaton, J., S. Kortum, B. Neiman, and J. Romalis (2016): "Trade and the global recession," *American Economic Review*, 106, 3401–3438.

Gao, X. (2007): "Business cycle accounting for the Chinese economy," .

Heathcote, J. and F. Perri (2002): "Financial autarky and international business cycles," *Journal of Monetary Economics*, 49, 601–627.

Huo, Z., A. A. Levchenko, and N. Pandalai-Nayar (2023): "Utilization-adjusted TFP across countries: Measurement and implications for international comovement," *Journal of International Economics*, 103753.

Johnson, R. C. (2014): "Trade in intermediate inputs and business cycle comovement," *American Economic Journal: Macroeconomics*, 6, 39–83.

Kobayashi, K. and M. Inaba (2006): "Business cycle accounting for the Japanese economy," *Japan and the World Economy*, 18, 418–440.

Kose, M. A., C. Otrok, and C. H. Whiteman (2003): "International business cycles: World, region, and country-specific factors," *American Economic Review*, 93, 1216–1239.

Kose, M. A. and K.-M. Yi (2001): "International trade and business cycles: is vertical specialization the missing link?" *American Economic Review*, 91, 371–375.

——— (2006): "Can the standard international business cycle model explain the relation between trade and comovement?" *Journal of International Economics*, 68, 267–295.

Lama, R. (2005): "Business Cycle Accounting in Developing Countries," .

Levchenko, A. A. and N. Pandalai-Nayar (2020): "TFP, news, and "sentiments": The international transmission of business cycles," *Journal of the European Economic Association*, 18, 302–341.

Obstfeld, M. and K. Rogoff (2000): "The six major puzzles in international macroeconomics: is there a common cause?" *NBER macroeconomics annual*, 15, 339–390.

Otsu, K. (2009): "International Business Cycle Accounting," IMES Discussion Paper Series 09-E-29, Institute for Monetary and Economic Studies, Bank of Japan.

Rouillard, J.-F. (2013): *National and International Business Cycles: the Role*

of Financial Frictions and Shocks, Doctoral Dissertation.

Stockman, A. C. and L. L. Tesar (1995): "Tastes and technology in a two-country model of the business cycle: explaining international comovements," *The American Economic Review*, 85, 168–185.

Wen, Y. (2007): "By force of demand: Explaining international comovements," *Journal of Economic Dynamics and Control*, 31, 1–23.

Chapter 2

Quantitative Exploration of Fiscal Rules for WAEMU Countries*

2.1 Introduction

Fiscal rules are long-lasting constraints on fiscal policy through numerical limits on budget aggregates. The objective of fiscal rules is to contain pressures to overspend to ensure fiscal responsibility and debt sustainability. Since 1985, there is a growing number of countries that adopted a fiscal rule.[2] A country can adopt either a national fiscal rule, a supranational fiscal rule, or both. A supranational fiscal rule is designed for a group of countries, generally constituted in an economic union such as the Central African Economic and Monetary Community (CEMAC), the East Africa Economic and Monetary Community, the Eastern Caribbean Currency Union (ECCU), the European Union, the West African Economic and Monetary Union (WAEMU).[3]

This chapter investigates the design of a fiscal rule for an economic union with a focus on the WAEMU. I solve for the design of a joint uniform fiscal rule and also for country-specific fiscal rules. I find that by restricting the rule to be uniform across members, an economic union forgoes sizable welfare gains. Considering that

*I'm indebted to my advisor, Guillaume Sublet for his invaluable guidance and support. I would like to thank my colleagues in the workshop group, organized by my advisor Guillaume Sublet at the University of Montreal, for their comments.

[2]According to Davoodi, Elger, Fotiou, Garcia-Macia, Han, Lagerborg, Lam, and Medas (2022): from 9 countries in 1985 to 105 countries in 2021.

[3]The WAEMU has 8 member states: Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo.

one country has a pecuniary externality (through the interest rate) on others, I show that it is beneficial for members to coordinate in the design of country-specific rules.

The chapter is motivated by two observations. The first observation is that the eight WAEMU countries are subjected to the same fiscal rule (as described in section 2.2.1). The rule was a balanced budget rule from 2000 to 2014, and a maximum of 3% deficit limit rule since 2015. The second observation is the heterogeneity of fiscal needs and fiscal implementation of WAEMU countries that I documented in section 2.2.2. I show that the budget deficits over GDP, the government expenditures over GDP, the government revenues over GDP, and the government debts over GDP are significantly different across WAEMU countries. In this paper, I answer the following two questions: i) How do the government finance and the citizenry's welfare of WAEMU member countries with the current fiscal rule compare to a counterfactual scenario with no rule? ii) Is there a Pareto improving reform of the current fiscal rule for the WAEMU?

To answer these questions, I use a theoretical framework where the central authority, in designing the fiscal rule for the union, considers the specificities of each economy and internalizes the spillover effects of each country's decisions on the other members of the union. I use a standard model of fiscal policy from the literature (Halac and Yared (2018)). In this framework, the central authority observes the characteristics of each government in the union when setting the rule. The governments of the economic union are heterogeneous in their fiscal needs and in their present bias. The government's fiscal needs are stochastic which represents the economic shocks that the country experiences. The distribution of shocks to fiscal needs captures the need for flexibility. The present bias of the government captures the incentive to over-borrow on the parts of members of an economic and monetary union. The role of the rule in the framework is then to provide enough flexibility to each government according to the shocks it faces while imposing discipline on the government to curb the incentive to overspend.

I distinguish two cases in my analysis. In the first case, the central authority ignores the spillover effects by considering each member country of the union as a small open economy so that each government takes the interest rate as given. The rule in this case is called an "uncoordinated fiscal rule" in the sense that it is equivalent to each country individually designing its fiscal rule. In the second case, the central authority internalizes the effects of each country's fiscal decision on the other members: it is the "coordinated fiscal rule". In the model, the channel of transmission of the spillover effects is the common interest rate of the union. More

specifically, the fiscal irresponsibility of one member of the union, by running an excess deficit, can increase the risk premium on the regional bond market leading to an increase in the regional interest rate. Conversely, a fiscal rule limits borrowing on the parts of members of the economic union which lowers the regional interest rate.

I calibrate the model's parameters and discipline this model using data from the common Central Bank database "La Base de Données Economiques et Financières de la BCEAO".[4] Using the model as a laboratory, I evaluate and propose reforms to the current homogeneous fiscal rule. I found that all the WAEMU countries benefit from the current homogeneous rule of a maximum of 3% deficit limit compared to a counterfactual scenario with no fiscal rule. In this context, the results imply that, for all the WAEMU countries, the political-economic frictions are high enough such that disciplining the governments with a 3% deficit limit enhances the welfare of the citizenry. However, we can even do better than the current homogeneous rule by setting a country-specific fiscal rule for the members of the union. I find that constraining all the countries to a uniform fiscal rule forgoes 24% of the welfare gains that the union could achieve with country-specific fiscal rules. When each country individually designs its rule, I find that the tightest optimal deficit limit is 0.64%, for Benin, and the loosest fiscal limit is 3.5% for Guinea Bissau. Except for Burkina Faso and Guinea Bissau, the six other countries would optimally choose a tighter deficit limit than the current 3% deficit limit. When the central authority internalizes the spillover effects, when designing the rule, I find that the tightest deficit limit is 2%, provided for Burkina Faso, and the loosest deficit limit is 12% provided for Benin. The coordinated fiscal rule grants more flexibility than the uncoordinated fiscal rule. I find that the pecuniary externality through the interest rate matters quantitatively for the design of the fiscal rule for the WAEMU.

The reason why the coordinated fiscal rule is less restrictive than the uncoordinated one is the following. The difference between coordinated and uncoordinated fiscal rules is that the members coordinate by taking the effects of the fiscal rule on the interest rate into account. I found that the coordinated fiscal rule increases the interest rate compared to the uncoordinated fiscal rule. A higher interest rate lowers the political economy tension because members are less tempted to give in to their present bias when the interest rate is higher. My results show that, from the uncoordinated fiscal rule to the coordinated one, the relative stringency of fiscal rules between some countries flips. The reason why it flips is that countries have

[4]BCEAO (Banque Centrale des Etats de l'Afrique de l'Ouest) is the Central Bank of West African states using the CFA currency.

different sensitivities to the general equilibrium effects. The heterogeneity in sensitivities across members of the union results from the calibration which estimates the degree of risk aversion which in turn governs the elasticity of intertemporal substitution. Countries that tend to have a deficit that responds a lot to shocks are also the ones that are more sensitive to the general equilibrium effects.

Literature Review

This paper relates to the literature on the design of rules to discipline a policy-making authority to act in the interest of the citizenry (Athey, Atkeson, and Kehoe (2005), Amador, Werning, and Angeletos (2006), Ambrus and Egorov (2013), Amador and Bagwell (2013), Halac and Yared (2014), and Sublet (2023)). This paper builds on Halac and Yared (2018) to study the design of fiscal rules for an economic union. More specifically, the paper quantifies the optimal fiscal rule to discipline the members of the WAEMU.

This paper is also related to the literature on the necessity of fiscal coordination in a monetary union (such as Hamada (1985), Grauwe (1992), Buiter, Corsetti, and Roubini (1993), Kenen (1995), and Chari and Kehoe (2004)). These papers discuss the importance of fiscal rules in monetary unions as the only tool to stabilize the national business cycle and the necessity of fiscal coordination to internalize the spillover effects of one member on the others. This paper shows that fiscal coordination calls for country-specific rules that take the international spillover through general equilibrium effects on other countries into account.

This paper contributes to the literature on fiscal rules design for WAEMU countries (e.g. Basdevant, Imam, Kinda, and Zdzienicka (2015), Dessus, Diaz-Sanchez, and Varoudakis (2016) and David, Nguyen-Duong, and Selim (2022)). This literature focuses on the effectiveness and adequacy of fiscal rules in the union through econometric analysis. My approach, in this paper, consists in calibrating a theoretical model and performing a counterfactual analysis of the fiscal rules.

2.2 The WAEMU System of Fiscal Rules and Empirical Facts on Countries Heterogeneity

This section presents the backgrounds of fiscal rules in WAEMU countries and a descriptive analysis of the fiscal practices of those countries.

2.2.1 The WAEMU System of Fiscal Rules

Seven countries of West Africa sharing the common West African CFA franc currency established, by signing a Treaty in 1994, the West African Economic and Monetary Union. The member states are Benin, Burkina Faso, Côte d'Ivoire, Mali, Niger, Senegal, and Togo. Later in 1997, these countries were joined by Guinea Bissau. The union was established to strengthen the economic and financial competitiveness of the Member States through the market integration and monetary union established earlier in 1962. The union aimed also to reinforce the fiscal discipline and coordination of fiscal and monetary policy after the devaluation of the CFA franc occurred in 1994. To this end, the eight-member states adopted on December 1999 the "Growth, Stability, Convergence and Solidarity Pact (GSCSP)". The Pact has been revised in 2015.

The initial pact lasted from 1999 to 2015. It stated eight rules divided into two orders of convergence criteria. First-order convergence criteria gathered a ceiling on fiscal deficit and debt to GDP and on CPI inflation and no accumulation of arrears. The second-order convergence criteria included ceilings on wages and salaries, floors on tax revenues, limits on current account deficits, and floors on investment-expenditures to revenue ratio. This paper is interested in evaluating the fiscal rules of the first-order convergence criteria. The deficit rule is defined as basic fiscal balance which is fiscal balance excluding grants. The debt ceiling was set at 70 % of GDP. I am interested, in this paper, in the evaluation of the current fiscal rule of a maximum of 3% deficit limit.

The GSCSP has been revised in 2015. The number of rules was reduced by three. The rule on the accumulation of arrears was withdrawn from the first-order criteria while the rules on current account deficit and investment-expenditures to revenue ratio were withdrawn from the second-order convergence criteria. The deficit rule was also modified such as the overall fiscal balance (grants included and externally financed capital expenditures) to be a maximum of 3% of GDP. This

revised GSCSP is in application since 2015 except that it has been suspended in 2020 because of the COVID-19 pandemic.

The main reason for the revision of the GSCSP is the violation of the fiscal rules by member states between 2000 to 2014. As displayed in table B.4.1, at least six out of eight countries have violated the basic deficit balance rule during the period 2000 to 2014. The high number of countries that have violated the prevailing rule suggests an inadequacy of that rule. Next, I will present my investigations on fiscal needs and fiscal practices across WAEMU countries which may explain the inadequacy of the uniform fiscal rules for the union.

2.2.2 Empirical Facts on WAEMU Countries Heterogeneity

This section presents the facts on the heterogeneity of member states of WAEMU. To this aim, I investigate the fiscal needs and fiscal behaviors across countries. I find that WAEMU countries are heterogeneous in the mean and the volatility of their budget deficits over GDP, government revenues over GDP, government spending over GDP, and government debt over GDP.

I use macro data from "La Base de Données Economiques et Financières de la BCEAO". This data is collected by the Central Bank of West African States serving the eight West African countries of WAEMU. I compare the means and volatility of budget balance, government revenue, government spending, and current debt across WEAMU countries.

Fact 1: Before the adoption of the fiscal rule WAEMU countries were heterogeneous in their fiscal needs and fiscal policy.– I use time series data from 1960 to 1999 to show that member states of WAEMU were heterogeneous before the setting of the uniform fiscal rule in GSCSP. As shown in Figure 2.1 the budget deficit is significantly different across countries in mean as well as in volatility. For example, the average budget deficit for Côte d'Ivoire is about two times that of Burkina Faso and the standard deviation of the budget deficit for Côte d'Ivoire is three times that of Mali. The differences in the mean and the volatility of budget deficit across WAEMU countries before 2000 are confirmed by statistics tests reported in Table B.5.1. As for the budget deficit, the WAEMU countries had differences in the mean and the volatility, before 2000, in their government revenue over GDP, government spending over GDP, and debt over GDP as reported in the Table B.5.1 and shown in Figures B.1.1, B.1.2, and B.1.3.

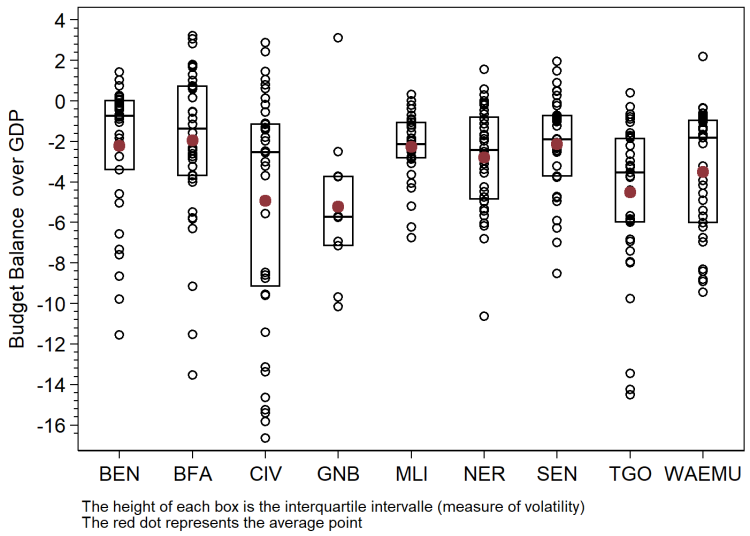


Figure 2.1: Budget Balance over GDP from 1960-1999
Source: BCEAO data and the author's representation

Fact 2: During the application phase of the fiscal rule WAEMU countries were heterogeneous in their fiscal needs and fiscal policy.– I use time series from 2000 to 2014 to show that member states of WAEMU are still heterogeneous during the years of application of fiscal rule leading to the modification of GSCSP. During this period, the average budget deficit for Burkina Faso was around three times that of Benin and Togo's budget deficit volatility was about twice that of Mali. Those differences in mean and volatility of budget deficit across WAEMU from 2000-2014 are held from statistics tests I performed and displayed in Table B.5.2. We can observe the same pattern of heterogeneity in mean and volatility on government revenue over GDP, government expenditure over GDP, and government debt over GDP during this period (see Figures B.2.1, B.2.2 and B.2.3 and Table B.5.2).

Facts 1 and 2 show that WAEMU countries are different from the perspective of their fiscal needs and fiscal practices. The design of fiscal rules for this union should consider the heterogeneity observed.

2.3 Theoretical Framework

This section presents the economic environment and model used to investigate the fiscal rule for WAEMU countries. The government objectives on spending and

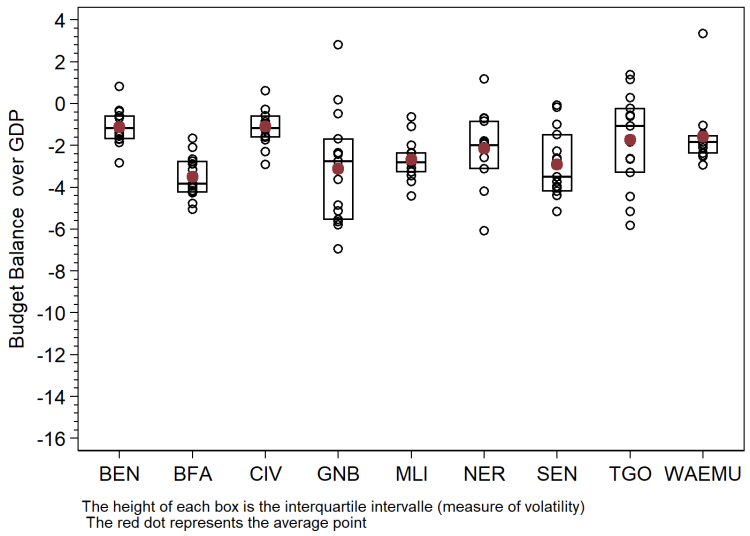


Figure 2.2: Budget Balance over GDP from 2000-2014
Source: BCEAO data and the author's representation

borrowing come from the interaction of the preference shocks the government experiences and the degree of present bias measuring the political-economic frictions toward spending of the government.

2.3.1 Setup

I rely on a model of fiscal policy for the quantitative evaluation of fiscal rules. The model is built on Halac and Yared (2018). I consider an economic and monetary union of N countries in which each government makes decisions on spending and borrowing.

I describe a two-period model extendable to an infinite horizon. At the begin of the first period, the government i observes a shock $\theta_i > 0$ to its economy drawn from a bounded set $\Theta_i = [\underline{\theta_i}, \bar{\theta_i}]$ with a continuously differentiable distribution function $F_i(\theta_i)$. After this shock, the government i chooses the first-period spending g_i and the second-period asset holding x_i according to its budget constraint:

$$g_i + \frac{x_i}{R} = \tau_i, \tag{2.1}$$

where τ_i is the government revenue at the initial period, and R is the gross interest rate that is endogenously determined in the Union.

In the view of the social planner, the citizenry's welfare when the government i spends g_i and holds assets x_i is

$$\mathbb{E}[\theta_i U(g_i) + \beta W(x_i)], \tag{2.2}$$

where β is the discount factor, $U'(.) > 0$, $U''(.) < 0$, $W'(.) > 0$ and $W''(.) < 0$ are first and second derivatives of $U(.)$ and $W(.)$. $U(g_i)$ represents the government i's utility from spending g_i and $W(x_i)$ is the second-period utility from carrying forward assets x_i (W is the continuation value). I consider $U(.)$ to be an exponential function so that I can interpret θ_i as a shock to government i's revenue (see section 5.4 of Amador et al. (2006)). For a general utility function, θ_i is a taste shock multiplying the first-period utility. As explained in Halac and Yared (2018) task shock is a tractable way to introduce flexibility in the model: therefore the marginal benefit of government spending increases with a high value of θ_i. This implies that the need for public spending is increasing with the severity of the shock.

After the realization of the shock to the economy, the government i's objective when choosing g_i and x_i is

$$\theta_i U(g_i) + \delta_i \beta W(x_i), \tag{2.3}$$

where $\delta_i \in (0, 1]$.

The government objective (2.3) differs from the social planner objective (2.2) through the way they discount the future. The government discounts more the future than the social planner. The implications of this difference are provided in subsection 2.3.2.

To close the model, we assume that the members of the union borrow or lend from each other such that the aggregate net borrowing in this union is zero in equilibrium. Let $g_i(\theta_i, R)$ and $x_i(\theta_i, R)$ be respectively government i's spending and asset holding when it experiences shock θ_i, the Union gross interest rate adjusts then for global resource constraint (2.4) to be verified,

$$\sum_{i=1}^{N}(g_i(\theta_i, R)) = \sum_{i=1}^{N} \tau_i. \tag{2.4}$$

2.3.2 Fiscal Rules

There are two frictions in the setting that generates a trade-off for the rule-making body. Unless $\delta_i = 1$ there is a disagreement between the social planner objective (2.2) and that of government i (2.3). Compared to the social planner, the government is present-biased in the sense that it discounts more the future. Then, the government i tends to overspend in the first period compared to the allocations of the social planner. I use this structure of preference to model the political-economic frictions of each country. The literature offers two arguments for such disagreements (see Jackson and Yariv 2014, 2015). It can arise because the government aggregates a heterogeneous citizen's preferences such that even if they are time consistent, the government becomes time inconsistent. The other argument for such preference is political turnover. Indeed, when there is political uncertainty, for instance, the government in power places a higher value on its spending, it discounts more the future. The latter argument is an example of political-economic frictions that motivated the use of present bias preferences in my model. From Chari and Kehoe (2004), governments of an economic and monetary union have also an incentive to overspend on behalf of the other parts when the common central bank lacks commitment; it is a monetary-economic friction. The present-biased parameter captures both the political-economic frictions and the monetary-economic frictions in my framework.

The second friction in the setting is the shock experienced by each government. Indeed, in the absence of uncertainty, the desirable rule would be a full commitment. Therefore, the ideal rule should be contingent on the shocks. But due to the large set of the realization of the shocks, we cannot design the rule for each value of the shock. Furthermore, the shocks may not be observable, and even if they are, their values cannot be verified by the citizenry.

To sum up, the present bias justifies the need for a rule, and the preference shock the need for flexibility. The two frictions in the model induce then a trade-off between flexibility and commitment. On one hand, a desirable rule should offer sufficient flexibility to the government to react to the shocks it experiences and, on the other hand, the rule should discipline it from overspending. The optimal rule then exhibits neither full commitment nor full flexibility.

I define the fiscal rule as a cutoff on the shock of each government i, θ_i^*, such that when this government experiences a shock higher than the cutoff $\theta_i > \theta_i^*$ its first-period spending and second-period asset are respectively $g_i^f(\theta_i^*, R)$ and $x_i^f(\theta_i^*, R)$. Whereas when the shock is below the cutoff, $\theta_i < \theta_i^*$, the government's first-period

spending and second-period asset are respectively $g_i^f(\theta_i, R)$ and $x_i^f(\theta_i, R)$. In other words, the fiscal rule provides full flexibility to a government that experiences a shock below a threshold and restricts the government otherwise. In that definition $g_i^f(.)$ and $x_i^f(.)$ are the optimal decision rules of government i's objective when given full flexibility. $g_i^f(.)$ and $x_i^f(.)$ maximize (2.3) subject to (2.1) and verify (2.5).

$$\theta_i U'(g_i^f(\theta_i, R)) = \delta_i \beta W'(x_i^f(\theta_i, R)) \tag{2.5}$$

As each government decision rule is one-to-one mapping with the preference shock, the definition of the fiscal rule is equivalent to a cap on government spending $g_i^f(\theta_i^*, R)$. Also, as I assume a constant government revenue, this definition of fiscal rule can be implemented with a maximum deficit limit as the current fiscal rule in WAEMU countries. I rely on this model to evaluate the current fiscal rule in WAEMU countries and to propose some reforms. The following sections present the quantitative strategies I use to answer my questions.

2.4 Evaluation of Current Uniform Fiscal Rule

I start with the evaluation of the current fiscal rule stated in GSCSP before investigating a potential reform to that rule. I will focus on evaluating the main rule of a maximum of 3% deficit limit in application since 2015. I compute for that evaluation the welfare variation from no rule situation for WAEMU countries to the uniform maximum of 3% deficit limit. For the evaluation of the current fiscal rule, I compare the 3% deficit limit rule to no rule situation for each country of WAEMU individually. Before presenting the results, I show the calibration strategy I adopted.

2.4.1 Calibration

As mentioned in section 2.3 there are two main ingredients in the model: the preference shock and the present-bias parameter. The identification of those ingredients is then crucial for my quantitative analysis.

Preference shock inference.– The preference shock captures the fiscal needs of each government. I infer its values and distribution using data from 1960 to 1999 to identify the behavior of the government in the absence of fiscal rule. I assume a Constant Absolute Risk Aversion (CARA) utility function to interpret

those shocks as shocks on government revenue: $U(g) = 1 - e^{-\alpha g}$. α is the degree of risk aversion of the government. I infer the value and distribution of the shocks on government revenue using the time series of public savings (which is also the new debt issues by the government) following Amador et al. (2006). To assess the unanticipated effect of a shock, I rely on the cyclical component of the public saving time series. I adopt a non-parametric approach to infer the distribution of shock to government revenue. The preference shock θ, as defined in my model, is related to the shock on government revenue through the relation $\theta = e^{-\alpha\epsilon}$; where ϵ is the shock on government revenue. Let $f_\epsilon(.)$ and $f_\theta(.)$ be the density function ϵ and θ respectively; the distribution of the preference is obtained as follows :

$$f_\theta(y) = \frac{1}{\alpha y} f_\epsilon(-\frac{1}{\alpha} ln(y)) \tag{2.6}$$

The graphs in Figure B.3 in the appendix represent the distributions of the shocks on government revenues and the distribution of preference shocks for some WAEMU countries.

Calibration of the coefficients of absolute risk aversion and of the degree of present bias.– For each country, I choose the risk aversion parameter for utility function α and the government present-bias parameter δ jointly such that the theoretical mean and variance of the budget balance match the first and the second moments of the budget deficit in the data from 1960 to 1999. The choice of this period ensures that the model is disciplined before the countries start the application of the fiscal rules. The calibration results are summarised in Table 2.1. All the WAEMU countries are risk-averse as $\boldsymbol{\alpha > 0}$. The degree of present bias is measured by $\boldsymbol{1 - \delta}$. Hence, in reading Table 2.1, countries with a lower value of δ exhibit a higher degree of present bias. My calibration results show that Côte d'Ivoire is the most present biased government and Mali is the least present biased government in WAEMU. In order words the government of Côte d'Ivoire would have the tendency to overspend on the parts of other members of the union either because of the political-economic frictions of the country or because of the monetary-economic frictions of the Central Bank.

As a robustness exercise, I consider an economic union whose governments are equally present-biased and calibrate only one present-bias parameter for all eight members of WAEMU. The results are located in Table B.6 of the appendix. I was able then to assess the extent to which the idiosyncratic shocks impact the design of the rule of the union. This exercise will show if idiosyncrasy is important enough

for the union, thus situating the role of fiscal rule in addition to the monetary policy in the union.

Table 2.1: α and δ calibration results

	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**

Note.– α is the absolute risk aversion parameter and $(1-\delta)$ is the degree of the government's present bias. BEN stands for Benin, BFA for Burkina Faso, CIV for Côte d'Ivoire, GNB for Guinea Bissau, MLI for Mali, NER for Niger, SEN for Senegal, and TGO for Togo. Source: The author's calculations

2.4.2 Welfare analysis of the current fiscal rule

I use a notion of government spending equivalent variation to evaluate the welfare variation from a benchmark policy to an alternative policy. This notion is similar to the "Consumption Equivalent Variation" notion. Let subscripts *bp* and *ap* denote respectively a benchmark policy allocation and an alternative policy allocation. $\mathbf{\Lambda}$ the government spending equivalent is defined as follows :

$$\mathbb{E}[\theta U(g^{bp}(\theta,R)(1+\mathbf{\Lambda}))+\beta W(x^{bp}(\theta,R))] = \mathbb{E}[\theta U(g^{ap}(\theta,R))+\beta W(x^{ap}(\theta,R))] \quad (2.7)$$

Λ is the maximum fraction of government expenditure that the citizenry would be willing to forgo for the government to choose the allocations of the alternative economy instead of that of the benchmark economy. In other words, it is the amount of government spending that makes the government indifferent between the benchmark economy and the alternative one. When the benchmark economy displays more welfare for citizens compared to the alternative economy, $\Lambda < 0$. This implies the citizenry would be willing to give $100 * \Lambda\%$ of government spending each year for the government to choose the benchmark economy allocations. On the opposite, when the alternative economy gives higher welfare, $\Lambda > 0$. The implication is that the citizens would be willing to give $100 * \Lambda\%$ of government spending every period for the government to choose the alternative economy allocations.

I use the parameters calibrated in Table 2.1 to quantify the welfare variation, for each member of WAEMU, from a counterfactual scenario with no fiscal rule to the current uniform fiscal rule. The results are summarized in Table 2.2. It comes out, from this table, that all WAEMU countries are better off moving from no rule to a 3% maximum deficit limit rule. For example, Benin citizens would be willing to provide an increase of government expenditures by 0.5% each period for the government to move from a no-rule economy to a maximum of 3% deficit rule.

Overall, the WAEMU homogeneous fiscal rule benefits all countries as $\Lambda > 0$ compared to a counterfactual scenario with no fiscal rule. Guinea Bissau benefits the most from the 3% deficit limit rule and Mali benefits the least from this rule compared to the counterfactual scenario with no fiscal rule.

Table 2.2: Welfare gain from no-rule to a 3% deficit limit rule

	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	**0.51**	**0.71**	**0.69**	**1.77**	**0.11**	**0.38**	**0.16**	**0.61**

Note.– The table shows the welfare government spending equivalent variation (Λ) in % with each government degree of present bias ($1-\delta$). BEN stands for Benin, BFA for Burkina Faso, CIV for Côte d'Ivoire, GNB for Guinea Bissau, MLI for Mali, NER for Niger, SEN for Senegal, and TGO for Togo. Source: The author's calculations

Indeed, there exists a threshold of present-bias parameter $\boldsymbol{\delta^*}$ below which the current fiscal rule benefits a country compared to the no-rule situation. The results in Table 2.3 show that the present bias parameter calibrated for all countries of the union is below the threshold. This means the political-economic frictions and/or the monetary-economic frictions of WAEMU countries are high enough so that disciplining them by the current fiscal rule is beneficial for their citizens.

Even if the current fiscal improves the welfare of WAEMU countries, could we do better than the homogeneous fiscal rule? The next section presents the design and the quantitative evaluation of a national optimal fiscal rule.

2.5 Uncoordinated Optimal Fiscal Rule

The section 2.4 shows that the governments overspend when they are provided full discretion such that a fiscal rule of a maximum 3% deficit limit of GDP is beneficial

Table 2.3: Present bias threshold for welfare gain

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

Note. – $(1-\delta)$ is the degree of the government's present bias and $(1-\delta^*)$ is the degree of the government's present bias threshold. BEN stands for Benin, BFA for Burkina Faso, CIV for Côte d'Ivoire, GNB for Guinea Bissau, MLI for Mali, NER for Niger, SEN for Senegal, and TGO for Togo. Source: The author's calculations

for all WAEMU countries compared to the no-rule situation. This section explores a potential reform to the current fiscal rule for WAEMU countries in the case the central authority that set the rule considers each country of the union as a small open economy.

2.5.1 Uncoordinated Fiscal Rule Design

The central authority considers that each country of the union takes as given the interest rate they face on their borrowing. This implies the fiscal rule design ignores the spillover effects of each country's behavior. In this case, the rule set up is equivalent to the case each country individually chooses its fiscal rule. The solution to the maximization problem of the union's welfare coincides with the solution to the maximization problem of each government's social welfare. Note that the allocations $\{g_i(\theta_i, R), x_i(\theta_i, R)\}$ in the welfare problem should satisfy the governments' budget constraints and objectives. Thus the allocations should verify the equation (2.5) for each government. It is an uncoordinated fiscal rule in the sense it is as if each country designs independently its fiscal rule.

The government i sets its fiscal rule such that it maximizes the expected welfare as follows:

$$\max_{\theta_i^* \in [\underline{\theta_i}, \bar{\theta_i}]} \left\{ \int_{\underline{\theta_i}}^{\theta_i^*} \Big(\theta_i U(g_i^f(\theta_i, R)) + \beta W(x_i^f(\theta_i, R))\Big) f_i(\theta_i) d\theta_i \quad + \right. \tag{2.8}$$
$$\left. \int_{\theta_i^*}^{\bar{\theta_i}} \Big(\theta_i U(g_i^f(\theta_i^*, R)) + \beta W(x_i^f(\theta_i^*, R))\Big) f_i(\theta_i) d\theta_i \right\}$$

The optimal uncoordinated fiscal rule (national rule) is defined as - given the

interest rate R, a cutoff θ^*_{iu} satisfying:

$$\frac{\mathbb{E}\left[\theta_i|\theta_i \geq \theta^*_{iu}\right]}{\theta^*_{iu}} = \frac{1}{\delta_i} \tag{2.9}$$

In practice, however, as it is currently for WAEMU, the central authority constrained all the countries in the union to adopt the same fiscal rule. In this case with an exogenous interest rate, to set the constraint uniform uncoordinated rule we must treat the union as a country. The constrained uniform fiscal under exogenous interest rate is defined as - given the interest rate R, a cutoff θ^*_{cu} satisfying:

$$\frac{\mathbb{E}\left[\theta|\theta \geq \theta^*_{cu}\right]}{\theta^*_{cu}} = \frac{1}{\delta} \quad , \tag{2.10}$$

where θ represents the common shock to the union and δ is the common present-bias parameter for the union.

I compare the uncoordinated fiscal rule to the current homogeneous 3% deficit limit rule and to the constrained fiscal rule.

2.5.2 Quantifying Optimal Uncoordinated Fiscal Rule for WAEMU Countries

I use data to quantify the optimal uncoordinated fiscal rule for each country from the equation (2.7). Then using the notion of the government spending equivalent variation (equation 2.7), I compare the welfare variation from the current homogeneous maximum of 3% deficit limit rule to the optimal uncoordinated fiscal rule for each country. The results I found are presented in Table 2.4. The Table shows that when the WAEMU countries independently design their fiscal rules, Benin, Côte d'Ivoire, Mali, Niger, Senegal, and Togo would have chosen a tighter rule than the prevailing 3% deficit rule while Burkina-Faso and Guinea Bissau would have set optimally a slacker deficit limit rule than the current 3% deficit rule. The tightest rule is chosen by Benin with a maximum of 0.64% budget deficit. The loosest rule is set by Burkina Faso with a maximum of 3.9% budget deficit. Moving from the current rule to the optimal rule would increase the citizenry's welfare for each country. In particular, the Benin citizens would be willing to give, each year, 0.125% of government spending for the adoption of the optimal fiscal rule (a maximum of 0.64% budget deficit rule) by the government of Benin.

As a robustness check, I suppose that all the union countries face the same

political-economic and or monetary-economic frictions when setting the optimal uncoordinated rule. The results are displayed in Table B.6.1. The optimal fiscal rule chosen by each country, when I assume that all the countries' governments have the same present bias parameter, is qualitatively similar to the fiscal rules when the countries experience different political or monetary economic frictions. Indeed, only the Guinea Bissau government would have set a looser fiscal rule than the 3% deficit limit; the remaining countries would set tighter fiscal rules.

Table 2.4: 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	**0.64**	**3.91**	**1.79**	**3.50**	**2.06**	**1.80**	**1.06**	**2.17**
Λ	**0.125**	**0.000**	**0.019**	**0.013**	**0.006**	**0.025**	**0.038**	**0.013**

Note.– The table shows the maximum deficit limit (DL) in % and the welfare government spending equivalent variation (Λ) in % with each government degree of present bias ($1-\delta$). BEN stands for Benin, BFA for Burkina Faso, CIV for Côte d'Ivoire, GNB for Guinea Bissau, MLI for Mali, NER for Niger, SEN for Senegal, and TGO for Togo. Source: The author's calculations

Comparison between a uniform rule and country-specific uncoordinated rule The country-specific fiscal rule design shows that six countries out of the eight countries would optimally set a tighter rule than the 3% deficit limit. In my model, when the central authority constrained the countries to a uniform rule, the optimal rule for WAEMU countries, from the evaluation of equation (2.10), is a maximum of 0.73% budget deficit limit. This result suggests that the rule maker would have optimally set the fiscal rule to a maximum of 0.73% deficit limit if it considered that the governments are present-biased. This optimal uniform rule is tighter than the current uniform rule. The goal of this exercise is also to compare the country-specific fiscal rule and the constrained fiscal rule in terms of welfare. I find that constraining the countries to a uniform rule forgoes 37% of welfare that could have been achieved with a country-specific rule.

To sum up, I find that the current fiscal rule benefits all WAEMU countries compared to the no-rule situation. However, we can do better than the homogeneous fiscal rule by setting a country-specific rule. When the central authority

ignores the spillover effects, constraining the countries forgoes a lot in terms of welfare. The next section examines the implication for the optimal fiscal rule design of the spillover effects through the interest rate.

2.6 Coordinated Optimal Fiscal Rule

Section 2.5 started the investigation of potential reform of fiscal rules in WAEMU countries when a central authority considers that the interest rate is specific for each country in the union. This section explores a potential reform of the fiscal rule in the union considering that each government's decisions impact the remaining countries through the interest rate. The interest rate is then endogenously determined in the model from the interactions of the decisions of WAEMU's member states.

2.6.1 Design of coordinated Fiscal Rule

The central authority jointly chooses a fiscal rule for each country by maximizing the union's social welfare knowing that the allocations are chosen to satisfy each government objective: it is a coordinated fiscal rule. This setting differs from the uncoordinated rule as it takes into account the externality of each member state's fiscal policy on the rest of the members. This externality is through the interest rate. Indeed, the union interest rate R level varies with the borrowing demand such that when country i, for example, increases its demand, everything else equals, R increases. The central authority in this setting internalizes this externality effect while it did not when designing the uncoordinated fiscal rule.

The central authority chooses a specific fiscal rule for each member state by maximizing the social welfare of the union. The program solved is :

$$\max_{\otimes_{i=1}^{n}\theta_i^*\in\otimes_{i=1}^{n}[\underline{\theta_i},\bar{\theta_i}]} \sum_{i}^{n} \upsilon_i \Big[\int_{\underline{\theta_i}}^{\theta_i^*} \Big(\theta_i U(g_i^f(\theta_i, R(\theta^*))) + \beta W(x_i^f(\theta_i, R(\theta^*))\Big) f_i(\theta_i) d\theta_i \tag{2.11}$$

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

$$\text{s.t. } \textstyle\sum_i^n \upsilon_i \int_{\underline{\theta_i}}^{\bar{\theta_i}} \Big((g_i^f(\theta_i, R)\Big) f_i(\theta_i) d\theta_i = \sum_i^n \upsilon_i \int_{\underline{\theta_i}}^{\bar{\theta_i}} \tau_i f_i(\theta_i) d\theta_i,$$

where $\theta^* = (\otimes_{i=1}^{n}\theta_i^*)$ and $\sum_i^n \upsilon_i = 1$ with υ_i being the weight of country i.

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

$$\begin{cases} \frac{\mathbb{E}\left[\theta_i | \theta_i \geq \theta_{ic}^*\right]}{\theta_{ic}^*} = \frac{1}{\delta_i} + \frac{R'(\theta_{ic}^*)}{(1-F(\theta_{ic}^*))\theta_{ic}^* U'(g_i^f(\theta_{ic}^*, R)) \frac{\partial g_i^f(\theta_{ic}^*, R)}{\partial \theta_{ic}^*}} (\rho_i + \lambda_i) \\ \sum_i^n \upsilon_i \int_{\underline{\theta_i}}^{\bar{\theta}_i} \left(g_i^f(\theta_i, R)\right) f_i(\theta_i) d\theta_i = \sum_i^n \upsilon_i \int_{\underline{\theta_i}}^{\bar{\theta}_i} \tau_i f_i(\theta_i) d\theta_i, \end{cases} \tag{2.12}$$

where ρ_i is the redistributive effect and λ_i is the disciplining effect are:

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

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

The redistributive effects ρ_i capture the impact of the interest rate on lenders and borrowers. Indeed, the higher the preference shock of a government is, the higher the government expenditures would be and the more the government will increase its borrowing. In this case, the next period's marginal cost of this debt depends on the level of interest rate such that a high level of interest rate harms more government that experiences a high shock. The central authority, searching to maximize social welfare, will put more weight on the high-type governments; it will be optimal to design a rule that lowers the interest rate. The objective to redistribute from lower type to higher type leads the central authority to reduce the government's flexibility, which will reduce the interest rate compared to the interest rate under an uncoordinated fiscal rule.

The second externality effects that are not internalized when designing the uncoordinated fiscal rule are the disciplining effects λ_i. They capture the sensibility of government spending and borrowing on the interest rate. Thus, assuming that a high level of interest rate limits government expenditures, this effect discourages governments that overborrow. Overall, a high-interest rate benefits the more to governments that experience a low shock and overborrowed relative to the first best allocation. Besides, a high-interest rate harms governments that experience a high shock because they underborrowed relative to their first best allocation. Therefore, an increase in the interest rate will constrain further those high-type

shock governments.

In the program solved by the central authority in equation (2.11), the fiscal rule is specific for each country. I will evaluate a similar design of rule where the central government constrained all the members of the union to set the same rule as we observe currently in WAEMU countries. To this end, I consider that all the countries experience the same political-economic and monetary-economic frictions such that I can compare the results to what I found in the uncoordinated fiscal rule design. I will compare the welfare implication of designing country-specific joint rules and a constraint joint rule for WAEMU countries when the spillover effects are internalized by the central authority.

2.6.2 Quantifying Coordinated Fiscal Rule for WAEMU Countries

I use the calibrated parameters in Table 2.1 to evaluate the coordinated fiscal rule; the results are summarized in Table 2.5. The country-specific coordinated fiscal rule optimally provides, in comparison with the maximum of 3% deficit limit, a large deficit limit for Benin and Mali, a medium deficit limit for Senegal, Niger, Togo, Côte d'Ivoire, and Guinea Bissau, and a small deficit limit for Burkina Faso. Comparing those rules to the current 3% deficit limit, only Burkina Faso is given less flexibility while more discretion is given to Benin, Mali, Senegal, and Niger. The rule provides the tightest maximum deficit limit to Burkina Faso (2%) and the loosest maximum deficit limit to Benin (12%). Moving from the current fiscal rule to the country-specific joint rule would benefit the union. Moving from the maximum of 3% deficit limit rule to the optimal country-specific coordinated rule would improve not only the welfare of the citizens of each country but also the welfare of the whole union's citizens. More specifically, the citizenry of Guinea Bissau would be willing for an increase of about 1.9% of government expenditures each year for the adoption of that country-specific rule. The smallest willingness to increase government spending goes to Senegal citizenry with an annual increase of 0.05%.

The equilibrium interest rate associated with the coordinated fiscal rule is 6.8% a year. This implies that internalizing the impact of a WAEMU's country fiscal decisions to the other members rise the interest from 5% to 6.8%. This level of interest rate reflects the net effect of redistributive and disciplining effects. The increase in the interest rate reflects that it is optimal to give more flexibility to some governments (especially those experiencing high shocks) to increase the fiscal

discipline in the union (especially for governments experiencing low shocks).

As a robustness check, I evaluate the coordinated fiscal rule by considering that all the union countries experience the same political-economic or monetary-economic frictions. The results in Table B.6.2 are consistent with the results I obtain for heterogeneous frictions among the governments. Besides, I evaluate the constrained uniform coordinated fiscal rule and compare it to the country-specific coordinated fiscal rule. It turns out that constraining the countries to a uniform rule forgoes 24% of welfare that would be achieved with a country-specific fiscal rule. The result suggests that the union would be better off by taking into account the specificity of each country while designing the coordinated fiscal rule.

The main message when comparing the coordinated and the uncoordinated fiscal rule is that the spillover effects matter for the design of the rule for the union. First, the interactions of the fiscal practices of members of the union induce an increase in the regional interest rate. Second, internalizing the spillover effects implies a more lax fiscal rule for WAEMU countries than the uncoordinated rule. Those results suggest that it would be more beneficial to increase the flexibility for the government of WAEMU.

The reason why the coordinated fiscal rule is less restrictive than the uncoordinated one is the following. The difference between coordinated and uncoordinated fiscal rules is that the central authority designs the coordinated rule by taking into account the effect of governments' fiscal behavior on the interest rate. Intuitively, because a fiscal rule effectively lowers the demand for borrowing, it also lowers the interest rate. A lower interest rate exacerbates the political economy tension because members are even more tempted to give in to their present bias when the interest rate is lower. My results show that the coordinated fiscal rule increases the interest rate compared to the uncoordinated fiscal rule. From the rationale I described, the higher interest rate lowers the political economy tension that leads to a less stringency coordinated fiscal rule.

My results show also that, from the uncoordinated fiscal rule to the coordinated one, the relative stringency of fiscal rules between some countries flips. The reason why it flips is that countries have different sensitivities to the general equilibrium effects. The heterogeneity in sensitivities across members of the union results from the calibration which estimates the degree of risk aversion which in turn governs the elasticity of intertemporal substitution. Countries that tend to have a deficit that responds a lot to shocks are also the ones that are more sensitive to the general equilibrium effects.

Table 2.5: Optimal coordinated fiscal rule

	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	**12.40**	**2.11**	**3.21**	**2.98**	**9.79**	**4.19**	**5.22**	**3.33**
Λ	**0.019**	**0.581**	**0.656**	**1.875**	**0.000**	**0.263**	**0.050**	**0.575**

Note.– The table shows the maximum deficit limit (DL) in % and the welfare government spending equivalent variation (Λ) in % with each government degree of present bias ($1-\delta$). BEN stands for Benin, BFA for Burkina Faso, CIV for Côte d'Ivoire, GNB for Guinea Bissau, MLI for Mali, NER for Niger, SEN for Senegal, and TGO for Togo. Source: The author's calculations

2.7 Conclusion and Extension

This chapter evaluates the current uniform fiscal rule for the West African Economic and Monetary Union (WAEMU) and proposes avenues for reforms. The current main fiscal rule in place in WAEMU is a maximum of 3% deficit limit rule. I start by documenting that the countries in this union are heterogeneous in their fiscal needs and their fiscal implementation. I find that, compared to a counterfactual scenario of a no-rule situation, all the union countries would benefit from enforcing the uniform fiscal rule of a maximum of 3% deficit limit. However, we could even do better than the uniform rule in place.

The reform to the current fiscal rule is a country-specific rule. When the rule-making authority considers each country as a small open economy, constraining the union member to the same fiscal rule would forgo 37% of the welfare that could have been achieved with a country-specific rule. On the other side, if the rule-making authority internalizes the spillover effects of the governments' members of the union behaviors when designing the rule, the country-specific fiscal rule would still increase the union's welfare by 32% of the welfare of the union under a constrained uniform rule.

My results suggest that the spillover effects matter for the design of the fiscal rule in WAEMU countries. This reinforces the necessity of coordination of the rule for the union. Indeed, more flexibility is required for governments when the spillover effects are considered in designing the rules.

In this chapter, I assess the welfare improvement of the country-specific rule over the constrained uniform rule through the utility gains and costs of my model. For that, I ignore the costs the implementation of the country-specific rule implementation could generate and the benefit of the simple uniform rule. I am aware that the implementation of the country-specific rule could politically challenging. Still, with regard to the welfare implication of country-specific rules in economic unions deserves careful attention from researchers as well as from political institutions.

One direction for this work would be to investigate the enforcement problems of fiscal rule in economic and monetary unions. As the unions are composed of independent countries, finding a unanimous enforcement mechanism is challenging. Note that the outcomes of this study are based on the perfect enforcement assumption.

References

Amador, M. and K. Bagwell (2013): "The theory of optimal delegation with an application to tariff caps," *Econometrica*, 81, 1541–1599.

Amador, M., I. Werning, and G.-M. Angeletos (2006): "Commitment vs. flexibility," *Econometrica*, 74, 365–396.

Ambrus, A. and G. Egorov (2013): "Comment on "Commitment vs. flexibility"," *Econometrica*, 81, 2113–2124.

Athey, S., A. Atkeson, and P. J. Kehoe (2005): "The optimal degree of discretion in monetary policy," *Econometrica*, 73, 1431–1475.

Basdevant, O., P. A. Imam, M. T. Kinda, and M. A. Zdzienicka (2015): *Strengthening the West African Economic and Monetary Union: The role of fiscal and market institutions in economic stabilization*, International Monetary Fund.

Buiter, W., G. Corsetti, and N. Roubini (1993): "Excessive deficits: sense and nonsense in the Treaty of Maastricht," *Economic policy*, 8, 57–100.

Chari, V. V. and P. J. Kehoe (2004): "On the desirability of fiscal constraints in a monetary union," .

David, M. A., A. Nguyen-Duong, and H. Selim (2022): *Strengthening the WAEMU Regional Fiscal Framework*, International Monetary Fund.

Davoodi, H. R., P. Elger, A. Fotiou, D. Garcia-Macia, X. Han, A. Lagerborg, W. R. Lam, and P. A. Medas (2022): "Fiscal Rules and Fiscal Councils: Recent Trends and Performance during the COVID-19 Pandemic," *IMF Working Paper*.

Dessus, S., J. L. Diaz-Sanchez, and A. Varoudakis (2016): "Fiscal rules

and the pro-cyclicality of public investment in the West African Economic and Monetary Union," *Journal of international development*, 28, 887–901.

Grauwe, P. d. (1992): "The economics of monetary integration," *Paul de Grauwe*.

Halac, M. and P. Yared (2014): "Fiscal rules and discretion under persistent shocks," *Econometrica*, 82, 1557–1614.

——— (2018): "Fiscal rules and discretion in a world economy," *American Economic Review*, 108, 2305–34.

Hamada, K. (1985): *The political economy of international monetary interdependence*, Cambridge, Mass.: MIT Press.

Jackson, M. O. and L. Yariv (2014): "Present bias and collective dynamic choice in the lab," *American Economic Review*, 104, 4184–4204.

——— (2015): "Collective dynamic choice: the necessity of time inconsistency," *American Economic Journal: Microeconomics*, 7, 150–78.

Kenen, P. B. (1995): *Economic and monetary union in Europe: Moving beyond Maastricht*, Cambridge University Press.

Sublet, G. (2023): "Fiscal Rules with Discretion for an Economic Union," *Working Paper*.

Chapter 3

Roadblocks, Time Delays and Bribery on Interstate Roads: the Effects on Regional Trade Integration in West Africa*

Individual contribution.– This chapter co-authored with Idossou Marius Adom assesses the effects of roadblocks, time delays, and bribes, occurring on interstate highways, on the regional trade integration in West Africa. The research of this chapter is conducted in a very collaborative way. The contribution of each author is transversal and is about 50/50.

3.1 Introduction

It is a well-known fact that regional trade within Africa is low compared to other regions in the world. The share of regional exports in Sub-Saharan Africa's total exports increased from 6% in 1980 to barely below 20% in 2016. That represents more than tripling over the period, and the region now has the highest share of intraregional trade integration among the world's emerging markets and developing economies. But compared with advanced economies, intraregional trade nonetheless remains relatively low (Arizala, Bellon, and MacDonald, 2018). According to the United Nations Conference on Trade and Development, intra-Africa

*This chapter is co-authored with Idossou Marius Adom who I really thank for his professionalism.

trade represents only 12.7% in 2021 against 68.5% in Europe and 58.5% in Asia.[2] Concerned with the situation, African countries established, in 2018, the African Continental Free Trade Area (AfCFTA) with the goal of eliminating tariffs and non-tariff barriers to trade.[3]

There are many reasons why intra-African trade is low. According to Longo and Sekkat (2004), besides traditional gravity variables, poor infrastructure, economic policy mismanagement and internal political tensions have a negative impact on trade among African countries. They additionally argue that, except for political tensions, the identified obstacles are specific to intra-African trade, since they have no impact on African trade with developed countries. In the same logic Njinkeu, Wilson, and Fosso (2008) examine the role of improved customs, regulatory environments, and upgrading services infrastructure on trade between African countries and find that improvement in ports and services infrastructure promise relatively more expansion in intra-African trade than other measures. Amoah (2014) also found a similar result, showing that infrastructure improvement by a trade partner of Ghana in Africa can improve significantly Ghana's trade. Kaminchia (2020) analyze the effects of improvement of transit roads' quality in the East African Community (EAC) and find that it lowered both domestic and cross-border trade costs and that the latter effect is larger than the former. This paper contributes to the literature by investigating the effect of some observed dubious practices – bribery and delays – on eight interstate roads in West Africa on bilateral trade. We document that roadblocks, delays and bribes are pervasive on West African interstate roads. During goods transportation, trucks experience up to more than 25 controls, are delayed by up to more than 5 hours and pay between 45 and 115 US dollars in bribes. Our empirical analyses show that the delays seriously impede bilateral trade between West African countries while corruption tend to match the "grease the wheels" theory.

This paper is related to the literature on the effects of corruption on trade. It is widely admitted that corruption negatively affects the macroeconomy – that is the so-called "sand the wheels" effect (Mauro, 1997; Gyimah-Brempong, 2002; Dincer and Gunalp, 2005; d'Agostino, Dunne, and Pieroni, 2016; Dimant and Tosato, 2018). But there are also channels through which corruption can positively affect the macroeconomy and trade. The so-called "grease the wheels" effect is also supported by a number of research works (Dreher and Gassebner, 2013; Dimant and Tosato, 2018). Musila and Sigué (2010) argue that efficiency-improving cor-

[2] `https://hbs.unctad.org/trade-structure-by-partner/` (accessed on 2023-04-12).
[3] `https://au-afcfta.org/about/`

ruption can lead to an increase in international trade when bribes may enable individuals to bypass bureaucratic delays or when resource-transferring bribes replace queuing costs. Their empirical analysis shows however that corruption in African countries has adverse effects on export and import trade. On the other hand, Socrates, Moyi, and Gathiaka (2020) support that a high level of corruption increased export survival rates in Kenya. But Majeed (2014) argues that the relationship between trade and corruption is non-monotonic. For Gil-Pareja, Llorca-Vivero, and Martínez-Serrano (2019), the result depends on the measurement of corruption. When perception-based indexes of corruption are used they find a non-generalized negative effect of corruption on trade, but with a structural model-based index of corruption, they find sensible evidence for the "grease the wheels" hypothesis when low and middle-income countries (which are those with weak institutions and high regulations) are implicated. de Jong and Bogmans (2011) use measures of trade-related corruption to investigate the effects of corruption on international trade and compare the results with those of corruption in general, distinguishing between corruption in an exporting economy and that in an importing economy. Both distinctions appear to be important. Corruption in general hampers international trade, whereas bribes paid to customs enhances imports.

We also contribute to the literature on the effects of delays on trade. Based on US import data, Hummels and Schaur (2013) famously estimate that each day in transit is equivalent to an advalorem tariff of 0.6 to 2.1 percent. According to the results of de Jong and Bogmans (2011), high waiting times at the border significantly reduce international trade. Puzzled by the collapse of world trade during the financial crisis of 2008 and 2009 and why it was much larger than the fall in world GDP and demand, Berman, de Sousa, Martin, and Mayer (2013) document that the fall in trade caused by financial crises is magnified by the time- to- ship goods between the origin and the destination country. Djankov, Freund, and Pham (2010) analyze data on the days it takes to move standard cargo from the factory gate to the ship in 98 countries and find that each additional day that a product is delayed prior to being shipped reduces trade by more than 1%, which is equivalent to a country distancing itself from its trade partners by about 70 km on average. The effect is even greater for time-sensitive goods, such as perishable agricultural products. Sant' Anna and Kannebley Júnior (2018) estimate the impacts of turnaround time on the volume of Brazilian exports and the number of categories of exported products. According to their results, each relative additional hour of delay in the average port is equivalent to a reduction of nearly 2% in rel-

ative local exports, and a 10% reduction in relative turnaround time can increase the relative number of exported product categories by around 1%. Plane (2021) studies the domestic costs of delivering an imported container from its arrival at an African seaport to its final destination and found that abnormal processing times matter for most sub-regions, especially for Central Africa. Socrates et al. (2020) also find that time to export is a significant determinant of firms' survival in the export market in Kenya, corroborating Berman et al. (2013), who found that the probability to exit and cease exporting is amplified by time-to-ship. On the other hand, Vijil, Wagner, and Woldemichael (2019) find that uncertainty in the time to clear imported inputs impacts neither the entry nor the exit rate but translates into lower survival rates for new exporters. Other papers show that time delays and uncertainty make firms import less frequently and build inventory (Alessandria, Kaboski, and Midrigan, 2010; Alessandria, Khan, and Khederlarian, 2021; Carreras-Valle, 2021).

In this paper, we use directly measured trade-related roadblocks, bribery and time delays on eight interstate roads in Western Africa between 2006 and 2013 to investigate their effects on bilateral trade in the region. These interstate roads connect three landlocked countries – Burkina Faso, Niger and Mali – to other coastal countries. The novelty of the data and the countries we study constitute a significant contribution to the literature.

The rest of the paper is organized as follows. In section 3.2 we set up a model theory to guide intuition about the expected effect of corruption and delays on bilateral trade. As regards corruption, the model is consistent with the "sand the wheels" view. Based on the model, we discuss our empirical strategy to investigate the effects of bribery and time delays on interstate roads on bilateral trade in West Africa in section 3.3. Section 3.4 presents the data we use, and section 3.5 our findings. We conclude in section 3.6.

3.2 Theory

In this section, we propose a theoretical model whose mechanisms guide intuition about the expected effects of corruption and delays on bilateral trade. We base on the existing literature and adopt the "sand the wheels" view of corruption as a hypothesis. Our model builds on Hummels and Schaur (2013) and Berman et al. (2013).

3.2.1 The model

We consider a world economy with N countries trading with each other. A firm can potentially export from a home country to many other countries. Let d denote any destination country. We assume that local and imported goods in the destination country d are differentiated, and exporters are subject to monopolistic competition. Home countries that export goods to destination d are indexed by the total time s it takes for the goods to arrive. We are interested in what happens during inland cross-border transportation of goods in West Africa. As the data show in section 3.4, drivers are subject to many checkpoints, bribery, and time delays on interstate highways. So we posit that s is the sum of two components as in equation (3.1). The first component s_n is the normal shipping time, determined by geography, i.e. by the distance between the origin and destination countries. The second component s_b captures the loss of time due to often redundant inspections, customs procedures, and corruption.

$$s = s_n + s_b \tag{3.1}$$

A representative consumer in country d chooses from the set of varieties $\mathcal{S}$, where $s = 0 \in \mathcal{S}$ corresponds to local good. The demand x_d^s for each variety s in country d is derived by maximizing the consumer's utility of the Dixit-Stiglitz type below.

$$\begin{aligned} \max_{x_d^s} & \left(\int_{s \in \mathcal{S}} \lambda(s) (x_d^s)^{\frac{\sigma-1}{\sigma}} \, ds \right)^{\frac{\sigma}{\sigma-1}} \\ s.t. & \int_{s \in \mathcal{S}} p_d^s x_d^s \, ds \leq P_d Y_d, \end{aligned} \tag{3.2}$$

where σ represents the elasticity of substituability between varieties, p_d^s the price set by the exporter of the variety s sold in destination d, P_d the aggregate price index in country d and Y_d the aggregate production in country d such that $P_d Y_d$ represents the income of the consumer in country d. $\lambda(s)$ is a decreasing function of s that captures the valuation of delivery time by the consumer. So, the consumer prefers quicker delivery as in Hummels and Schaur (2013). The demand for variety s in destination country d is as follows.[4]

$$x_d^s = Y_d \left(\frac{\lambda(s) P_d}{p_d^s} \right)^{\sigma} \tag{3.3}$$

[4]See appendix C.1.1 for details of derivation.

In the home country s, we assume that labor is the only production factor as is often the case in international trade models (Melitz, 2003; Berman et al., 2013). Thus, an exporter shipping goods from country s to country d faces a demand x_d^s from that country, and chooses his price p_d^s to maximize the present value of profit V_d^s. The exporter problem is defined as follows.

$$V_d^s = \max_{p_d^s} p_d^s x_d^s - \phi(s)(w+\tau)x_d^s \tag{3.4}$$
$$s.t. \quad x_d^s = Y_d \left(\frac{\lambda(s) P_d}{p_d^s} \right)^{\sigma},$$

where w is the labor cost per unit of production, and τ represents the average bribery per unit of goods shipped. In fact, the data in section 3.4 show that significant amounts of bribes are extorted from drivers conveying goods on interstate highways in West Africa. $\phi(s)$ in an iceberg cost increasing in the shipping time s. As in literature, $\phi(s) \geq 1$ so that for one unit of good ordered the exporter ships $\phi(s)$. The fraction $\phi(s) - 1$ of the goods is lost during the shipping. In our setting, this fraction increases with the duration of delivery.

Solving the exporter's profit maximization problem stated in equation (3.4), we obtain the following optimal price and export quantities.[5]

$$p_d^s = \frac{\sigma}{\sigma - 1}(w+\tau)\phi(s) \tag{3.5}$$

$$x_d^s = Y_d P_d^{\sigma} \left[\frac{(\sigma - 1)}{\sigma(w+\tau)\phi(s)} \cdot \lambda(s) \right]^{\sigma} \tag{3.6}$$

3.2.2 Predictions of the model

The simple and tractable model we set above delivers interesting predictions about competitiveness and bilateral trade between partner countries.

Time delay, bribery, and competitiveness.– Trade competitiveness is the ability to sustainably supply quality goods at a lower price. Lack of competitiveness is often pointed out when it comes to the relatively low trade between African countries (Valensisi and Lisinge, 2013; United Nations, 2022). But analyses of this type generally refer to low productivity of firms. However, our model shows in a tractable way that bribery and delays during shipping can also undermine the

[5] See appendix C.1.2 for details of derivation.

competitiveness of exporters. This is shown in equation (3.5). Indeed, the price charged by an exporter is a markup over the marginal cost of the product, which includes not only the wage bill of production but also bribery and delay costs incurred during shipping. To the extent that corruption and time delays are pervasive on West African interstate highways, competitiveness is undermined and trade is reduced ultimately.

Time delay, bribery, and trade volume.– From our model, the equilibrium quantity on the export market is negatively related to bribery and delays during shipping (equation (3.6)). The negative effect of bribery is indirect and seeps in through the price charged by the exporter. It is a consequence of the competitiveness effect. Therefore, normal production cost (w) and delivery delays ($\phi(s)$) also deter quantities by deteriorating competitiveness. This price effect depends on the elasticity of export demand. On the other hand, the equilibrium quantity is further negatively affected by the distaste of the consumer at the destination country for long shipping. That is because $\lambda(s)$ is decreasing in s. From equation (3.3), we notice that the consumer demand for a variety is negatively related to the time before delivery and positively related to the price ratio P_d/p_d^s.

In sum, this theoretical framework suggests that heavy time delays and bribery on interstate highways can undermine competitiveness and hamper trade. Next, we aim to quantify the effect, if any, of delays and bribery on West African interstate roads on bilateral trade. Our empirical strategy laid out in section 3.3 builds on the theoretical framework.

3.3 Empirical strategy

The main goal of this paper is to quantify from the data the effects, if any, of delays and bribery on West African interstate highways on bilateral trade between connected countries. In this section, we derive an empirical strategy to achieve this goal from the theoretical model we just presented. We start by taking the logarithm of equation (3.6):

$$\log(x_d^s) = \log(Y_d) + \sigma \log(P_d) + \sigma \log\left(\frac{\lambda(s)}{\phi(s)}\right) - \sigma \log(w+\tau) + \sigma \log\left(\frac{\sigma-1}{\sigma}\right) \quad (3.7)$$

Taking into account equation (3.1), we now expand equation (3.7) to the form of a standard gravity equation. We additionally include country and time-fixed effects. Thus, our estimation equation is as follows:

$$\log(X_{ijt}) = \mu_j + \eta_t + \alpha_1 \log(Y_{jt}) + \alpha_2 \log(\frac{P_{it}}{P_{jt}}) + \gamma_1 \log(Dist_{ij}) + \gamma_2 \log(s_{b,ijt}) + \tag{3.8}$$
$$\theta \log(NbCtrl_{ijt}) + \lambda \log(\tau_{ijt}) + \beta_1 Z_{1,it} + \beta_2 Z_{2,jt} + \epsilon_{ijt},$$

where subscripts i, j, and t stand respectively for origin country, destination country, and year. X is aggregate export, Y is GDP, and P is the price index. μ and η are respectively country and year fixed effects. $Dist$ is the distance between origin and destination countries, used to instrument for the *normal* shipping time s_n between the two places, $NbCtrl$ the number of control points on the road between places i and j, and ϵ an error term. Finally, Z is a vector of possible additional control variables.

Endogeneity and identification.– Our coefficients of interest are γ_2, θ and λ. They capture respectively the effect of delays, the number of controls, and bribes on the roads. Those are arguably exogenous since they result mostly from administration organization, governance, and culture, and from lack of infrastructure and adequate technology (Ocean Shipping Consultants, Ltd., 2008; Djankov et al., 2010; Barka, 2012; Montagnat-Rentier and Parent, 2012; The World Economic Forum and The Global Alliance for Trade Facilitation, 2016) One can still worry about the risk of reversal causality: more bilateral trade implies more traffic on the roads, which in turn can lead to more controls, delays, and bribes. However, that is unlikely because traffic is not that busy on those interstate roads. Yet, in a robustness exercise, we instrument controls, delays, and bribes with their respective lags.

To avoid the bias of omitted variables that can lead to endogeneity we consider in Z control variables that the existing literature considers as important for trade: common language, contiguity, tariffs, and being a member of an economic union. All the countries in our data except Ghana are French-speaking and members of the West African Economic and Monetary Union (WAEMU), and all the pairs share a common border. WAEMU countries don't apply tariffs among themselves but had common tariffs toward other countries since 2001. Thus, these control variables are all perfectly correlated in our sample. Then we just use one: a common language. Besides, we include a fixed effect of time and country or corridor. These capture the effect of any omitted variable specific to countries and corridors. Finally, the estimation errors in our regressions are robust to heteroskedasticity and clustered either by corridor or reporter country.

3.4 Data

Our empirical analysis uses data from various sources, including Improved Road-Transport Governance (IRTG), Trade Map from the International Trade Centre (ITC), the World Development Indicators (WDI) from the World Bank, and GeoDist from The CEPII.

3.4.1 Data sources

IRTG data.– We rely on the Improved Road-Transport Governance (IRTG) reports to construct a novel data set that measures trade-related roadblocks, delays, and bribes on interstate highways in Western Africa. IRTG is an initiative jointly set up by the Economic Community of West African States (ECOWAS) and the West African Economic and Monetary Union (WAEMU), on interstate roads, with the financial support of the U.S. Agency for International Development (USAID) through its West Africa Trade Hub/Accra (WATH/A), and of the Sub-Saharan African Transport Program financed principally by the World Bank. Its goal is to quantify the number of roadblocks on a given corridor, corridors with the highest number of barriers, total bribes paid, and length of delays at those roadblocks, and to know who is responsible. To this end, survey data were collected on a quarterly basis from October 2006 until June 2013.[6] Trained IRTG agents distribute data-collection sheets to drivers in ports (or inland ports). They choose only drivers with trucks in good condition (according to legal standards) and with paperwork in order. Their counterparts at the other end of the corridor collect the completed data-collection sheets from drivers completing their journeys. If the agents judge the data reliable, they computerize it and send it to the Information Technology Department of the WAEMU Commission for analysis. Thus, the survey approach is robust and tried to avoid gross measurement errors. We collect the data from the annexes of individual IRTG reports from the first to the 24th accessed on the Borderless Alliance website [7]. The data covers eight corridors linking eight countries. Table 3.1 and Figure 3.1 present the roads. Overall, the data is an unbalanced panel at corridor and country levels.

[6]Maybe the IRTG project expands beyond June 2013. But the last report we are able to get is the 24th on that date.

[7]`https://borderlesswa.com/publications/`, under "Road Governance Reports". Accessed on April 15, 2023.

Table 3.1: IRTG corridors

# corridor	**Corridor name**	**Partner 1**	**Partner 2**	**Length of corridors in Km**
1	Abidjan-Bamako	Côte d'Ivoire	Mali	1174
2	Ougadougou-Abidjan	Burkina-Faso	Côte d'Ivoire	1263
3	Bamako-Dakar	Mali	Senegal	1365
4	Ougadougou-Bamako via Heremakono	Burkina-Faso	Mali	934
5	Ougadougou-Bamako via Koury	Burkina-Faso	Mali	1035
6	Cotonou-Niamey	Benin	Niger	1041
7	Ougadougou-Lomé	Burkina-Faso	Togo	1020
8	Ougadougou-Tema	Burkina-Faso	Ghana	992

Figure 3.1: IRTG road map

Source: IRTG 22^{nd} report.

Trade Map and WDI data.– The Trade Map and the WDI data sets are well-known and widely used. We draw bilateral and total trade data (imports and exports) from the Trade Map, while aggregate variables like GDP, inflation rate, and population are provided by the WDI. These are at an annual frequency.

GeoDist.– Finally, we get data on the distance between countries from the GoeDist database of the CEPII. [8]

3.4.2 Summary statistics

Controls, delays, and bribes on the roads.– According to the IRTG data, controls, delays and bribes are pervasive on West African interstate roads or corridors. The average number of controls a goods truck undergoes between 2006 and 2013 ranges from 12.5 on the Cotonou-Niamey corridor to 26.25 on the Ouagadougou-Bamako via Hermakono corridor. This amounts to two to three controls every hundred kilometers on most of the roads (Figure 3.2).

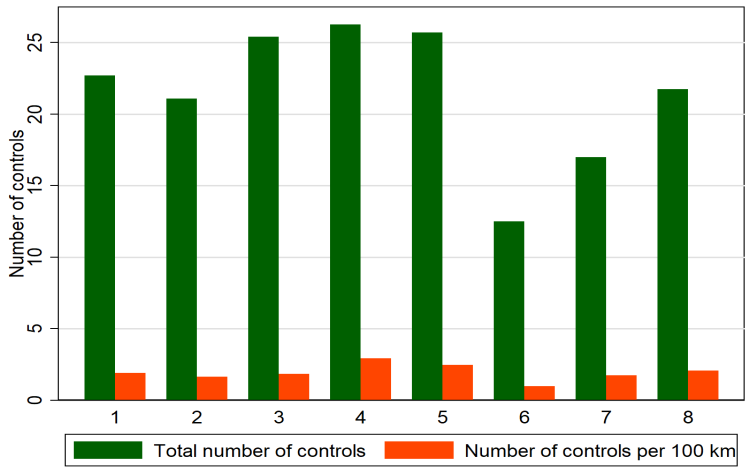


Figure 3.2: Average total control on West African interstate roads between 2006 and 2013

Notes.- The Figure represents the number of controls on interstate roads (corridors) 1 to 8 between 2006 and 2013. Corridor 1 is Abidjan-Bamako, 2 Ougadougou-Abidjan, 3 Bamako-Dakar, 4 Ouagadougou-Bamako via Heremakono, 5 Ougadougou-Bamako via Koury, 6 Cotonou-Niamey, 7 Ouagadogou-Lomé, and 8 Ouagadogou-Tema.

Of course, these multiple and often redundant controls generate delays during the transportation of goods. The average total related delay in the same period varies from 114 minutes on the Cotonou-Niamey corridor to 321 minutes on the Bamako-Dakar corridor. Put differently, trucks get delayed 11 to 32 minutes every hundred kilometers (Figure 3.3). If the average speed of trucks on the roads is 70

[8] `http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=6`

km/h, the delays are equivalent to the connected countries being distanced from each other by some 133 to 374 more kilometers.

Controls and delays are also opportunities for corrupt uniformed officers to collect bribes. IRTG data provide a measurement of unlawful payments on the roads. To rule out legal penalties, the surveys selected only truck drivers that had their papers in order and whose truck is in good condition. The data show, as in Figure 3.3, that bribes on the road can reach significant amounts. The average bribe per trip between 2006 and 2013 is about 20 thousand Francs CFA ($US 45) on Cotonou-Niamey, Ouagadougou-Lomé, and Ouagadougou-Tema corridors. That is about 5% of the average yearly GDP per capita in the eight countries in the same period, or 70% of the monthly minimum wage in Togo in 2018. On the five remaining corridors, the average bribe per trip over the period ranges between 40 thousand Francs CFA ($US 90) and 52 thousand Francs CFA ($US 115). Put differently, these bribe figures represent 10 to 13 percent of the average yearly GDP per capita in the eight countries in the same period, or 1.4 to 1.8 times the monthly minimum wage in Togo in 2018.

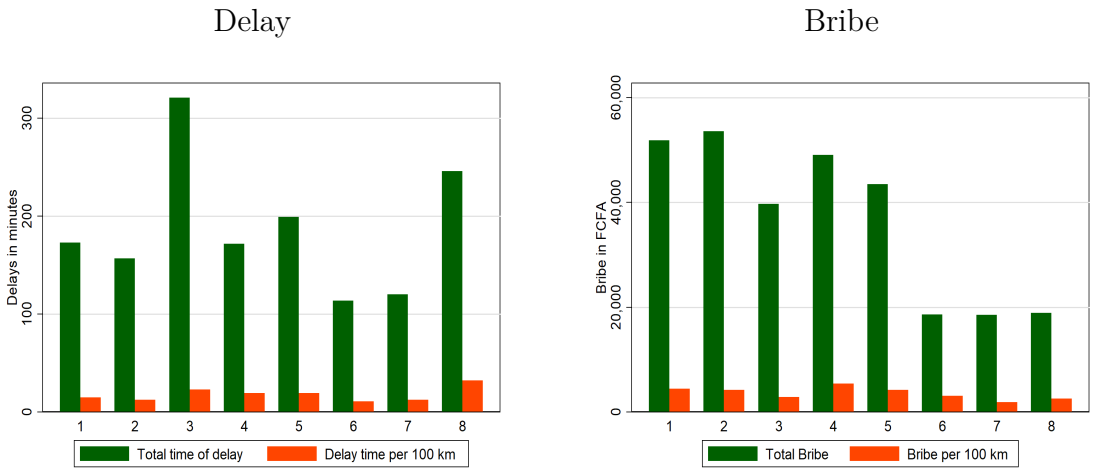


Figure 3.3: Average total delay and bribe on West African interstate roads in 2006-2013

Notes.- The Figure represents the number of controls on interstate roads (corridors) 1 to 8 between 2006 and 2013. Corridor 1 is Abidjan-Bamako, 2 Ougadougou-Abidjan, 3 Bamako-Dakar, 4 Ouagadougou-Bamako via Heremakono, 5 Ougadougou-Bamako via Koury, 6 Cotonou-Niamey, 7 Ouagadogou-Lomé, and 8 Ouagadogou-Tema. Bribe is presented in Franc CFA, the local currency of the countries, except Ghana whose currency is the Cedi. Based on the IRGT reports, we use the exchange rates $US 1 = 450 FCFA, and $US 1 = 1.24 Cedi. Source: IRTG reports and the authors' calculations.

Figures 3.4 and 3.5 decompose the controls, delays, and bribes by country. They show that controls are most pervasive in Côte d'Ivoire, Ghana, Mali, Senegal, and Togo. Delays are the longest in these countries, except Togo. The amount of bribes is by far the most important in Côte d'Ivoire, followed by Mali and Senegal.

In Figure 3.6, we show the proportions of controls and bribes by uniformed service. It appears that customs are responsible for 34% of controls and 33% of bribes. They are followed by the police service for 31% of controls and 26% of bribes. The remaining is accounted for by the gendarmerie (21% of controls and 19% bribes) and other undefined services.

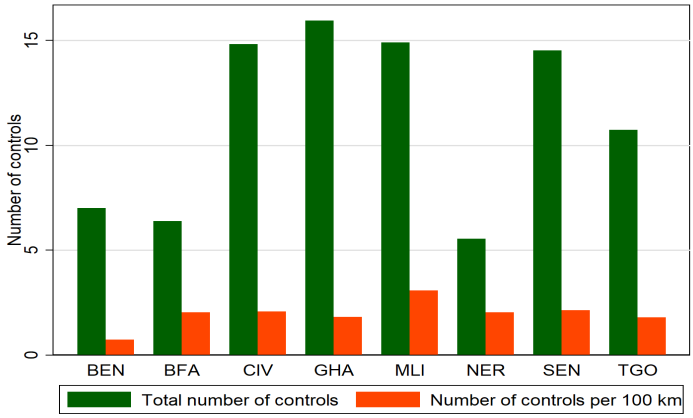


Figure 3.4: Average total control on West African interstate roads between 2006 and 2013

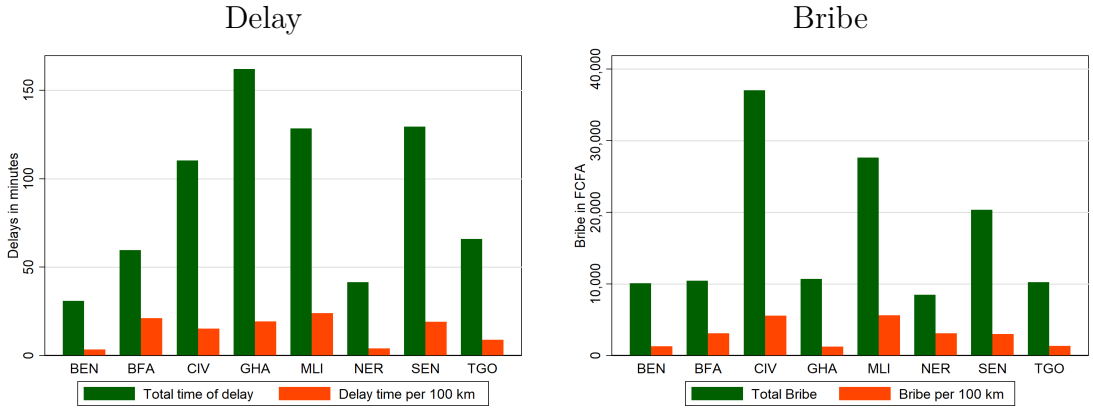


Figure 3.5: Average total delay and bribe on West African interstate roads between 2006 and 2013 by country

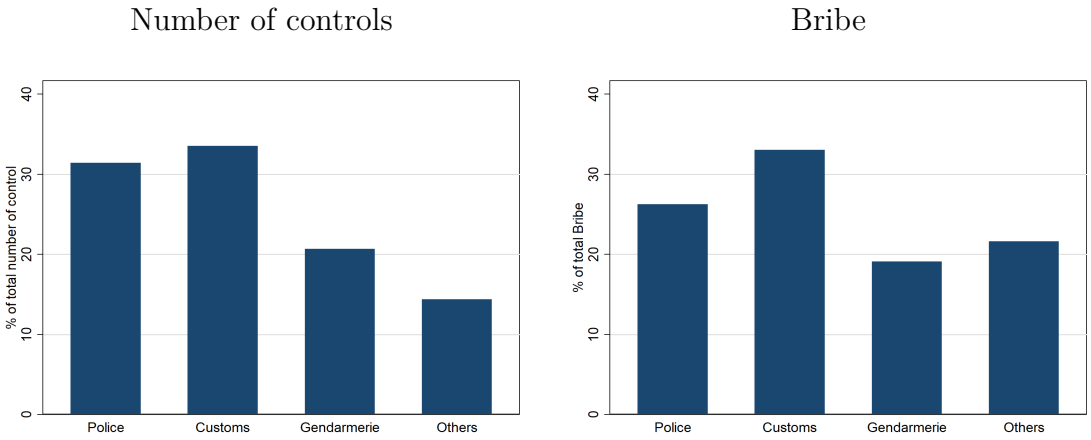


Figure 3.6: Average total delay and bribe on West African interstate roads between 2006 and 2013 by uniformed service

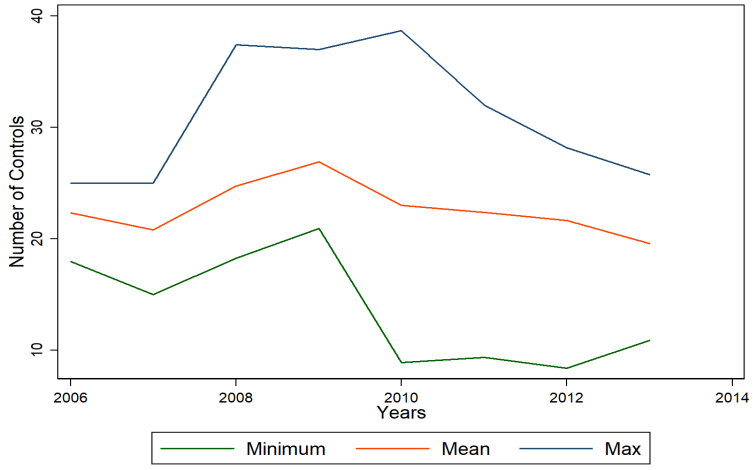


Figure 3.7: Evolution of the number of control on West African interstate roads in 2006-2013

The evolution of trends over time does not show significant improvements either. In Figure 3.7, the number of controls has increased on the roads from 24 to 27 between 2006 and 2009. From 2010 we observe a decrease, but the average number of controls is only a little lower in 2013 than it was in 2006. On the other hand, delays and bribes increased between 2008 and 2011 before they decreased to the levels they were in 2006 (Figure 3.8).

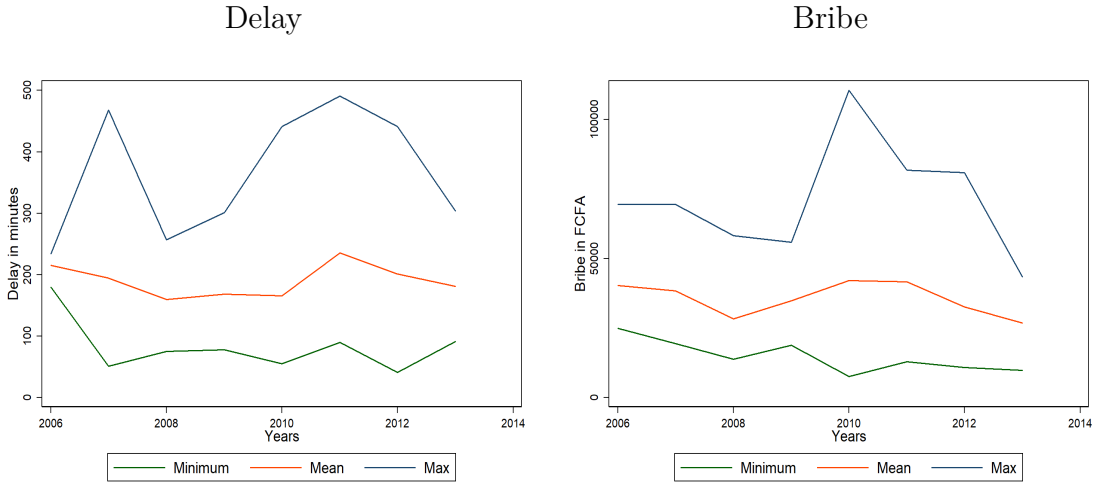


Figure 3.8: Evolution of delay and bribe on West African interstate roads in 2006-2013

Trade.– In our empirical analysis, we estimate the effect of controls, delays, and bribes on the West African interstate roads on bilateral trade between the connected countries.We provide here some summary statistics about bilateral trade. Figure 3.9 shows the average volume of trade with the rest of the world for the eight countries, and the average proportion of bilateral trade. We measure the volume of trade for each country as the half sum of imports and exports with the rest of the world; and we define bilateral trade as the half sum of imports and exports between pairs of countries connected by the corridors (see Table 3.1). The dashed line in the figure shows that there is an increasing trend of trade during the period 2006-2013. Similarly, the solid line shows that the average share of bilateral trade flow in the countries' total trade with the rest of the world has slightly increased during the same period. However, bilateral trade between the countries remains relatively low as shown in Table 3.2. The pairs of countries that trade most are Mali and Senegal (8.5%), Burkina Faso and Côte d'Ivoire (6.2%), and Côte d'Ivoire and Mali (4.08%). The share of bilateral trade between Benin and Niger is less than 1%.

We next estimate econometric equations to assess whether controls, delays, and bribes observed on the roads contribute to lower bilateral trade between the countries.

Table 3.2: Bilateral trade share between 2006 and 2013

Partner 1	**Partner 2**	**Bilateral trade share in %**	
		Mean	**SD**
Côte d'Ivoire	Mali	4.08	2.72
Burkina-Faso	Côte d'Ivoire	6.20	4.90
Mali	Senegal	8.50	3.75
Burkina-Faso	Mali	1.28	0.65
Benin	Niger	0.95	0.81
Burkina-Faso	Togo	3.22	0.57
Burkina-Faso	Ghana	2.36	1.49

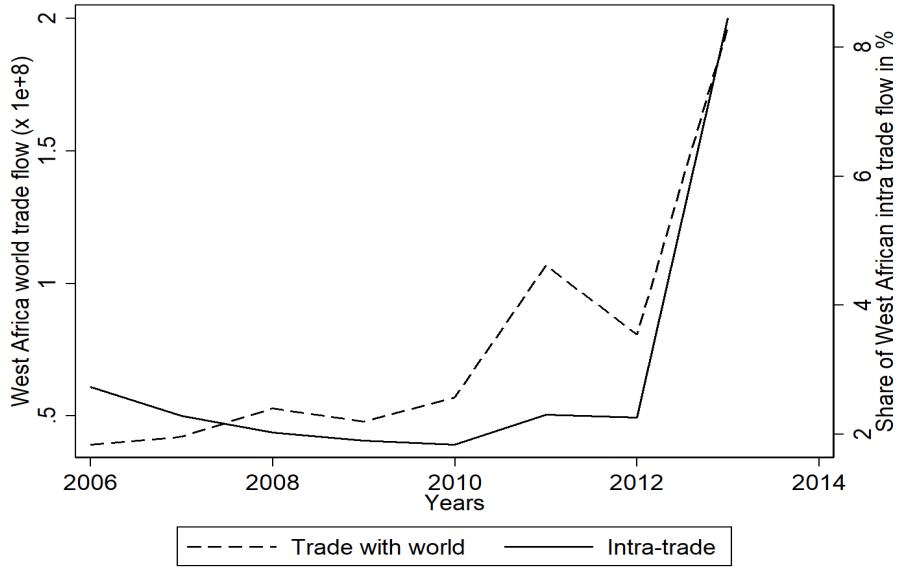


Figure 3.9: Evolution of Trade in West Africa

Note.- The Figure shows on the left y-axis the average volume of trade with the rest of the world for the eight countries our data covers. The volume of trade with the rest of the world is computed as half the sum of imports and exports with the rest of the world. On the right y-axis, the Figure shows the average proportion of bilateral trade in the total trade. Source: Trade Map data and the authors' calculations.

3.5 Estimations

The aim of this section is to quantify the effects of time delays and bribes on bilateral trade in West Africa. For this purpose, we consider two sets of estima-

tions. We find that, along the corridors, the delays on the interstate highways negatively and significantly affect the trade and the bribes appear to increase the trade while the number of controls have a positive but not significant impact on the trade. When we consider the unlawful practices in each section of the corridors, the delays in the origin countries negatively and significantly decrease the trade.

3.5.1 Impact of bribe and delay on West Africa Intra Trade

To assess the effects of roadblocks, delays, and bribes on trade across the eight West African countries in our data, we rely on the estimation of two kinds of panel equations. The first assesses the effects of roadblocks, bribes, and delays along the corridors, and the second, those effects on each side of the corridors.

Effects of roadblocks, delays and bribes on bilateral trade along corridors.– The panel equation estimated to assess the impact of poor and unlawful practices along the corridors is the following:

$$\begin{aligned}\log(X_{ijt}) = \mu_{ij} + \eta_t + \alpha_1 \log(Y_{jt}) + \alpha_2 \log(Y_{it}) + \varphi \log(\frac{P_{it}}{P_{jt}}) + \gamma_1 \log(Dist_{ij}) \quad (3.9)\\ + \gamma_2 \log(s_{b,ijt}) + \theta \log(NbCtrl_{ijt}) + \lambda \log(\tau_{ijt}) + \beta_1 Z_{1,it} + \beta_2 Z_{2,jt} + \epsilon_{ijt},\end{aligned}$$

where $\{X_{ijt}\}$ is the average of imports and exports across the pairs of countries that connect each corridor. Our variables of interest $\log(s_{b,ijt})$, $\log(NbCtrl_{ijt})$, and $log(\tau_{ijt})$ are the log of time delays, number of controls, and bribes along the interstate highways corridors in eight West African countries. We consider the first difference of all variables that have a trend including the dependent variable.

Table 3.3 displays the estimated parameters of interest of the equation (3.9). We made four estimations of this equation varying among the corridor fixed effect and the time fixed effect. It comes out that including the fixed effects increases the percentage of the variation of trade accounted for by the explanatory variables as indicated by the within coefficient of determination $(R - sq)$. The final estimate of our coefficients of interest is displayed in the last column of the table. The time delays on interstate highways negatively and significantly affect trade in West Africa. More specifically, everything else equal, a 1% increase in the time delays per 100 km will decrease bilateral trade growth by 1.24 percentage points. However, the bribes along the corridors positively impact bilateral trade supporting the "grease the wheels" theory of corruption. Indeed, everything else equal, an increase

of 1% of bribes on the highways will raise the bilateral trade by 0.822 percentage points. On the other hand, the impact of the number of control is positively low but non-significant on bilateral trade in West Africa.

Table 3.3: Regression on trade flows along corridors

	(1)	(2)	(3)	(4)
Log Bribe per 100 km Corr	0.969	0.110	1.027	0.822**
	(0.762)	(0.327)	(0.881)	(0.266)
Log Delay per 100km Corr	−0.444	0.168	−0.608	−1.240***
	(0.538)	(0.314)	(1.031)	(0.287)
Log Nb control per 100 km Corr	−1.181	0.653*	−1.114	0.019
	(1.100)	(0.338)	(1.602)	(0.183)
Observations	34	34	34	34
R-sq	0.023	0.123	0.350	0.600
Time fixed effects	No	No	Yes	Yes
Corridor fixed effects	No	Yes	No	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: log trade flows along corridors. The full estimates of these equations are reported in Table C.3.1 in the Appendix. In parenthesis are the robust and clustered standard deviations.

Bilateral trade and delay and bribe in each country.– After our investigations on how roadblocks, delays, and bribes along the corridors affect the trade, we aim to disentangle those effects across each country connected by the corridors. The panel equation we estimate for that purpose is the following:

$$\begin{aligned}\log(X_{ijt}) = \mu_i + \eta_t + \alpha_1 \log(Y_{jt}) + \varphi \log(\frac{P_{it}}{P_{jt}}) + \gamma_1 \log(Dist_{ij}) + \gamma_2 \log(s_{b,ijt}) \quad (3.10)\\ + \gamma_3 \log(s_{b,jit}) + \theta_1 \log(NbCtrl_{it}) + \theta_2 \log(NbCtrl_{jt}) + \lambda_1 \log(\tau_{ijt})\\ + \lambda_2 \log(\tau_{jit}) + \beta_1 Z_{1,it} + \beta_2 Z_{2,jt} + \epsilon_{ijt},\end{aligned}$$

Where the $\log(X_{ijt})$ is the log of either the exports or the imports of country i to or from country j. Our variables of interest s_b, τ, and $NbCtrl$ are split to account for the poor and unlawful practices occurring in each countryside of the corridors. We also take the difference of the variables that have a trend including the dependent variable.

The results of the estimate of our variables of interest when the dependent variable is the exports are reported in Table 3.4. As indicated by the within coefficient of determination ($R - sq$) the country-fixed effects and the time-fixed effects improve the percentage of variation of trade explained by the regressors. After controlling for the fixed effects, it turns out that only the delays that occurred in the origin country of exportation impacts significantly the bilateral trade. More specifically an increase of delay time by 1% per 100 km, everything else equal, will lower the export growth of origin countries along corridors by 1.19 percentage points. The number of controls in the origin countries also has a negative, though non-significant, effect on exports. The bribes in the destination countryside have a positive but non-significant effect on exports.

To assess the impacts of roadblocks, delays, and bribes on imports we estimate the equation (3.10) with imports as the dependent variable. The estimates for our variables of interest reported in Table 3.5 show that the effects of time delays and roadblocks in the destination country on imports are negative but not significant. More generally, none of the variables of interest is significant in this regression.

Table 3.4: Exports regressions

	(1)	(2)	(3)	(4)
Log Bribe per 100 km O	0.230	0.314*	0.151	0.264
	(0.329)	(0.143)	(0.234)	(0.470)
Log Delay per 100km O	−0.551	−0.653	−0.779***	−1.187***
	(0.405)	(0.526)	(0.232)	(0.240)
Log Bribe per 100 km D	−0.116	0.210	−0.215**	0.104
	(0.130)	(0.727)	(0.100)	(0.174)
Log Delay per 100km D	0.347**	0.848*	0.107	0.286
	(0.139)	(0.369)	(0.084)	(0.388)
Log Nb control per 100 km O	0.514	−0.083	0.645	−0.011
	(0.350)	(0.273)	(0.465)	(0.405)
Log Nb control per 100 km D	0.245	1.094	0.369	1.121
	(0.562)	(0.545)	(0.506)	(0.723)
Observations	66	66	66	66
R-sq	0.133	0.230	0.296	0.388
Time fixed effects	No	No	Yes	Yes
Country fixed effects	No	Yes	No	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: log trade flows from the country to abroad. In parenthesis are the robust and clustered standard deviations.

Table 3.5: Imports regressions

	(1)	(2)	(3)	(4)
Log Bribe per 100 km O	−0.116	0.210	−0.215	0.104
	(0.166)	(0.528)	(0.131)	(0.517)
Log Delay per 100km O	0.347	0.848	0.107	0.286
	(0.400)	(0.575)	(0.348)	(0.585)
Log Bribe per 100 km D	0.230	0.314	0.151	0.264
	(0.460)	(0.341)	(0.419)	(0.293)
Log Delay per 100km D	−0.551	−0.653	−0.779	−1.187
	(0.513)	(0.692)	(0.576)	(0.707)
Log Nb control per 100 km O	0.245	1.094	0.369	1.121
	(0.561)	(1.021)	(0.621)	(1.154)
Log Nb control per 100 km D	0.514	−0.083	0.645	−0.011
	(0.335)	(0.293)	(0.438)	(0.521)
Observations	66	66	66	66
R-sq	0.133	0.230	0.296	0.388
Time fixed effects	No	No	Yes	Yes
Country fixed effects	No	Yes	No	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: log trade flows from the country to abroad. In parenthesis are the robust and clustered standard deviations.

3.5.2 Alternative specifications: robustness

For our main specification, we assess the effects of roadblocks on trade in West Africa by considering the number of controls, delays, and bribes per 100 km. This specification allows us, everything else equal, to infer the impacts of roadblocks on the trade occurring on other corridors knowing the unlawful practices per 100 km.

As a robustness check, we consider an alternative specification where our variables of interest are the total values instead of those values per 100 km. More precisely, we estimate the equations (3.9) and (3.10) with $NbCtrl$, s_b, and τ being respectively the total number of controls, the total time delays, and the total amount of bribes either along the corridor or in each countryside of the corridors.

Along the corridors, the estimated parameters of our variables of interest are roughly consistent with those obtained with the main specification (see Table 3.6). The time delay still has a negative and statistically significant effect on trade. This effect is however lower. Besides, even if the bribes still positively impact the trade, their effects appear no longer significant.

Table 3.6: Regression on Trade flows along corridors for alternative specification

	(1)	(2)	(3)	(4)
Log Bribe Corr	0.435	0.309	0.456	0.458
	(0.743)	(0.311)	(1.044)	(0.466)
Log Delay Corr	−0.167	0.485	−0.636	−0.874*
	(0.640)	(0.479)	(0.870)	(0.419)
Log Nb control Corr	−1.532	0.310	−1.099	0.176
	(1.777)	(0.254)	(2.061)	(0.233)
Observations	34	34	34	34
R-sq	0.000	0.141	0.292	0.551
Time fixed effects	No	No	Yes	Yes
Corridor fixed effects	No	Yes	No	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: log trade flows along corridors. In parenthesis are the robust and clustered standard deviations.

The results of our estimated parameters are also broadly consistent with the main specification when we separate the effects of roadblocks, delays, and bribes in each countryside of corridors. The results of regressions on exports in Table

3.7 show that the time delays and the number of controls in the origin country still negatively affect the trade. In addition, we now found that the bribes in the destination country, everything else equal, harm the trade in the region.

Table 3.7: Exports regressions for alternative specification

	(1)	(2)	(3)	(4)
Log Bribe O	0.040	0.361	−0.072	0.324
	(0.220)	(0.229)	(0.153)	(0.374)
Log Delay O	−0.548	−0.565	−0.880***	−1.119***
	(0.427)	(0.462)	(0.138)	(0.156)
Log Bribe D	−0.202	−0.096	−0.347	−0.156
	(0.182)	(0.702)	(0.218)	(0.238)
Log Delay D	0.300*	0.895	−0.053	0.274
	(0.154)	(0.476)	(0.112)	(0.562)
Log Nb control O	0.814	−0.392	1.216***	−0.013
	(0.614)	(0.525)	(0.431)	(0.707)
Log Nb control D	0.453	2.253*	0.885	2.554*
	(0.888)	(1.044)	(0.730)	(1.087)
Observations	66	66	66	66
R-sq	0.127	0.282	0.314	0.447
Time fixed effects	No	No	Yes	Yes
Country fixed effects	No	Yes	No	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: log trade flows from the country to abroad. In parenthesis are the robust and clustered standard deviations.

The estimates of the regressions on imports reported in Table 3.8 show that the delays and the number of controls in the destination countries negatively affect trade. A 1% increase in time delays in the destination country, everything else equals, will lower the growth rate of imports by 1.11 percentage points. On the other hand, while the bribes in the origin countries negatively impact the imports, the bribes in the destination countries appear to have a positive effect. The effects of bribes are however low and statistically not significant.

Table 3.8: Imports regressions for alternative specification

	(1)	(2)	(3)	(4)
Log Bribe O	−0.202	−0.096	−0.347	−0.156
	(0.140)	(0.453)	(0.233)	(0.502)
Log Delay O	0.300	0.895	−0.053	0.274
	(0.525)	(0.660)	(0.500)	(0.707)
Log Bribe D	0.040	0.361	−0.072	0.324
	(0.330)	(0.347)	(0.321)	(0.280)
Log Delay D	−0.548	−0.565	−0.880	−1.119*
	(0.624)	(0.719)	(0.649)	(0.487)
Log Nb control O	0.453	2.253	0.885	2.554
	(0.872)	(1.651)	(1.077)	(1.775)
Log Nb control D	0.814	−0.392	1.216	−0.013
	(0.780)	(0.561)	(0.982)	(1.113)
Observations	66	66	66	66
R-sq	0.127	0.282	0.314	0.447
Time fixed effects	No	No	Yes	Yes
Country fixed effects	No	Yes	No	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: log trade flows from the country to abroad. In parenthesis are the robust and clustered standard deviations.

3.6 Conclusion

In this paper we rely on the Improved Road-Transport Governance reports to construct a novel data set that measures trade-related roadblocks, time delays, and bribes on eight interstate roads in Western Africa between 2006 and 2013 to investigate their effects on bilateral trade in the region. These interstate roads connect three landlocked countries – Burkina Faso, Niger, and Mali – to other coastal countries. We document that roadblocks, delays, and bribes are pervasive on the roads. Our empirical analyses show that the delays seriously impede bilateral trade between the connected countries while the effect of corruption is positive. That is in line with the "grease the wheels" theory of corruption and should not be seen as a good thing because people's willingness to pay bribes is motivated by their desire to relax the constraints imposed by roadblocks and delays. It is advisable that the interested countries improve the practices on the roads to help trade integration and development.

References

Alessandria, G., J. P. Kaboski, and V. Midrigan (2010): "Inventories, Lumpy Trade, and Large Devaluations," *American Economic Review*, 100, 2304–2339.

Alessandria, G., S. Y. Khan, and A. Khederlarian (2021): "Taking Stock of Trade Policy Uncertainty: Evidence from China's Pre-WTO Accession," Working Paper, World Bank, Washington, DC.

Amoah, G. (2014): "Intra-African Trade: Issues Involved in Improving Ghana's Trade with the Rest of Africa," *Developing Country Studies*, 4.

Arizala, F., M. Bellon, and M. MacDonald (2018): "Sub-Saharan Africa is becoming more integrated - which will aid growth but is not without risk," Finance & Development, International Monetary Fund.

Barka, H. B. (2012): "Border Posts, Checkpoints, and Intra-African Trade: Challenges and Solutions," Tech. rep., The African Development Bank.

Berman, N., J. de Sousa, P. Martin, and T. Mayer (2013): "Time to Ship during Financial Crises," *NBER International Seminar on Macroeconomics*, 9, 225–260, publisher: The University of Chicago Press.

Carreras-Valle, M.-J. (2021): "Increasing Inventories: Role of Delivery Times," Ph.D. thesis, University of Minnesota.

de Jong, E. and C. Bogmans (2011): "Does corruption discourage international trade?" *European Journal of Political Economy*, 27, 385–398.

Dimant, E. and G. Tosato (2018): "Causes and Effects of Corruption: What Has Past Decade's Empirical Research Taught Us? A Survey," *Journal of Economic Surveys*, 32, 335–356.

Dincer, O. C. and B. Gunalp (2005): "Corruption, Income Inequality, and Growth: Evidence from U.S. States," *SSRN Electronic Journal*.

Djankov, S., C. Freund, and C. S. Pham (2010): "Trading on Time," *The Review of Economics and Statistics*, 92, 166–173.

Dreher, A. and M. Gassebner (2013): "Greasing the wheels? The impact of regulations and corruption on firm entry," *Public Choice*, 155, 413–432, publisher: Springer.

d'Agostino, G., J. P. Dunne, and L. Pieroni (2016): "Government Spending, Corruption and Economic Growth," *World Development*, 84, 190–205.

Gil-Pareja, S., R. Llorca-Vivero, and J. A. Martínez-Serrano (2019): "Corruption and international trade: a comprehensive analysis with gravity," *Applied Economic Analysis*, 27, 3–20.

Gyimah-Brempong, K. (2002): "Corruption, economic growth, and income inequality in Africa," *Economics of Governance*, 3, 183–209.

Hummels, D. L. and G. Schaur (2013): "Time as a Trade Barrier," *American Economic Review*, 103, 2935–2959.

Kaminchia, S. (2020): "Effect of transit road quality on trade costs in East Africa," *African Development Review*, 32, 316–326.

Longo, R. and K. Sekkat (2004): "Economic Obstacles to Expanding Intra-African Trade," *World Development*, 32, 1309–1321.

Majeed, M. T. (2014): "Corruption and Trade," *Journal of Economic Integration*, 29, 759–782.

Mauro, P. (1997): *Why worry about corruption ?*, no. 6 in Economic issues, Washington, D.C: International monetary fund.

Melitz, M. J. (2003): "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 71, 1695–1725.

Montagnat-Rentier, G. and G. Parent (2012): "Customs administration reform and modernization in Francophone sub-Saharan Africa, 1995-2010," *Revue d'économie du développement*, 20, 105–146.

Musila, J. W. and S. P. Sigué (2010): "Corruption and International Trade: An Empirical Investigation of African Countries," *World Economy*, 33, 129–146.

Njinkeu, D., J. S. Wilson, and B. P. Fosso (2008): *Expanding Trade Within Africa: The Impact Of Trade Facilitation*, Policy Research Working Papers, The World Bank.

Ocean Shipping Consultants, Ltd. (2008): "DIAGNOSTICS DES INFRASTRUCTURES NATIONALES EN AFRIQUE," Tech. rep., Ocean Shipping Consultants, Ltd.

Plane, P. (2021): "What Factors Drive Transport and Logistics Costs in Africa?" *Journal of African Economies*, 30, 370–388.

Sant' Anna, V. P. and S. Kannebley Júnior (2018): "Port efficiency and Brazilian exports: A quantitative assessment of the impact of turnaround time," *The World Economy*, 41, 2528–2551.

Socrates, M. K., E. Moyi, and K. Gathiaka (2020): "Explaining Export Duration in Kenya," *South African Journal of Economics*, 88, 204–224.

The World Economic Forum and The Global Alliance for Trade Facilitation (2016): *The Global Enabling Trade Report*, World Economic Forum, and Global Alliance for Trade Facilitation.

United Nations (2022): *Rethinking the Foundations of Export Diversification in Africa: The Catalytic Role of Business and Financial Services : Economic Development in Africa Report 2022*, Geneva: United Nations, oCLC: 1342986610.

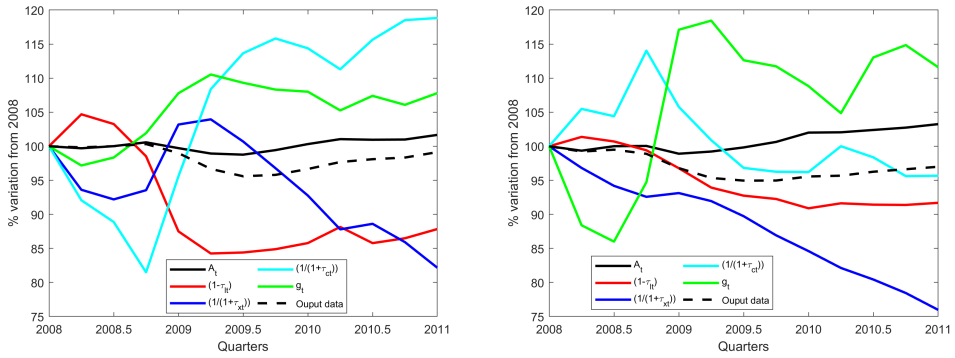
Valensisi, G. and R. T. Lisinge (2013): *Trade facilitation from an African perspective*, United Nations, Economic Commission for Africa.

Vijil, M., L. Wagner, and M. T. Woldemichael (2019): *Import Uncertainty and Export Dynamics*, World Bank, Washington, DC.

Appendix A

Appendix to Chapter 1

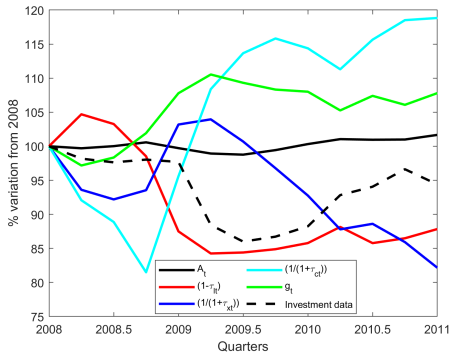
A.1 Evolution of wedges and aggregate variables



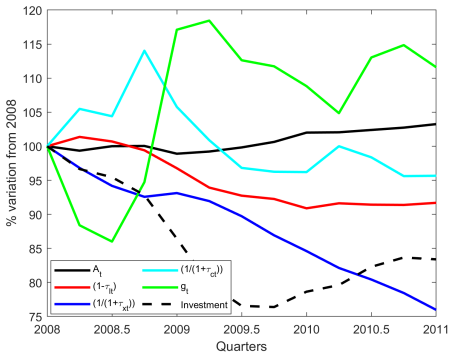
(a) Output and wedges for Canada (b) Output and wedges for US

Figure A.1.1: Output and wedges

A.2 Output Data and Output Prediction of models with just one wedge

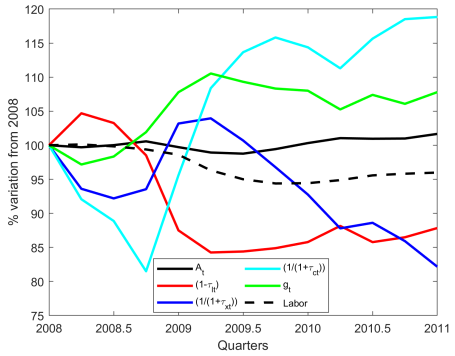


(a) Investment and wedges for Canada

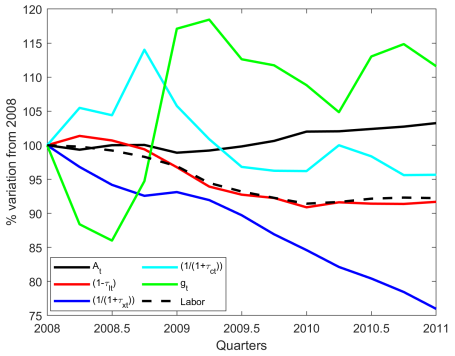


(b) Investment and wedges for US

Figure A.1.2: Investment and wedges

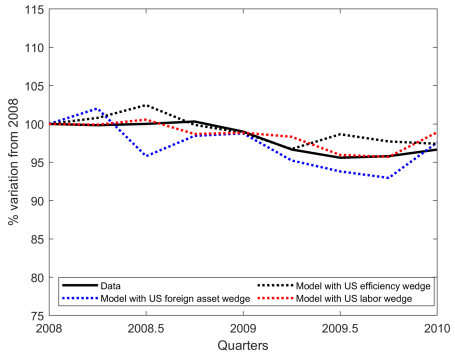


(a) Labor and wedges for Canada

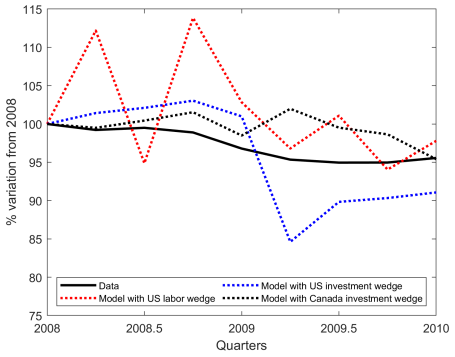


(b) Labor and wedges for US

Figure A.1.3: Labor and wedges



(a) Output for Canada



(b) Output for US

Figure A.2.1: Output in Data and Output models predictions

A.3 2007-2008 crisis Description

Table A.3.1: Changing in aggregates during the crisis

			Change of aggregates in %		
	Peak	Through	***Y***	***X***	***L***
Canada	2007Q4	2009Q4	-3.34	-11.76	-5.57
US			-4.44	-21.35	-8.57

Notes.- The Table shows the decrease in percentages of output Y, investment X, and labor L and the periods of the peak and Through of those variables for the US and Canada. Q4 stands for the fourth quarter. Source: The author's calculations.

A.4 Proof of propositions

A.4.1 Proof of proposition 1

Without assets trading in the world economy, the net export equals zero every period. We know that the net export is:

$$(X - M)_t^i = p_t^i(y_t^i - c_{ht}^i - x_t^i) - p_t^j c_{ft}^i$$

As the firms are in a competitive market, their profit is zero every period such that

$$p_t^i y_t^i = w_t^i l_t^i + r_t^i k_t^i$$

Then by replacing the firm revenue with the net export equation, we get:

$$(X - M)_t^i = w_t^i l_t^i + r_t^i k_t^i - p_t^i(c_{ht}^i + x_t^i) - p_t^j c_{ft}^i$$

We also know that the government wedge is equal to the transfers to the household state by the following equation:

$$tr_t^i = g_t^i = p_t^j \tau_{ct}^i c_{ft}^i + p_t^i \tau_{xt}^i x_t^i + \tau_{lt}^i w_t^i l_t^i \tag{A.1}$$

Then using the budget constraint 1.4 (with $b_t^i = 0$) and A.1, we obtain $(X-M)_t^i = 0$.

A.4.2 Proof of proposition 2

Let assume $\mathcal{A}^i = \left(c_{ht}^i, c_{ft}^i, x_t^i, l_t^i, b_t^i\right)_{t=0}^{\infty}$ i=(h,f) solve equations in proposition 2 and let prove there exist price $\mathcal{P}^i = (p_t^i, w_t^i, r_t^i, r_t^*)_{t=0}^{\infty}$ such that $\mathcal{A}^i$ and $\mathcal{P}^i$ is a competitive equilibrium.
The proof is straightforward when we make the following assumptions:

- Normalize a price: $\forall t, p_t^h = 1$
- Compute $p_t^f = \frac{u_{2t}^h(.)}{u_{1t}^h(.)(1+\tau_{ct}^h)}$
- Compute $w_t^i = p_t^i F_{2t}^i(.)$
- Compute $r_t^i = p_t^i F_{kt}(.)$
- Using non-arbitrage condition, compute

$$r_{t+1}^* = \frac{1}{(1-\tau_{bt+1}^i)}\left(\frac{1}{1+\tau_{xt}^i}\frac{p_{t+1}^i}{p_t^i}(F_{kt+1} + (1-\delta)(1+\tau_{xt+1}^i)) - 1\right) \tag{A.2}$$

Indeed,

- From the wage rate and interest rate equations, firms optimize as shown by equations A.3 and A.4;
- From equations 1.17 and 1.18 of proposition 2, resource constraints are satisfied;
- Combining the remind equations and prices we get the FOC of households problems (equations A.5 to A.8 for each country i) ;
- The budget constraints (equations 1.4 for each country) are satisfied by using them to compute the assets variables.

First order conditions of firms optimization problems

$$w_t^i = p_t^i F_{lt}(.) \tag{A.3}$$

$$r_t^i = p_t^i F_{kt}(.) \tag{A.4}$$

First order conditions of household optimization problems

Using the Lagrangian procedure we get the following equations:

$$u_{c_f t}(.) = u_{c_h t}(.)(1 + \tau^i_{ct})\frac{p^j_t}{p^i_t} \tag{A.5}$$

$$u_{lt}(.) = -u_{c_h t}(.)(1 - \tau^i_{lt})\frac{w^i_t}{p^i_t} \tag{A.6}$$

$$u_{c_h t}(.)\frac{1}{p^i_t} = \beta^i E_t \left[u_{c_h t+1}(.)(1 + (1 - \tau^i_{bt+1})r^*_{t+1}))\frac{1}{p^i_{t+1}} \right] \tag{A.7}$$

$$u_{c_h t}(.)(1 + \tau^i_{xt}) = \beta^i E_t \left[u_{c_h t+1}(.)(\frac{r^i_{t+1}}{p^i_{t+1}} + (1 - \delta)(1 + \tau^i_{xt+1})) \right] \tag{A.8}$$

Appendix B

Appendix to Chapter 2

B.1 Heterogeneity in fiscal needs for WAEMU countries from 1960-1999

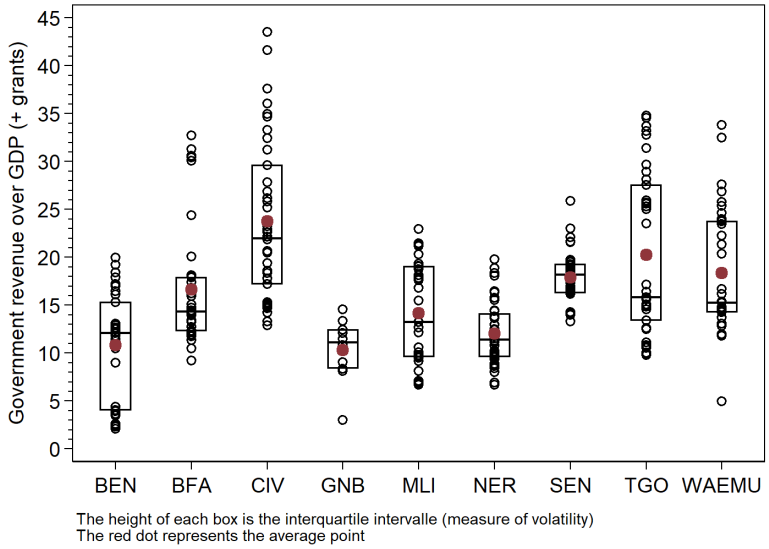


Figure B.1.1: Government revenue over GDP from 1960-1999
Source: BCEAO data and the author's representation

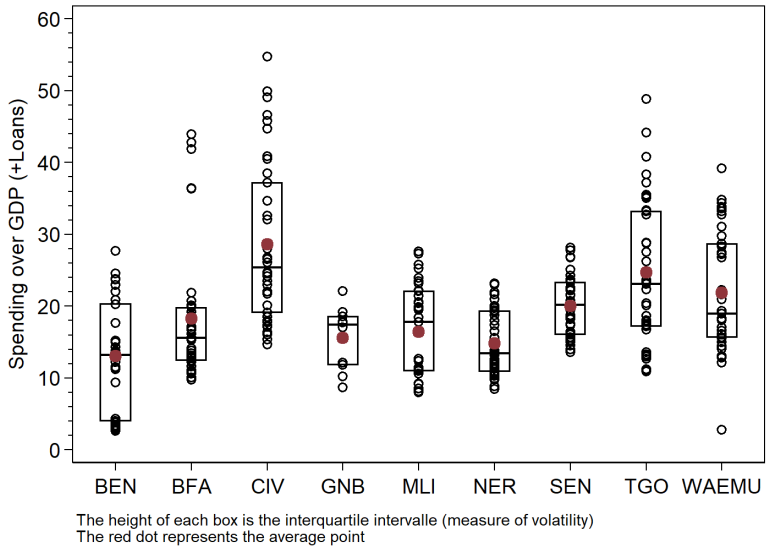


Figure B.1.2: Government Spending over GDP from 1960-1999
Source: BCEAO data and the author's representation

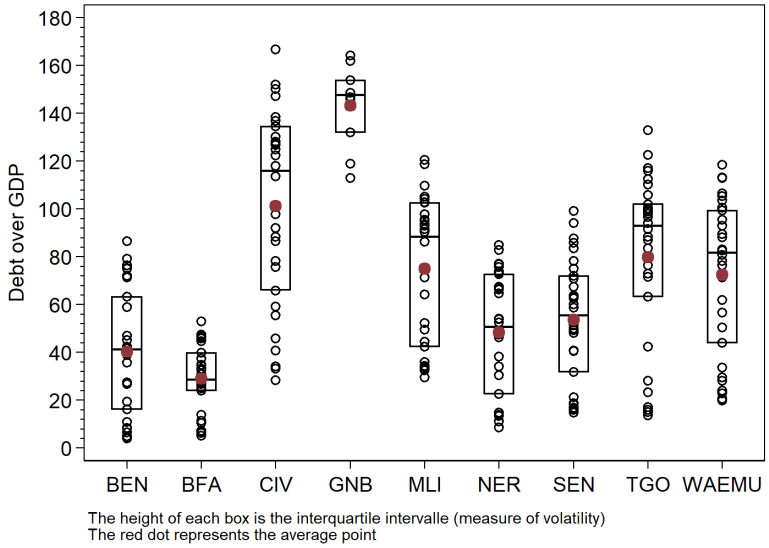


Figure B.1.3: Government debt over GDP from 1960-1999
Source: BCEAO data and the author's representation

B.2 Heterogeneity in fiscal needs for WAEMU countries from 2000-2014

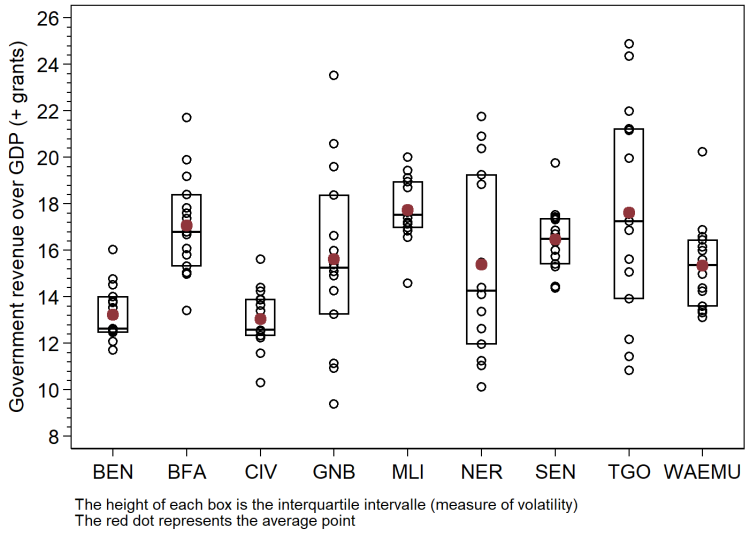


Figure B.2.1: Government revenue over GDP from 2000-2014
Source: BCEAO data and the author's representation

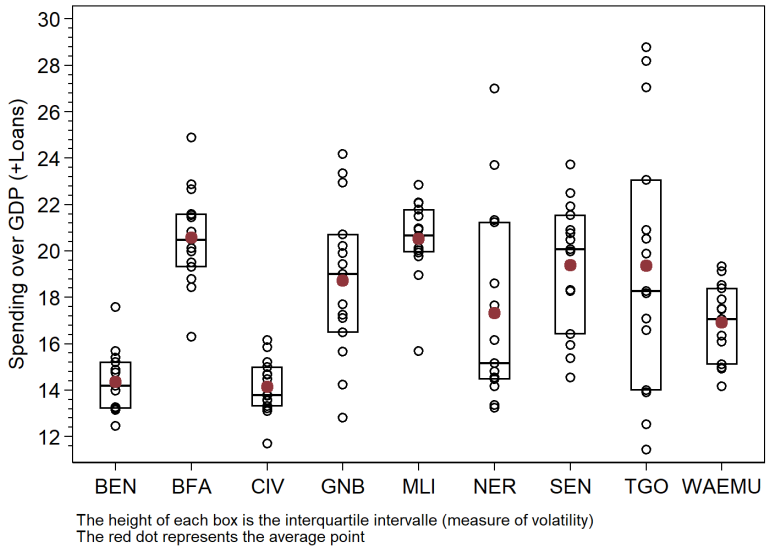


Figure B.2.2: Government Spending over GDP from 2000-2014
Source: BCEAO data and the author's representation

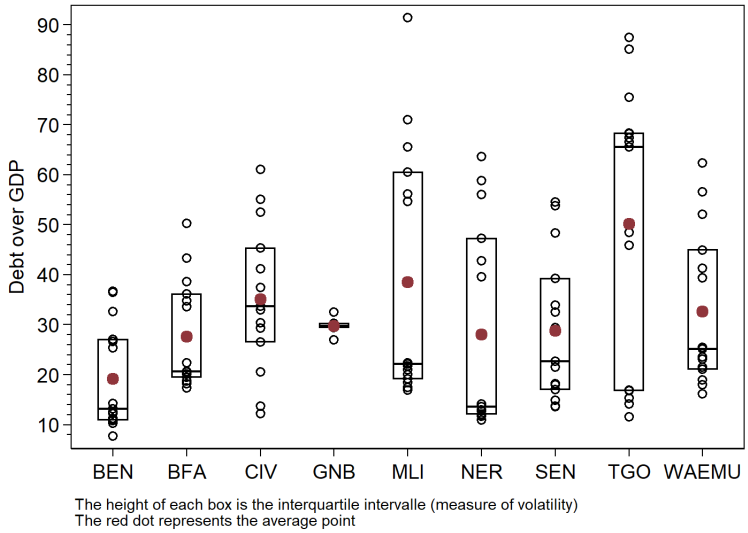


Figure B.2.3: Government debt over GDP from 2000-2014
Source: BCEAO data and the author's representation

B.3 Distribution of shock on revenues and preference shock

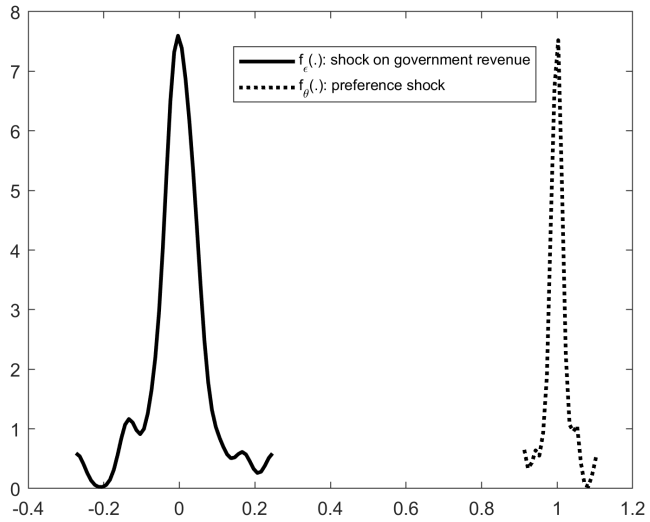


Figure B.3.1: Distribution of shocks for Benin
Source: BCEAO data and the author's calculations

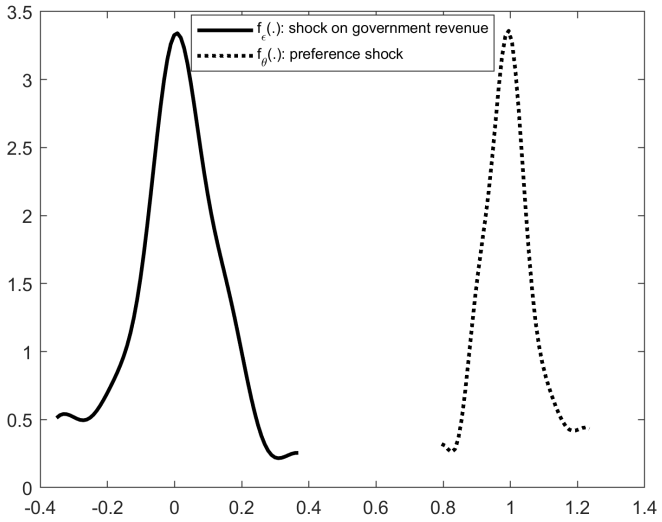


Figure B.3.2: Distribution of shocks for Côte d'Ivoire
Source: BCEAO data and the author's calculations

B.4 Number of countries that violate the deficit rule between 2000-2014

Table B.4.1: Summary statistics on the current rule violation

	2002	**2004**	**2006**	**2008**	**2010**	**2012**	**2014**
Deficit limit* >3% GDP	*3*	*2*	*2*	*3*	*2*	*2*	*2*
Deficit limit >0% GDP	*8*	*7*	*6*	*7*	*6*	*8*	*8*

Note.– Number of countries that violated the rules each year. Deficit limit * calculation excluded externally financed capital expenditures. Source: BCEAO data and the author's calculations

B.5 Homogeneity tests

Table B.5.1: Homogeneity tests for the period 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***

Note.– Levene's test for equality of variances is used to test variances homogeneity. Source: BCEAO data and the author's calculations

Table B.5.2: Homogeneity tests for the period 2000-2014

		Fstat	*p-values*
Revenue	H0: Mean equality	***3.385***	***0.003***
	H0: Variance equality	***3.250***	***0.004***
Spendings	H0: Mean equality	***10.240***	***0.000***
	H0: Variance equality	***7.667***	***0.000***
Budget Balance	H0: Mean equality	***1.294***	***0.260***
	H0: Variance equality	***2.150***	***0.044***
Debts	H0: Mean equality	***15.971***	***0.000***
	H0: Variance equality	***19.085***	***0.000***

Note.– Levene's test for equality of variances is used to test variances homogeneity.
Source: BCEAO data and the author's calculations

Table B.5.3: Homogeneity tests for the period 1960-2019

		Fstat	*p-values*
Revenue	H0: Mean equality	***13.601***	***0.000***
	H0: Variance equality	***12.558***	***0.000***
Spendings	H0: Mean equality	***12.583***	***0.000***
	H0: Variance equality	***14.435***	***0.000***
Budget Balance	H0: Mean equality	***2.040***	***0.049***
	H0: Variance equality	***3.454***	***0.001***
Debts	H0: Mean equality	***25.544***	***0.000***
	H0: Variance equality	***26.042***	***0.000***

Note.– Levene's test for equality of variances is used to test variances homogeneity.
Source: BCEAO data and the author's calculations

B.6 Robustness Check

Table B.6.1: Findings of uncoordinated country-specific rule with same δ

	BEN	*BFA*	*CIV*	*GNB*	*MLI*	*NER*	*SEN*	*TGO*
δ	**0.93**	**0.93**	**0.93**	**0.93**	**0.93**	**0.93**	**0.93**	**0.93**
DL	**0.84**	**1.56**	**0.39**	**3.49**	**1.83**	**1.56**	**0.70**	**2.32**
Λ	**0.17**	**0.03**	**0.06**	**0.01**	**0.03**	**0.05**	**0.11**	**0.01**

Note.– The table shows the maximum deficit limit (DL) in % and the welfare government spending equivalent variation (Λ) % with each government degree of present bias ($1-\delta$). BEN stands for Benin, BFA for Burkina Faso, CIV for Côte d'Ivoire, GNB for Guinea Bissau, MLI for Mali, NER for Niger, SEN for Senegal, and TGO for Togo. Source: The author's calculations

Table B.6.2: Findings of coordinated country-specific rule with same δ

	BEN	*BFA*	*CIV*	*GNB*	*MLI*	*NER*	*SEN*	*TGO*
δ	**0.93**	**0.93**	**0.93**	**0.93**	**0.93**	**0.93**	**0.93**	**0.93**
DL	**11.81**	**3.36**	**9.21**	**2.86**	**6.41**	**4.17**	**4.13**	**8.02**
Λ	**0.019**	**0.025**	**0.200**	**1.056**	**0.181**	**0.344**	**0.138**	**0.138**

Note.– The table shows the maximum deficit limit (DL) in % and the welfare government spending equivalent variation (Λ) in % with each government degree of present bias ($1-\delta$). BEN stands for Benin, BFA for Burkina Faso, CIV for Côte d'Ivoire, GNB for Guinea Bissau, MLI for Mali, NER for Niger, SEN for Senegal, and TGO for Togo. Source: The author's calculations

- The equilibrium interest rate is 7.24%

Appendix C

Appendix to Chapter 3

C.1 Theory

C.1.1 Derivation of consumer's demand for variety s in country d

The program solved by the consumer is as follows:

$$\max_{x_d^s} \left(\int_0^1 \lambda(s)(x_d^s)^{\frac{\sigma-1}{\sigma}} ds \right)^{\frac{\sigma}{\sigma-1}} \tag{C.1}$$

$$\text{s.t. } \int_0^1 p_d^s x_d^s ds \leq P_d Y_d$$

Let γ the Lagrange multiplier so that the first order condition of the problem implies that:

$$x_d^s = \left(\frac{\sigma}{\sigma - 1} \frac{\gamma p_d^s}{\lambda(s)} \right)^{-\sigma} \tag{C.2}$$

To get rid of γ, let express the ratio of demand for two varieties s and s' as follow:

$$\frac{x_d^s}{y_d^{s'}} = \left(\frac{p_d^s}{p_d^{s'}} \frac{\lambda(s')}{\lambda(s)} \right)^{-\sigma} \tag{C.3}$$

Integrating C.3 over all the variety gives:

$$\int_0^1 (p_d^s x_d^s) ds = \int_0^1 \left[p_d^s y_d^{s'} \left(\frac{p_d^s}{p_d^{s'}} \frac{\lambda(s')}{\lambda(s)} \right)^{-\sigma} \right] ds \tag{C.4}$$

Using the budget constraint of consumers we get

$$Y_d P_d = y_d^{s'} \left(\frac{\lambda(s')}{p_d^{s'}} \right) \int_0^1 \left(\lambda^\sigma(s) (p_d^s)^{1-\sigma} \right) ds \tag{C.5}$$

Let's define the index price P_d as follow:

$$P_d = \int_0^1 \left(\lambda^\sigma(s) (p_d^s)^{1-\sigma} \right) ds \tag{C.6}$$

So that the demand of consumers for variety s in country d is:

$$x_d^s = Y_d \left(\frac{p_d^s}{\lambda(s) P_d} \right)^{-\sigma} \tag{C.7}$$

C.1.2 Derivation of the price set by the exporter of variety s to country d

The program solved by the exporter is :

$$\max_{p_d^s} V_d^s \equiv p_d^s x_d^s - \phi(s)(w+\tau) x_d^s \tag{C.8}$$

$$\text{s.t. } y_d = f(P_d, p_d^s, Y_d)$$

The first order condition of the program is:

$$x_d^s + p_d^s \frac{\partial x_d^s}{\partial p_d^s} - \phi(s)(w+\tau) \frac{\partial x_d^s}{\partial p_d^s} = 0$$

The exporter of variety s to country d takes as given the index price P_d such that $\frac{\partial x_d^s}{\partial p_d^s} = -\sigma \frac{x_d^s}{p_d^s}$. Substituting this expression into the first order condition gives the equilibrium price p_d^s

$$p_d^s = \frac{\sigma}{\sigma - 1} (w+\tau) \phi(s) \tag{C.9}$$

Finally, when we substitute the price into the demand equation we get

$$x_d^s = Y_d P_d^\sigma \left[\frac{\sigma}{\sigma - 1} (w+\tau) \phi(s) \frac{1}{\lambda(s)} \right]^{-\sigma} \tag{C.10}$$

C.2 Data

Table C.2.1: summary statistics by corridor

Nb	Quarters	Nb of Trips		Police Control		Customs Control		Gendamerie Control		Others Control		Total of Control		Control per 100 km	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	14	96.36	33.87	7.31	2.20	2.61	1.99	4.85	1.89	8.96	7.94	22.71	7.47	1.93	0.64
2	14	80.79	53.64	4.37	2.11	5.39	2.05	3.92	2.47	7.21	5.60	21.08	5.51	1.66	0.44
3	15	139.47	33.79	9.94	1.92	2.99	1.03	11.22	5.16	1.24	1.15	25.41	7.50	1.84	0.67
4	25	69.10	30.60	6.81	1.44	8.86	2.03	5.97	1.53	4.33	2.83	26.25	5.36	2.94	0.68
5	14	59.29	22.60	6.22	0.81	9.76	2.07	5.77	1.13	3.43	2.63	25.69	4.48	2.47	0.43
6	2	110.00	35.36	4.00	0.00	3.00	0.00	5.50	0.71	0.00	0.00	12.50	0.71	1.00	0.00
7	25	178.50	49.46	24.93	100.86	7.94	2.08	2.85	1.33	1.21	1.03	17.00	3.61	1.75	0.51
8	25	96.90	46.13	8.87	2.12	10.41	2.53	1.72	1.56	1.39	1.36	21.75	3.67	2.08	0.36

Nb	Police Bribe		Customs Bribe		Gendamerie Bribe		Others Bribe		Total Bribe		Bribe per 100 km		Delay time		Delay per 100 km	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	10297	3101	5514	2887	5921	1560	30697	25559	51875	23888	4419	2035	173	76	15	6
2	7264	2834	8881	5231	6453	2957	31027	21933	53624	22915	4246	1814	157	84	12	6
3	15430	3765	9990	4140	12589	6036	3282	1557	39723	10662	2847	828	321	112	23	7
4	11416	2357	123121	531671	9266	2650	11179	6589	49054	12567	5436	1603	172	49	19	7
5	11159	3304	17537	5759	7957	1540	6861	3622	43529	11560	4206	1117	199	64	19	6
6	4429	112	2735	0	11131	1632	298	182	18592	1926	3092	1661	114	28	11	3
7	5026	2068	7126	2525	3831	1543	2532	2680	18516	6843	1894	839	120	45	12	6
8	5074	1577	8264	3157	2319	913	3280	3995	18938	7030	2548	1317	246	85	32	20

Notes.- The table shows summary statistics of the number of controls, delays, and bribes on interstate roads (corridors) 1 to 8 between 2006 and 2013. Corridor 1 is Abidjan-Bamako, 2 Ougadougou-Abidjan, 3 Bamako-Dakar, 4 Ouagadougou-Bamako via Heremakono, 5 Ougadougou-Bamako via Koury, 6 Cotonou-Niamey, 7 Ouagadogou-Lomé, and 8 Ouagadogou-Tema. Source: IRTG reports and the authors' calculations.

Table C.2.2: Summary statistics by country

Country	Quarters	Nb of Trips		Police Control		Customs Control		Gendamerie Control		Others Control		Total of Control		Control per 100 km	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
BEN	2	81.00	5.66	3.20	0.14	0.70	0.14	3.00	0.71	0.00	0.00	7.00	0.71	0.75	0.07
BFA	103	100.58	60.61	2.89	17.33	3.65	1.35	0.99	0.35	0.55	0.54	6.39	1.37	2.05	0.90
CIV	28	88.57	44.73	3.21	1.79	1.51	1.45	2.58	1.79	7.45	6.27	14.82	5.43	2.09	1.03
GHA	25	96.90	46.13	7.65	2.21	7.46	2.00	0.66	1.35	0.93	0.94	15.93	3.27	1.82	0.37
MLI	68	89.73	42.98	4.92	1.15	3.68	1.83	4.15	1.55	2.38	2.34	14.90	5.66	3.09	1.49
NER	2	71.50	19.09	0.85	0.07	2.00	0.14	2.45	0.07	0.15	0.21	5.55	0.07	2.05	0.07
SEN	15	139.47	33.79	5.87	1.71	0.63	0.32	7.71	4.34	0.30	0.40	14.52	6.00	2.13	0.90
TGO	25	178.50	49.46	16.59	65.73	4.59	1.21	1.85	1.30	0.78	0.61	10.73	3.15	1.81	1.76

Country	Police Bribe		Customs Bribe		Gendamerie Bribe		Others Bribe		Total Bribe		Bribe per 100 km		Delay time		Delay per 100 km	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
BEN	3363	113	937	1	5604	1632	208	182	10112	1927	1313	250	31	27	4	2
BFA	2081	854	4896	2947	1922	738	1579	1984	10477	4514	3136	1233	60	29	21	18
CIV	3994	2679	3080	2521	3083	2210	27649	23302	37065	20514	5575	3152	110	66	15	9
GHA	3452	1615	4529	2940	496	1024	2261	3405	10718	6451	1235	746	162	81	19	10
MLI	8325	2584	8280	4902	5543	2547	5653	5048	27648	11639	5604	2948	128	64	24	10
NER	910	219	1650	209	5611	119	297	293	8469	18	3125	6	42	59	4	6
SEN	8507	3185	2354	1329	8897	5065	1464	984	20358	7961	2996	1180	129	49	19	7
TGO	3123	1672	3864	1908	1926	1413	1384	1745	10233	5480	1354	713	66	26	9	4

Notes.- The table shows summary statistics of the number of controls, delays, and bribes observed in countries on the interstate roads (corridors) of Table C.2.1 between 2006 and 2013. BEN stands for Benin, BFA for Burkina Faso, CIV for Côte d'Ivoire, GHA for Ghana, MLI for Mali, NER for Niger, SEN for Senegal, and TGO for Togo. Source: IRTG reports and the authors' calculations.

C.3 Results of regressions

Table C.3.1: Regression on Trade flows along corridors

	(1)	(2)	(3)	(4)
Log Bribe per 100 km Corr	0.969	0.110	1.027	0.822**
	(0.762)	(0.327)	(0.881)	(0.266)
Log Delay per 100km Corr	−0.444	0.168	−0.608	−1.240***
	(0.538)	(0.314)	(1.031)	(0.287)
Log Nb control per 100 km Corr	−1.181	0.653*	−1.114	0.019
	(1.100)	(0.338)	(1.602)	(0.183)
Inflation Diff	−0.002	−0.028	−0.003	0.003
	(0.029)	(0.040)	(0.046)	(0.036)
Log Distance	0.471	0.000	1.272	0.000
	(0.537)	(.)	(1.436)	(.)
Common language	−0.016	0.000	−0.108	0.000
	(0.569)	(.)	(0.890)	(.)
D.Diff Log Real GDP per capita O	5.475*	2.680*	10.023*	6.240***
	(3.034)	(1.399)	(5.122)	(0.665)
D.Diff Log Real GDP per capita D	6.199	4.019	6.864*	4.394**
	(3.900)	(4.010)	(3.988)	(1.719)
Observations	34	34	34	34
R-sq	0.023	0.123	0.350	0.600
Time fixed effects	No	No	Yes	Yes
Corridor fixed effects	No	Yes	No	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: log trade flows along corridors. In parenthesis are the robust and clustered standard deviations.

Table C.3.2: Regression on Trade flows along corridors for alternative specification

	(1)	(2)	(3)	(4)
Log Bribe Corr	0.435	0.309	0.456	0.458
	(0.743)	(0.311)	(1.044)	(0.466)
Log Delay Corr	−0.167	0.485	−0.636	−0.874*
	(0.640)	(0.479)	(0.870)	(0.419)
Log Nb control Corr	−1.532	0.310	−1.099	0.176
	(1.777)	(0.254)	(2.061)	(0.233)
Inflation Diff	−0.005	−0.027	−0.005	−0.014
	(0.048)	(0.046)	(0.060)	(0.041)
Log Distance	0.241	0.000	1.450	0.000
	(1.218)	(.)	(1.784)	(.)
Common language	0.149	0.000	−0.117	0.000
	(1.124)	(.)	(1.395)	(.)
D.Diff Log Real GDP per capita O	3.149	3.839**	6.856	5.572***
	(2.524)	(1.577)	(5.352)	(1.371)
D.Diff Log Real GDP per capita D	3.730	5.392	3.131	4.585
	(5.374)	(4.352)	(4.201)	(2.654)
Observations	34	34	34	34
R-sq	0.000	0.141	0.292	0.551
Time fixed effects	No	No	Yes	Yes
Corridor fixed effects	No	Yes	No	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: log trade flows along corridors. In parenthesis are the robust and clustered standard deviations.

Table C.3.3: Exports regressions

	(1)	(2)	(3)	(4)
Log Bribe per 100 km O	0.230	0.314*	0.151	0.264
	(0.329)	(0.143)	(0.234)	(0.470)
Log Delay per 100km O	−0.551	−0.653	−0.779***	−1.187***
	(0.405)	(0.526)	(0.232)	(0.240)
Log Bribe per 100 km D	−0.116	0.210	−0.215**	0.104
	(0.130)	(0.727)	(0.100)	(0.174)
Log Delay per 100km D	0.347**	0.848*	0.107	0.286
	(0.139)	(0.369)	(0.084)	(0.388)
Log Nb control per 100 km O	0.514	−0.083	0.645	−0.011
	(0.350)	(0.273)	(0.465)	(0.405)
Log Nb control per 100 km D	0.245	1.094	0.369	1.121
	(0.562)	(0.545)	(0.506)	(0.723)
Inflation Diff	−0.028***	−0.059	−0.027***	−0.053
	(0.010)	(0.042)	(0.008)	(0.034)
Log Distance	0.113	0.000	0.092	0.000
	(1.272)	(.)	(0.646)	(.)
Common language	−0.215	0.000	−0.493***	0.000
	(0.154)	(.)	(0.089)	(.)
D.Diff Log Real GDP per capita D	−2.855	0.571	−4.042***	−1.435
	(3.518)	(7.440)	(1.498)	(4.793)
Observations	66	66	66	66
R-sq	0.133	0.230	0.296	0.388
Time fixed effects	No	No	Yes	Yes
Country fixed effects	No	Yes	No	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: log trade flows from the country to abroad. In parenthesis are the robust and clustered standard deviations.

Table C.3.4: Exports regressions for alternative specification

	(1)	(2)	(3)	(4)
Log Bribe O	0.040	0.361	−0.072	0.324
	(0.220)	(0.229)	(0.153)	(0.374)
Log Delay O	−0.548	−0.565	−0.880***	−1.119***
	(0.427)	(0.462)	(0.138)	(0.156)
Log Bribe D	−0.202	−0.096	−0.347	−0.156
	(0.182)	(0.702)	(0.218)	(0.238)
Log Delay D	0.300*	0.895	−0.053	0.274
	(0.154)	(0.476)	(0.112)	(0.562)
Log Nb control O	0.814	−0.392	1.216***	−0.013
	(0.614)	(0.525)	(0.431)	(0.707)
Log Nb control P	0.453	2.253*	0.885	2.554*
	(0.888)	(1.044)	(0.730)	(1.087)
Inflation Diff	−0.016	−0.059	−0.016	−0.052
	(0.029)	(0.036)	(0.023)	(0.033)
Log Distance	−0.552	0.000	0.064	0.000
	(0.632)	(.)	(0.459)	(.)
Common language	−0.302	0.000	−0.529***	0.000
	(0.295)	(.)	(0.140)	(.)
D.Diff Log Real GDP per capita D	−3.280	0.033	−4.268**	−2.330
	(2.292)	(7.287)	(2.034)	(5.455)
Observations	66	66	66	66
R-sq	0.127	0.282	0.314	0.447
Time fixed effects	No	No	Yes	Yes
Country fixed effects	No	Yes	No	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: log trade flows from the country to abroad. In parenthesis are the robust and clustered standard deviations.

Table C.3.5: Imports regressions

	(1)	(2)	(3)	(4)
Log Bribe per 100 km O	−0.116	0.210	−0.215	0.104
	(0.166)	(0.528)	(0.131)	(0.517)
Log Delay per 100km O	0.347	0.848	0.107	0.286
	(0.400)	(0.575)	(0.348)	(0.585)
Log Bribe per 100 km D	0.230	0.314	0.151	0.264
	(0.460)	(0.341)	(0.419)	(0.293)
Log Delay per 100km D	−0.551	−0.653	−0.779	−1.187
	(0.513)	(0.692)	(0.576)	(0.707)
Log Nb control per 100 km O	0.245	1.094	0.369	1.121
	(0.561)	(1.021)	(0.621)	(1.154)
Log Nb control per 100 km D	0.514	−0.083	0.645	−0.011
	(0.335)	(0.293)	(0.438)	(0.521)
Inflation Diff	0.028**	0.059	0.027**	0.053
	(0.014)	(0.048)	(0.012)	(0.033)
Log Distance	0.113	0.000	0.092	0.000
	(1.465)	(.)	(1.427)	(.)
Common language	−0.215	0.000	−0.493*	0.000
	(0.385)	(.)	(0.281)	(.)
D.Diff Log Real GDP per capita O	−2.855	0.571	−4.042	−1.435
	(5.092)	(7.091)	(4.100)	(7.875)
Observations	66	66	66	66
R-sq	0.133	0.230	0.296	0.388
Time fixed effects	No	No	Yes	Yes
Country fixed effects	No	Yes	No	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: log trade flows from the country to abroad. In parenthesis are the robust and clustered standard deviations.

Table C.3.6: Imports regressions for alternative specification

	(1)	(2)	(3)	(4)
Log Bribe O	−0.202	−0.096	−0.347	−0.156
	(0.140)	(0.453)	(0.233)	(0.502)
Log Delay O	0.300	0.895	−0.053	0.274
	(0.525)	(0.660)	(0.500)	(0.707)
Log Bribe D	0.040	0.361	−0.072	0.324
	(0.330)	(0.347)	(0.321)	(0.280)
Log Delay D	−0.548	−0.565	−0.880	−1.119*
	(0.624)	(0.719)	(0.649)	(0.487)
Log Nb control O	0.453	2.253	0.885	2.554
	(0.872)	(1.651)	(1.077)	(1.775)
Log Nb control P	0.814	−0.392	1.216	−0.013
	(0.780)	(0.561)	(0.982)	(1.113)
Inflation Diff	0.016	0.059	0.016	0.052
	(0.037)	(0.045)	(0.029)	(0.031)
Log Distance	−0.552	0.000	0.064	0.000
	(1.024)	(.)	(1.206)	(.)
Common language	−0.302	0.000	−0.529	0.000
	(0.399)	(.)	(0.327)	(.)
D.Diff Log Real GDP per capita O	−3.280	0.033	−4.268	−2.330
	(4.320)	(6.107)	(3.155)	(6.631)
Observations	66	66	66	66
R-sq	0.127	0.282	0.314	0.447
Time fixed effects	No	No	Yes	Yes
Country fixed effects	No	Yes	No	Yes

Note: *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: log trade flows from the country to abroad. In parenthesis are the robust and clustered standard deviations.