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Essays in Macroeconomics and International Trade

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À ma défunte mère *TRAORE Chidan*,

À mon père *KONE N'Golo*,

Et à mon oncle *KONE Pichi*.

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RÉSUMÉ

Cette thèse explore des questions clés de macroéconomie et de politique commerciale, en se concentrant sur les règles budgétaires, les accords commerciaux régionaux et la transmission de l'inflation en Afrique. Elle se compose de trois chapitres indépendants mais thématiquement liés.

Le premier chapitre examine l'impact économique de la règle budgétaire équilibrée (BBR) de la Suisse, introduite en 2003. Contrairement aux règles budgétaires traditionnelles qui imposent un plafond fixe au déficit, la BBR suisse ajuste la limite du déficit en fonction de l'écart entre le PIB réel et son niveau potentiel. En utilisant la méthode du contrôle synthétique, je montre que la BBR a eu un impact positif sur la croissance économique suisse entre 2003 et 2018. Je développe un modèle de croissance endogène dans lequel un gouvernement à court terme alloue inefficacement les ressources. Le modèle suggère qu'en réduisant la dette publique, la BBR atténue l'effet d'éviction, permettant ainsi un investissement privé accru en recherche et développement (R&D) tout en libérant de l'espace budgétaire pour l'investissement public en R&D. Une analyse quantitative calibrée sur la Suisse indique que la BBR augmente la croissance annuelle de 1,27 point de base, entraînant un gain de PIB de 1% après dix ans. De plus, contrairement aux règles budgétaires équilibrées traditionnelles qui réduisent souvent le bien-être, la BBR flexible de la Suisse l'améliore, ce qui explique son application durable.

Le deuxième chapitre réexamine les effets des accords commerciaux régionaux (ACR) sur le commerce intra-africain. En utilisant un modèle de gravité structurel, un estimateur Pseudo Poisson Maximum Likelihood (PPML) et une approche de Différences-en-Différences hétérogène, je traite des défis majeurs d'estimation, notamment le biais de sélection dû aux flux commerciaux nuls, l'adoption échelonnée des ACR et leurs effets hétérogènes selon les régions et le temps. Je constate que les ACR ont augmenté le commerce intra-africain de 62% à 77% entre 1995 et 2019, bien que ces chiffres soient inférieurs à la plupart des estimations précédentes. En outre, mes résultats indiquent que les ACR mettent généralement entre cinq et huit ans pour avoir un impact significatif sur les flux commerciaux.

Le troisième chapitre examine comment les chocs de productivité, notamment les chocs climatiques et politiques dans un pays d'origine, influencent l'inflation dans un pays de destination via le commerce en Afrique. En utilisant une approche par variables instrumentales (IV), j'établis que ces chocs propagent des pressions inflationnistes au-delà des frontières par le biais du commerce. Pour approfondir ce mécanisme, j'étends le modèle de commerce international d'Eaton et Kortum (2002) pour inclure des considérations monétaires et analyser comment les ACR peuvent amplifier la transmission des chocs. J'applique le modèle pour étudier les effets potentiels de la Zone de libre-échange continentale africaine (ZLECAf), adoptée en 2021, sur la dynamique de l'inflation et ses implications pour la coordination des politiques monétaires des économies africaines.

Dans l'ensemble, cette thèse contribue à la compréhension de la politique budgétaire, de l'intégration commerciale et de la stabilité macroéconomique en apportant des preuves empiriques et des perspectives théoriques sur la BBR suisse, l'efficacité des ACR africains et la transmission de l'inflation par le commerce.

Mots clés: Règle budgétaire équilibrée, dette publique, croissance économique, économie du commerce, chocs climatiques, accord commercial régional (ACR), Zone de libre-échange continentale africaine (ZLECAf)

ABSTRACT

This thesis explores key macroeconomic and trade policy issues, focusing on fiscal rules, regional trade agreements, and inflation transmission in Africa. It consists of three independent but thematically connected chapters.

The first chapter examines the economic impact of Switzerland's Balanced Budget Rule (BBR), introduced in 2003. Unlike traditional fiscal rules that impose a fixed deficit ceiling, Switzerland's BBR adjusts the deficit limit based on the deviation of real GDP from its potential level. Using the synthetic control method, I show that the BBR has positively influenced Switzerland's economic growth from 2003 to 2018. I develop an endogenous growth model in which a shortsighted government inefficiently allocates resources. The model suggests that by reducing public debt, the BBR mitigates the crowding-out effect, enabling more private investment in research and development (R&D) while also freeing up fiscal space for public R&D investment. A quantitative analysis calibrated to Switzerland indicates that the BBR raises annual growth by 1.27 basis points, leading to a 1% GDP gain after ten years. Furthermore, unlike traditional balanced budget rules that often reduce welfare, Switzerland's flexible BBR enhances welfare, explaining its sustained enforcement.

The second chapter revisits the effects of Regional Trade Agreements (RTAs) on intra-African trade. Using a structural gravity model, a Pseudo Poisson Maximum Likelihood (PPML) estimator, and a heterogeneous Difference-in-Differences approach, I address key estimation challenges, including selection bias from zero trade flows, staggered adoption of RTAs, and heterogeneous effects across regions and time. I find that RTAs have increased intra-African trade by 62% to 77% from 1995 to 2019, although these figures are lower than most previous estimates. Additionally, my results indicate that RTAs typically take five to eight years to significantly impact trade flows.

The third chapter investigates how productivity shocks, particularly climatic and political shocks in an origin country, influence inflation in the destination country through trade in Africa. Using an instrumental variable (IV) approach, I establish that these shocks propagate inflationary pressures across borders via trade. To further explore this mechanism, I extend the Eaton and Kortum (2002) international trade model to incorporate monetary considerations and analyze how RTAs can amplify the transmission of shocks. I apply the model to study the potential effects of the African Continental Free Trade Agreement (AfCFTA), adopted in 2021, on inflation dynamics and its implications for monetary policy coordination across African economies.

Overall, this thesis contributes to the understanding of fiscal policy, trade integration, and macroeconomic stability by providing empirical evidence and theoretical insights on Switzerland's BBR, the effectiveness of African RTAs, and inflation transmission through trade.

Keywords: Balanced Budget Rule, Public Debt, Economic Growth, Trade Economics, Climatic Shocks, RTA, AfCFTA

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CHAPTER 1

BALANCED BUDGET RULE AND ECONOMIC GROWTH

Fansa Koné*

This paper studies the impact of a new Balanced Budget rule (BBR) on economic growth adopted in Switzerland's constitution in 2003. Its distinctive feature is that the government deficit limit is flexible depending on the comparison between real and potential GDP, unlike the traditional fixed 3% deficit limit in the European Union. First, using a synthetic control method, I document that from 2003 to 2018, the BBR adoption positively impacted Switzerland's economic growth . Second, I build an endogenous growth model with a shortsighted government making inefficient decisions. I find that by reducing public debt, the BBR tempers the "crowding-out effect of debt" and frees up resources for private investment in R&D. Additionally, by reducing the service of the debt, it frees up resources for public investment in R&D. These investments, in turn, foster economic growth. Third, the model calibrated to Switzerland shows that the long-term yearly growth effect of the new BBR is 1.27 basis points, which compounds to a 1% GDP gain after 10 years. Furthermore, compared to traditional BBRs, which reduce welfare, the new BBR increases it, providing a rationale for the lack of enforcement of traditional BBRs.

Keywords: Balanced Budget Rule, Public Debt, Economic Growth, Political Economy

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Introduction

Fiscal rules are gaining widespread usage across countries. According to the IMF, Balanced Budget Rules (BBRs) are the most widely adopted fiscal rules. The number of countries implementing them rose from only 6 in 1990 to 93 in 2020 (Davoodi et al., 2022). This is because BBRs enhance fiscal sustainability, they are associated with smaller deficits, better credit ratings, and less political manipulation of budgets (Rose, 2010; Alesina and Perotti, 1996). These benefits have prompted countries to adopt BBRs to address their rising public debt levels. Nevertheless, such rules by imposing on governments to limit their spending, affect their discretion in managing fiscal policy. By doing so, they could alter their ability to invest in public goods such as infrastructure, education, or research and development. These constraints may therefore hinder long-term economic growth prospects. However, the predominant literature on fiscal rules focuses on their role in public debt management, with little consideration given to their potential impact on economic growth. Some exceptions include Stockman (2001); Aghion et al. (2014), and Uchida and Ono (2021).

This paper focuses on the effect of a new type of Balanced Budget Rule on economic growth, known as **Balanced Budget Rule over the Business Cycle (BBR)** [1]. The intuition behind this rule is that the government deficit limit depends on whether the real Gross Domestic Product (GDP) is higher or lower than the potential GDP. If the country is in a recession, meaning the real GDP is lower than the potential GDP, the government is allowed to run a deficit. Conversely, during an expansion, a surplus is required. The size of the deficit (or surplus) is proportional to the magnitude of the recession (or expansion). A distinctive feature of this rule is that the deficit is not constrained to a single fixed value, unlike the 3% deficit limit applied in European Union or the West African Economic Monetary Union (WAEMU).

Switzerland has been at the forefront of implementing this rule and has incorporated it into its constitution since 2003. The rule has been successful in managing Switzerland's debt (Asatryan et al., 2018), which has motivated other nations to implement

1. Henceforth, BBR will be used to designate this rule whenever there is no confusion.

similar rules (Chile in 2014, Grenada in 2015, Germany in 2016, Austria in 2017)[2]. To the best of my knowledge, this paper is the first to study the effect of this type of BBR on economic growth. It has three main findings.

First, I find that the BBR adoption has positively impacted Switzerland's economic growth from 2003 to 2018 compared to a counterfactual scenario without BBR. To obtain this result, I used a synthetic control method to construct the counterfactual for Switzerland. Indeed, for aggregate units as countries, finding a suitable single comparison unit is challenging. The idea of the synthetic control is to use a convex combination of many countries such that they can replicate Switzerland's characteristics without the BBR. I find that a convex combination of Canada, the US, Luxemburg, and Norway can closely track Switzerland's GDP per capita. The results are robust to many standard tests. In addition, using a neoclassical growth model, I conduct a growth accounting exercise to identify the key drivers of Switzerland's economic growth. I find that changes in total factor productivity (TFP), which includes institutional changes, were the primary driver of growth, rather than changes in labor or capital accumulation. More importantly, TFP growth increased significantly after the adoption of the BBR in 2003 (see Figure 1.5). Furthermore, the total spending in R&D started increasing in the early 2000s, which is the period where the rule has been adopted (see Figure A.3). Based on these results, I built a model to better understand the mechanisms behind the effect of the BBR on economic growth. The model also served to conduct counterfactual analyses.

Second, I develop an endogenous growth model in which the government makes inefficient decisions due to political frictions. Indeed, recent literature extensively demonstrates that governments should not be viewed as social planners, as their objectives—such as re-election—can significantly influence their decision-making (see Yared (2019) for a thorough discussion). In this paper, I consider a government which is present-biased

2. Chile has revised its constitutional BBR of 2001 multiple times, with the latest version being created in 2014. This latest version shares a key feature with Switzerland's BBR, which is to focus on the potential GDP. Grenada also adopted a similar rule in 2015. A new structural balance rule was enshrined in Germany's constitution in June 2009. After a transition period, starting in 2011, it took full effect in 2016 for the Federal government. The rule calls for a structural deficit of no more than 0.35 percent of GDP for the Federal government. In 2017 Austria adopted a rule similar to Germany's but not yet in the constitution. It is currently too early to assess the effect on these countries' growth. The IMF Fiscal rules data set from 2017 contains further information on these rules.

or myopic, meaning that it values short-term outcomes over long-term outcomes. In the model, growth is driven by both public and private investments in R&D. The political friction results in a strictly positive level of public debt in the balanced growth path whereas it is zero when there is no political friction. This "high" level of debt in the political friction economy diverts resources from private agents towards government bond purchases creating a crowding-out effect on private investment in R&D. In the meantime, it also reduces resources left to the government because of public debt and interest payment. The introduction of the Balanced Budget Rule in this framework reduces the inefficient debt accumulation and counters the crowding out effect of debt by freeing up resources for private investment in R&D. Moreover, by reducing the debt and thus the service of the debt, the government also makes more investments in R&D. These two channels increase growth. Calibrating this model to Switzerland, the yearly long-run effect of the BBR is estimated to be 1.27 basis points which compounded to a 1% GDP gain after 10 years compared to a scenario with no fiscal rule.

Third the paper compares the new Balanced Budget Rule to "traditional" cap on deficit Balanced Budget Rules such as the 3% deficit limit in the European Union and WAEMU, and a strict zero deficit rule. The comparison has been done both in terms of growth and welfare. Compared to traditional BBRs, the new BBR exhibits growth twice as much as that of traditional BBRs. The reason is that in traditional BBRs, the primary concern is strictly adhering to the deficit limit, irrespective of the economic conditions (whether a recession or an expansion). When the deficit limit is reached during a recession, compliance with the rule can be achieved either by cutting government spending on public goods and investments or by raising taxes. The first channel is the **direct effect**: a reduction in public spending on research and development (R&D) directly reduces economic growth. The second channel is the **indirect effect**: raising taxes diminishes citizens' disposable income, leading to lower private investment in R&D, which further reduces economic growth. Unlike the traditional BBR, the new BBR directly ties government actions to economic conditions. Specifically, if GDP falls below its potential, the new BBR allows the government to run a higher deficit, while if GDP exceeds potential, the rule imposes savings. This flexibility enables the government to maintain higher investment levels (**direct effect**) and lower taxes (**indirect effect**) as opposed to the traditional BBRs that limit the deficit regardless of economic conditions. Lower private and public investment under the traditional BBR explains why economic growth tends to be slower compared to the new BBR.

Using a consumption equivalent variation, I also find that traditional BBRs reduce welfare by 5.86% while the new BBR increases it by 7.44% compared to a scenario without fiscal rule. Similar direct and indirect channels mentioned above explain this result. Specifically, imposing a traditional BBR in the context of high public debt or high deficit does not lead to significant long-term growth. Instead, it alters government behavior in the short run, leading to reduced investment and a *diminished provision of public goods* (direct effect) as well as higher taxes, which lower disposable income and *reduce citizens' consumption* (indirect effect) [see Figure A.10 in the appendix]. An additional reason why welfare is higher under the new BBR is the higher economic growth it enables, which provides more resources for both public goods and private consumption. This result may help explain the **lack of effective enforcement of traditional BBRs** (Reuter, 2019) since their full enforcement is welfare-reducing [3].

Related literature. This paper contributes to three strands of literature. Firstly, it builds on the existing literature on the empirical evidence of Balanced Budget Rules (BBRs) on the economy. Most of the studies in this area have primarily focused on the effects of BBRs on public finance management. These studies include seminal papers such as Poterba (1994, 1995, 1996); Inman (1996); Levinson (1998); Bohn and Inman (1996). For instance, Bohn and Inman (1996) investigated the effects of BBRs on the 47 states in the US from 1970 to 1991 and found that the retrospective (end-of-the-year) balance requirements positively impacted a state's general fund surplus. None of the above studies examined the BBR over the business cycle under consideration in this paper since this rule is recent in practice. However, recent research by Asatryan et al. (2018) studied Switzerland's case in more detail. In addition to applying a difference-in-differences design on historical data for a large set of countries dating back to the

3. As shown in Reuter (2019), governments comply with traditional balanced budget rules (BBRs) only 35% of the time, while compliance with debt rules is significantly higher at 88%.

nineteenth century. They found that the introduction of a constitutional BBR leads to a reduced probability of experiencing a sovereign debt crisis. Specifically, they found that after the BBR adoption in Switzerland, its debt declined by 30 percentage points. Nonetheless, this paper is the first to empirically investigate the effects of the BBR over the business cycle on economic growth. By doing so, this study aims to contribute to the ongoing debate on the impact of fiscal rules on economic performance.

Secondly, this paper contributes to the existing literature on frameworks for analyzing balanced budget rules (BBRs). Notable works in this area include those of Battaglini and Coate (2008), Barseghyan et al. (2013), Azzimonti et al. (2016), and Barseghyan and Battaglini (2016). However, these studies model zero-deficit BBRs, which are known to be procyclical and may result in higher taxes and reduced public spending during recessions, as well as lower taxes and increased public spending during booms. This behavior of public policy is not supported by empirical evidence (Barseghyan and Battaglini, 2016). In contrast, I model a Balanced Budget Rule (BBR) over the business cycle, allowing for deficits during recessions and surpluses during booms—a feature that helps the government face adverse economic shocks without violating the rule. In addition, these papers do not focus on the growth effect of BBRs which is the primary objective of this paper. To do so, I build an endogenous growth model with political friction. This friction justifies the introduction of a fiscal rule in the model.

Thirdly, it contributes to the literature on the political economy of public debt, fiscal policy, and economic growth (Persson and Svensson, 1989; Alesina and Tabellini, 1990; Stockman, 2001; Debortoli and Nunes, 2008; Fatás and Mihov, 2006; Aguiar and Amador, 2011; Checherita-Westphal and Rother, 2012; Heinemann et al., 2014; Arawatari and Ono, 2021; Aghion et al., 2014). A recent study is Uchida and Ono (2021), where in an overlapping-generations model with physical and human capital accumulation, they analyze the effects of a debt ceiling on a government's policy formation and its impact on growth and welfare. Their results show that the debt ceiling induces the government to shift the tax burdens from older to younger generations, but it stimulates physical capital accumulation and may increase public education expenditure, leading to a higher growth rate. In contrast to them and based on my empirical findings, I have no capital in my model and focus on the TFP (namely R&D) as the main driver of growth. By doing so, this study extends the framework of Barseghyan and Battaglini (2016) by considering a present biased government as an exogenous political friction, in contrast to their focus on legislative bargaining with pork barrel spending.

The remainder of this paper is organised as follows. Section 2 presents the empirical analysis, followed by the model's description in Section 3. Section 4 provides a quantitative evaluation of the proposed model, while Section 5 concludes and identifies avenues for future research.

1.1 Empirical analysis of the effect of BBR on growth

Using the synthetic control method, I construct a counterfactual for Switzerland, which adopted a Balanced Budget Rule (BBR) in 2003. I find that, since the rule's adoption, Switzerland's GDP per capita has grown at an average yearly rate of 0.95% faster than its counterfactual over the 2003-2018 period. Before delving into the details of the empirical strategy, I will first present Switzerland's BBR and the data used for this analysis.

1.1.1 Switzerland's BBR, data, and descriptive statistics

Here I present the data, their sources, and some descriptive statistics used for the empirical assessment of the BBR.

Switzerland's BBR

In 2001, Switzerland implemented a fiscal rule, which can be found in article 126 of its Constitution. This rule, commonly referred to as the "debt brake", "debt containment rule" or "Balanced Budget Rule over the business cycle (BBR)," became effective in 2003.

The Balanced Budget Rule (BBR) is anchored in the Constitution and can only be changed through a popular vote. It was overwhelmingly approved by 85% of voters on December 2, 2001. The rule has two primary objectives: (1) to maintain a structurally balanced budget, and (2) to allow for automatic stabilizers to function(Kraan and Ruffner (2005))[4]. The rule is based on the principle that government spending (G_t) should be lower or equal to the business cycle-adjusted revenue ($k_t R_t$), where $k_t = \frac{y_t^*}{y_t}$ is the business cycle adjustment factor. The term y_t is the real GDP while y_t^* is the trend (or potential) real GDP. Specifically, if $y_t \leq y_t^*$ a deficit is allowed but when $y_t > y_t^*$ a surplus is required. Since potential GDP is not observed, it should be estimated. Before 2021, it has been determined by a modified Hodrick and Prescott (HP) filter (Bruchez, 2003), but since 2021 the Federal Financial Administration (FFA) has been using the production function and the output gap is calculated by the State Secretariat for Economic Affairs (SECO).

The BBR is applied twice: first to budget forecasts and then to actual outcomes. A compensation account is used to determine deviations that must be credited or debited in the account. Any deficits in this account must be considered when setting new expenditure ceilings for the following years. If the deficit exceeds 6% of expenditure, the excess amount must be eliminated within the next three annual budgets. Further details on the BBR can be found in Kraan and Ruffner (2005); Geier (2011); Salvi et al. (2020).

The data and their sources

The data sets used in this part come from the IMF database on fiscal rules where I identify the different fiscal rules for each country. Indeed, I need many countries to construct a counterfactual for Switzerland. From IMF fiscal monitor and World Economic Outlook I get countries debt/GDP, investment rate (total investment as a percentage of GDP). I get GDP per capita from Maddison Project Database 2020 . From World Development Indicators (WDI), I selected the following variables with the potential to affect economic growth: Trade openness (Import plus export), inflation rate, Private and public

4. Let automatic stabilizers function implies deficits in periods of recessions and surpluses in economic upturns.

sectors R & D, labor force [5], industry share [6] and educational attainment [7]. I also take data on the level of democracy as a proxy for the institutional setup from Center for Systemic Peace [8]. The institutional setup is important because good institutions create a better framework for growth including justice, and property rights protection (Acemoglu et al., 2019). Good institutions can also incentivize technical progress and innovation.

These data cover 41 years from 1978 to 2018 and 23 OECD countries. The list of countries is presented in Table A.1 in appendix A.1. Since I'm interested in constructing a counterfactual, it is important to have countries that are expected to be driven by similar structural processes as Switzerland. Thus, I choose OECD countries because they have many common features and are comparable, namely in terms of GDP per capita, level of development, education, institutions (democracy), and so on. Additionally, only Switzerland adopted the BBR over the business cycle in 2003, so the counterfactual constructed using other countries could be seen as Switzerland without the BBR. Nevertheless, I did not take all OECD countries into account because of data availability and particular crises affecting some countries. As stated in Abadie (2021), it is important to eliminate from the donor pool any units that may have suffered large idiosyncratic shocks to the outcome during the study period. Therefore, I excluded the Czech Republic, Estonia, Hungary, the Slovak Republic, and Slovenia because their jurisdictional status has changed since 1980. I also excluded Italy and Greece because they were much more affected by the European debt crisis. However, the best counterfactual estimate does not include these countries even when I keep them in the donor pool.

5. Labor force participation rate is the proportion of the population ages 15-64 that is economically active: all people who supply labor for the production of goods and services during a specified period.

6. Industry corresponds to ISIC divisions 10-45 and includes manufacturing (ISIC divisions 15-37). It comprises value added in mining, manufacturing (also reported as a separate subgroup), construction, electricity, water, and gas (from World Bank Group).

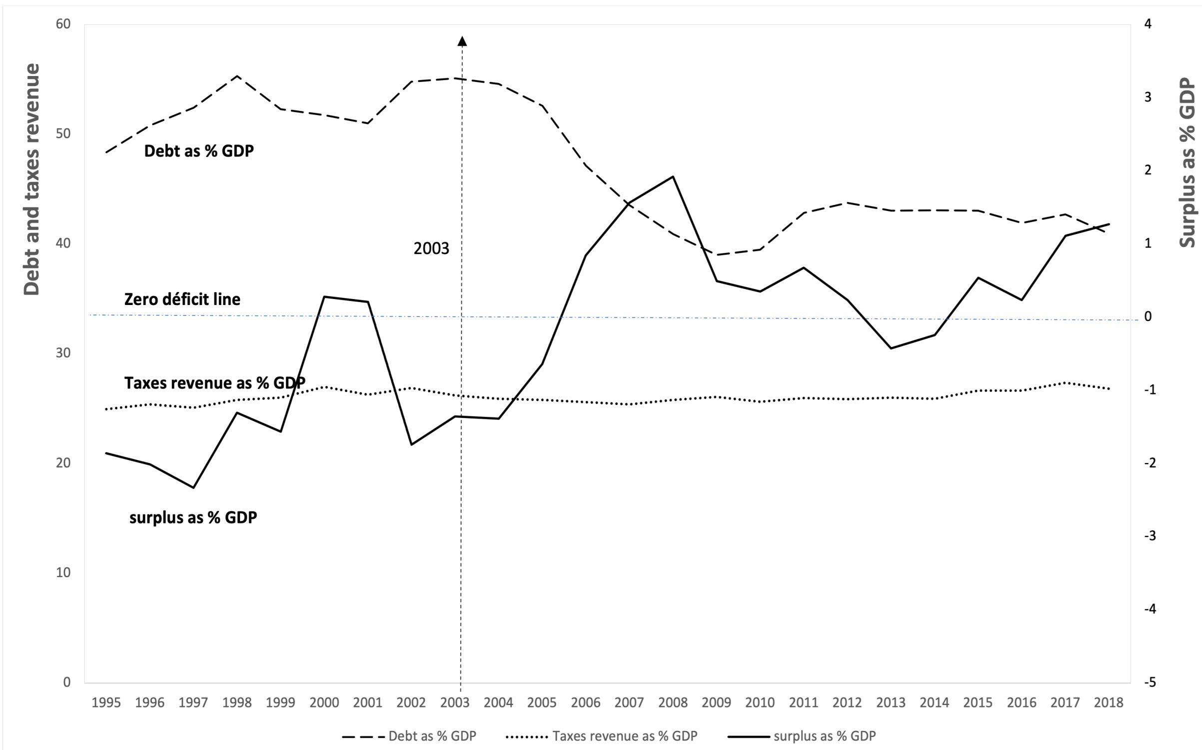
7. % population aged 25-64 which attained the tertiary level (from Barro and Lee, January 2016)

8. I retrieved the variable *"polity 2"*. *polity 2* is a score ranging from -10 (hereditary monarchy) to +10 (consolidated democracy). It analyses real-time political events to provide the scores. These events include political competition, political instability, respect for institutions, power concentration, etc.

Descriptive statistics

Here I present public finance data for Switzerland that may have been impacted by the BBR. Specifically, Figure 1.1 displays the changes in debt, tax revenue, and surplus as a proportion of GDP before and after the BBR was implemented. The information presented here is based on data collected from the OECD.

Figure 1.1 – taxes revenue, debt, and surplus



Note: All three variables presented here have been retrieved from OECD Stat. A negative surplus indicates a deficit. The vertical line at 2003 marks the adoption of the BBR.

The surplus displayed in Figure 1.1 increased after the adoption of the BBR, rising from a deficit of 1.35% in 2003 to a surplus of almost 2% of GDP in 2008. Consequently, the debt decreased significantly from 55% in 2003 to 35% in 2009, representing a reduction of 20% in debt as a share of GDP in just six years. However, due to the financial crisis, the surplus decreased from 2008 onwards. The impact of the BBR on Switzerland's debt has been studied in more detail in Asatryan et al. (2018). It is worth noting that tax revenue remained steady throughout the period, at around 25% of GDP. This is because any increase in taxes would require a constitutional amendment in Switzerland, as stated in Geier (2011).

Figure A.6 in Appendix A.1 does not clearly demonstrate the impact of the BBR on Switzerland's economic growth. However, if we exclude the 2008 subprime crisis, the graph suggests that Switzerland's GDP changes were more stable and consistently positive after 2003. Nevertheless, a more rigorous analysis is necessary to precisely identify the effect of the BBR on Switzerland's economic growth. The upcoming section will present a detailed empirical approach to estimate this effect.

1.1.2 Empirical Strategy

To estimate a counterfactual for aggregate units such as regions or countries, a suitable single comparison doesn't exist. Abadie and Gardeazabal (2003) proposed a method adapted to these situations: the synthetic control. The intuition is that a combination of comparison units often better reproduces the characteristics of the unit. A brief description of the method is as follows.

Let $Y_{i,t}^1$ be Switzerland's GDP per capita with BBR and $Y_{i,t}^0$ Switzerland's GDP per capita without BBR. If we could observe these two variables, the causal effect would be estimated through $\alpha_{it} = Y_{i,t}^1 - Y_{i,t}^0$. But because we do not observe Switzerland without BBR after the adoption of the rule, we need to estimate $Y_{i,t}^0$. The idea is that a weighted average of countries in a control group can represent Switzerland's properties (called: synthetic Switzerland). The weights $W = (w_1, ..., w_J)'$, J being the number of countries in the donors' pool, are selected to minimize $\|X_1 - X_0W\|$. The vectors X_1 and X_0 are of dimension $kx1$ and kxJ. They represent the characteristics during the period before the adoption of the BBR for the treated unit and untreated units respectively. As characteristics in X_0 and X_1 I choose GDP per capita, investment rate, trade openness, schooling, inflation rate, industry share, unemployment rate, labor force, and level of democracy [polity 2]. The symbol $\|.\|$ is the distance defined as:

$$(\sum_{m=1}^{k} v_m \, (X_{1m} - X_{0m} W)^2)^{1/2} \tag{1.1}$$

v_m is the relative importance of each variable. For each fixed $V = (v_1, ..., v_k)$ the weights $W(V) = (w_1, ..., w_J)'$ are chosen to minimize the root Mean Square prediction error (RMSPE) in the pre-intervention period defined as RMSPE $= \left(\frac{1}{T} \sum_{t=1}^{T} \left(Y_{1t} - \sum_{j=1}^{J} w_j Y_{jt} \right)^2 \right)^{1/2}$.[9]

The donors pool is composed of OECD countries. Once the weights are estimated, we can have the counterfactual (synthetic Switzerland) as $Y_{s,t}^0 = \sum_{j=1}^{J} w_j Y_{j,t}$. For a full and recent description of the model, a discussion on data requirements, and robustness tests, see Abadie (2021). The results of our study are presented in the next subsection.

1.1.3 Empirical results

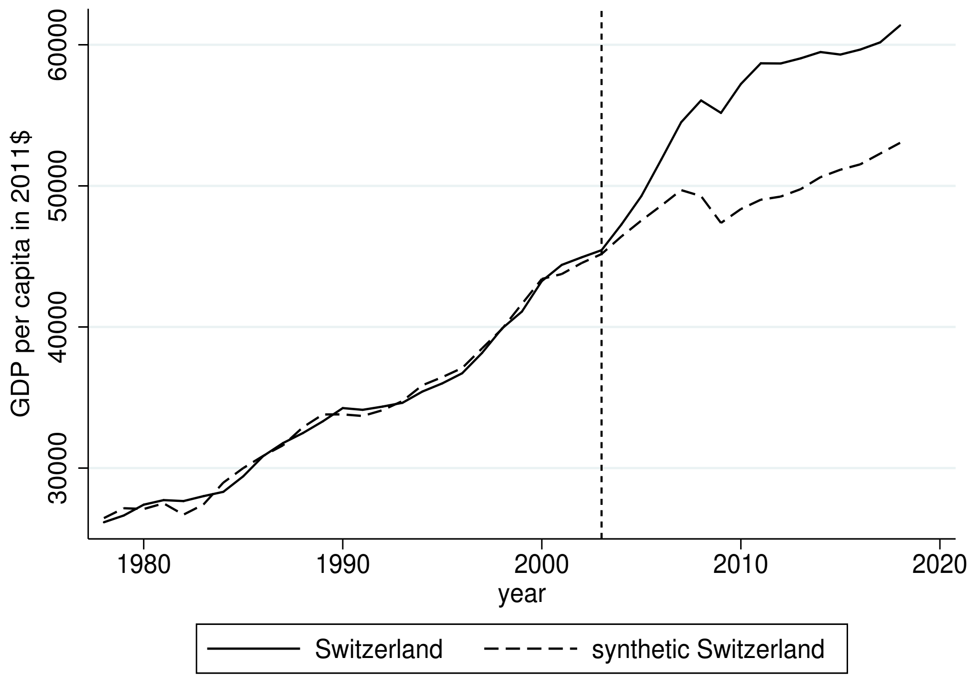
The following subsections present and discuss the results of the synthetic control analysis, which is then complemented by a growth accounting exercise aimed at investigating some mechanisms behind Switzerland's growth.

1.1.3.1 Baseline results

The results in Figure 1.2 show that synthetic Switzerland is a combination of Canada (with a weight of 40.2%), the United States (39.4%), Luxembourg (15.2%), and Norway (5.3%). It provides a visual representation of how well the synthetic estimate approximates Switzerland's GDP per capita. The Figure depicts that Switzerland's actual GDP per capita and its synthetic counterpart (synthetic Switzerland) were similar in the period before the intervention (1978-2002). However, following the implementation of the Balanced Budget Rule over the business cycle (BBR), a clear divergence emerged between Switzerland and its counterfactual, suggesting that the adoption of the BBR has had an

9. The variable importance v_m is determined through a data-driven process. We start by setting an initial value for v_m and selecting the corresponding weights. This process is iterated until the weights are optimized to closely match Switzerland's GDP with that of its counterfactual (Abadie and Gardeazabal, 2003; Abadie, 2021).

Figure 1.2 – The BBR effect on GDP per capita



Synthetic is a weigthed average of Canada (40,2%), US (39,4%), Luxembourg (15,2%), Norway (5,3%).

impact on Switzerland's GDP per capita.

Focusing on the post-intervention period (2003-2018), Table 1.1 below presents the average growth rates for Switzerland and its counterfactual after the implementation of the Balanced Budget Rule (BBR). To analyze this period, I divided it into two subperiods: before and after the 2008 financial crisis, and into two equal subperiods of seven years each.

Table 1.1 – Average growth rates in %

Countries	2003-2010	2011-2018	2003-2008	2009-2018	2003-2018
Switzerland	3.27	0.64	3.31	1.2	2.04
Synthetic Switzerland	1.05	1.14	0.83	1.27	1.09
Difference	2.2	-0.5	2.48	-0.07	0.95

Note: Here I present the average growth rates for Switzerland and its counterfactual for the post-intervention period. I show two different splinting of the period. The first one is just diving the 14 years post-intervention period in 2. The second is before the financial crisis and after.

The findings reveal that during the first seven years after the BBR adoption, Switzerland experienced an average growth rate of 3.27%, compared to 1.05% for its counterfactual, representing Switzerland without the BBR. This corresponds to a 2.2% difference in growth. However, in the subsequent seven years, Switzerland's growth slowed down, averaging 0.64% compared to 1.14% for its counterfactual, representing a difference of -0.5%. Overall, Switzerland has grown 0.94% higher than its counterfactual, leading to 15% higher GDP per capita ten years after the rule's adoption, as shown in appendix Figure A.2.

Table 1.2 displays the means of various variables during the pre-intervention period (1978-2002) for Switzerland, synthetic Switzerland, and the 22 OECD countries in the donor pool. Only variables with a relative importance of more than 0.15% in constructing the counterfactual are included, namely GDP per capita, debt over GDP, inflation, democracy, unemployment, and labor force. The results reveal that, except for debt over GDP, the means of synthetic Switzerland are closer to the means of Switzerland's variables than to the means of these variables in the donor pool (OECD).

Table 1.2 – Means of variables on the preintervention period

Variables	Switzerland	Synthetic Switzerland	OECD
GDP per capita	28843.29	28326.39	24525.389
Debt over GDP	43.0603	58.45146	55.519604
Inflation	2.317375	3.690289	7.9120184
Democracy	10	9.817581	8.4934058
Unemployment	3.188333	6.473994	7.70625
Labor force	80.40385	73.99676	69.54359

Note: Here I present the most important variables (more than 0.15% as contribution) in constructing Switzerland's counterfactual in terms of GDP per capita.

Although the synthetic control does not closely approximate the values of some predictors, such as debt over GDP, unemployment, and labor force, it may not be a significant issue. This is because synthetic Switzerland closely tracks Switzerland's trajectory of the outcome variable, GDP per capita, during a validation period, as shown in Figure 1.4a (Abadie, 2021).

These baseline results could be influenced by various factors. For example, since the construction of the counterfactual was designed to match Switzerland's preintervention characteristics, it may not be surprising to observe a divergence between the two after the rule's adoption, as the postintervention period was not targeted. Moreover, the countries used to construct the counterfactual should not have experienced large shocks that Switzerland did not experience. In the following subsection I discuss the robustness of the results.

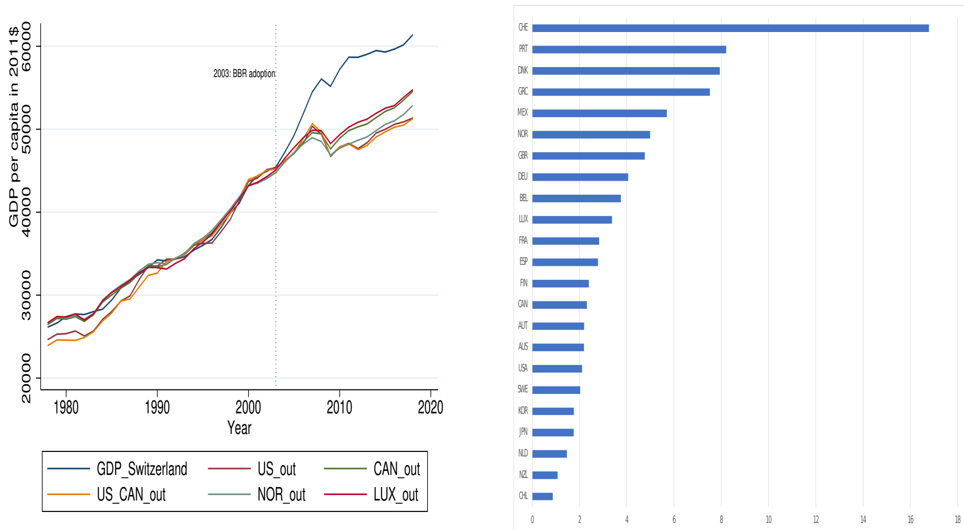
1.1.3.2 Robustness

Here I present four standard robustness tests in the synthetic control literature to investigate the robustness of my results. These tests are: leave one country-out performance, in-space placebo test, in-time placebo test, and out-of-sample performance.

Because synthetic Switzerland is a weighted average of Canada (40,2%), the US (39,4%), Luxembourg (15,2%), and Norway (5,3%), we may ask what happens if we leave each of these countries out. I do that and present the results in Figure 1.3a. I even take simultaneously Canada and the US out which account for 80% in the best synthetic estimation presented earlier. Even with this extreme case, we still estimate the positive effect of the BBR on GDP. Although the effect appears to have been reduced, it can be attributed to the lack of fit. Indeed, in the preintervention period when we look at the `US_CAN_out` graph, we see that it doesn't fit very well. This could explain why counterfactual Switzerland estimated without Canada and the US is a little bit close to Switzerland in the post-intervention period. Even though the difference is still significant. This first test shows that the results are not driven by a particular country. Table A.2 in Appendix A shows the weights of countries for each of these cases.

Another interesting question is to ask if the effects that I just estimated can be due to other factors than the BBR. To answer this question I run an *in space placebo test*. The purpose of this test is to assess whether the gap observed for Switzerland may have been created by factors (common to all or some countries in the sample) other than the Balanced Budget Rule in 2003. The principle of this test is to simulate that each country in the donor pool adopted akin BBR in 2003. If a similar effect to that of Switzerland is observed, it can be concluded that the effect estimated is not solely attributable to the BBR, but rather other factors that may have contributed to it. Let's remind the Root Mean Square Prediction Error (RMSPE) which is defined as $\text{RMSPE} = \left(\frac{1}{T}\sum_{t=1}^{T}\left(Y_{1t} - \sum_{j=1}^{J} w_j Y_{jt}\right)^2\right)^{1/2}$. It is a measure of the difference between a country and its counterfactual estimate. A high measure suggests that the country is far from its counterfactual estimate in terms of GDP per capita. I compute the ratio of the Root Mean Square Prediction Error (RMSPE) during the post-intervention period (2003-2018) to that during the pre-intervention period (1978-2002). If there is an effect for a particular country, we should observe a high ratio. The key criterion is whether there are ratios as high as that of Switzerland (CHE), which is the country of interest in this study. As shown in Figure 1.3b, Switzerland's RMSPE in the post-intervention period is 17 times higher than during the pre-intervention period, which is significantly higher than that of any other country. The second highest ratio, observed for Portugal (PRT), is only 8, far below Switzerland's 17.

The credibility of a synthetic control estimator relies on its ability to replicate the evolution of the outcome variable of the treated unit over a prolonged pre-intervention period (Abadie, 2021). Therefore, to guarantee that the effect estimated is not caused by overfitting in the pre-intervention period, it is crucial to conduct an out-of-sample performance test as a robustness check. Indeed, it is possible to think that the observed effect in the post-intervention period is merely a result of overfitting, where the weights are estimated to match Switzerland's GDP per capita in the pre-intervention period. To address this concern, the pre-intervention period is split into two sets: a test sample from 1978 to 1992 and a validation sample from 1993 to 2003. The pre-intervention period from 1978 to 1992 is used to estimate the counterfactual. When doing so Synthetic Switzerland is a weighted average of the US (0.536), Sweden (0.329), and Luxemburg (0.135). As shown in Figure 1.4a, there is no effect in the validation sample since the rule has not been adopted yet during this period. However, after the rule's adoption in 2003, the effect remains. It is worth noting that the rule was adopted in the constitution in 2001 to be implemented in 2003. This might explain why the effect seems to have started even before 2003. Based on these results, it can be concluded that the observed effects are not due to overfitting in the pre-intervention period. Also, the fact that the



(a) Leave one country out

(b) In space placebo test

Figure 1.3 – Leave one country out and in space placebo tests

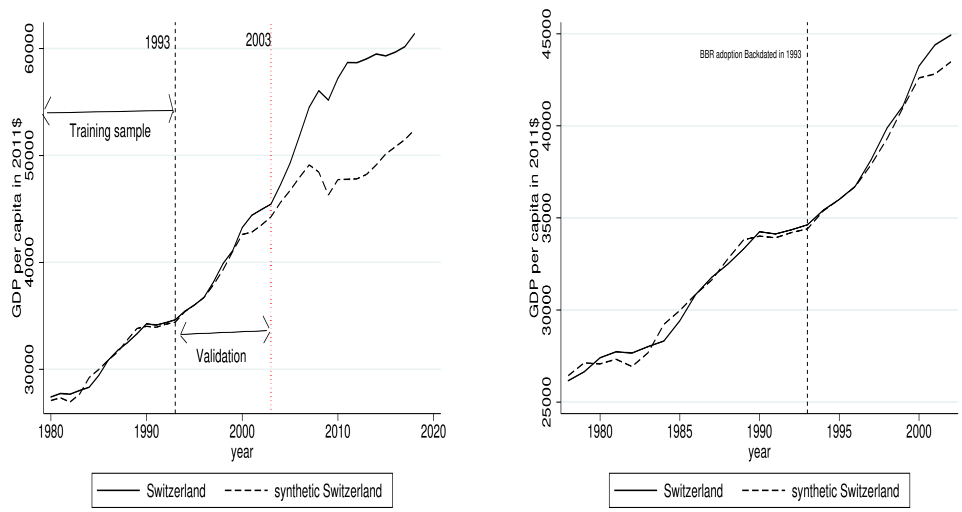
Synthetic control closely tracks Switzerland's GDP in 1.4a is an indication of a low bias in the synthetic estimation (Abadie, 2021).

Another test closely related to the previous one is the *in time placebo test* depicted in Figure 1.4b. This test is conducted by limiting the data to the pre-intervention period, from 1978 to 2002, and simulating a Balanced Budget Rule for Switzerland in 1993. Since there were no BBR implemented between 1993 and 2003, one would anticipate no effect when performing this estimation. As illustrated in Figure 1.4b, I find no effect.

In Appendix B (Figure A.1), I conducted a final test, a data-driven method by leaving out one variable at a time to evaluate the sensitivity of the results to the variables used in constructing the counterfactual. The results show that even after removing one variable at a time, the results remain robust.

The findings from the various robustness tests are in agreement with the baseline findings, demonstrating that the adoption of the BBR has led to increased economic growth in Switzerland. Now, what mechanisms could explain these results? I'll use a neoclassical growth model to provide some intuition to answer that question.

The neoclassical growth model explains growth through three main factors: capital, labor, and total factor productivity (TFP). Since TFP encompasses institutions, and given



(a) Out of sample performance

(b) In time placebo test

Figure 1.4 – Out of sample and in time placebo tests

that the Balanced Budget Rule (BBR) has been adopted into the Swiss constitution, it is reasonable to expect TFP to be the primary driver of Switzerland's growth. We examine this hypothesis with a growth accounting exercise.

1.1.3.3 Growth accounting for Switzerland and its counterfactual

Our analysis so far has demonstrated that Switzerland experienced higher growth after 2003 compared to its synthetic counterfactual. It is necessary to determine whether this shift can be attributed to changes in the country's institutions (i.e. TFP), capital, or labor. To answer this question, I conduct a growth accounting exercise, following Bergoeing et al. (2002). The neoclassical growth model posits that economic growth is driven by three main factors: labor, capital accumulation, and total factor productivity (TFP).

Total factor productivity (TFP) is a residual after taking the impact of changes in capital and labor inputs out of changes in real output. It takes into account the impact of technical progress (such as R&D), the discovery of natural resources, and changes in institutions (such as the adoption of the BBR in Switzerland's constitution in 2003). However, from my knowledge, Switzerland did not experience any significant technical progress or natural resource discoveries in or around 2003. Therefore, it is likely that at least part of changes in TFP was due to institutional changes, specifically the adoption of the BBR in the constitution.

According to the neoclassical growth model, the GDP (Y_t) can be represented by Cobb-Douglass technology as:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{1.2}$$

where L_t, is labor: K_t is capital and A_t is Total Factor Productivity (TFP) which is calculated as the residual after accounting for capital and labor as follows :

$$A_t = \frac{Y_t}{K_t^{\alpha} L_t^{1-\alpha}} \tag{1.3}$$

Based on Kaldor's facts, we transform this equation in terms of GDP per working-age person. This expression also allows for comparisons across countries. The transformation gives :

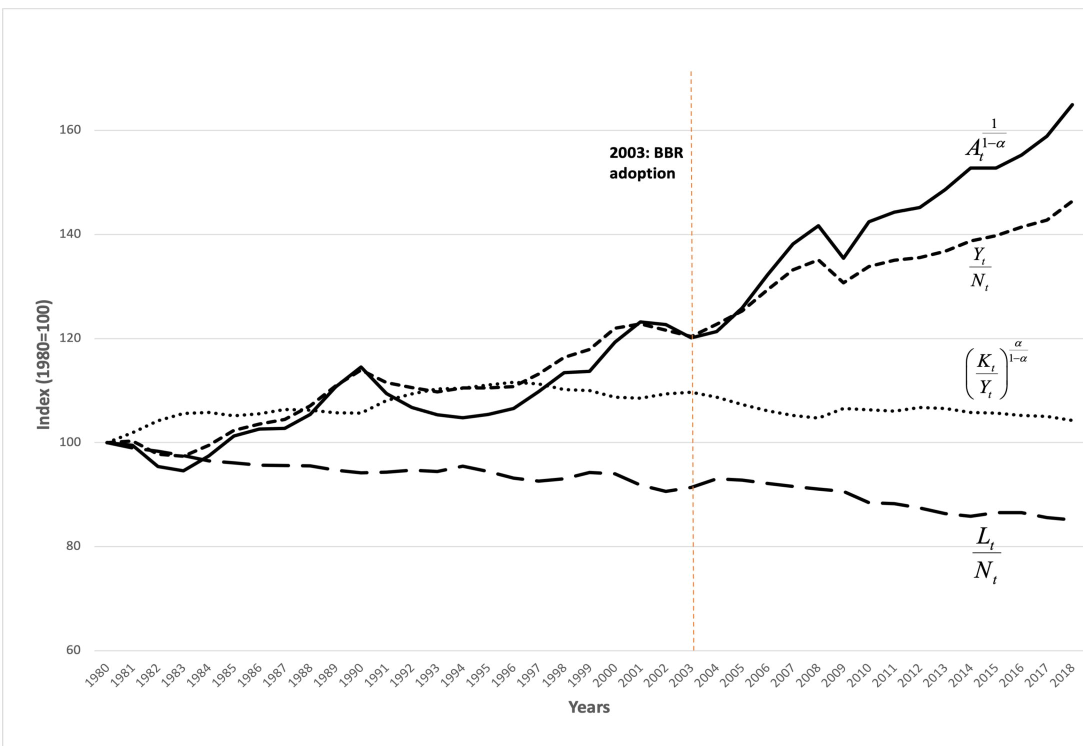
$$\frac{Y_t}{N_t} = A_t^{\frac{1}{1-\alpha}} (\frac{K_t}{Y_t})^{\frac{\alpha}{1-\alpha}} \frac{L_t}{N_t} \tag{1.4}$$

N_t is the working-age population. While we observe L_t and N_t, we do not observe the capital stock K_t. So one needs to construct it. To do so, I use the perpetual inventory method. The evolution of the stock of capital is given by $K_{t+1} = (1-\delta)K_t + I_t$; I_t is the investment and δ is the depreciation rate. The data used for growth accounting covers the period from 1980 to 2018. The data sources used are the World Development Indicators. Specifically, the data used includes the Consumption of Fixed Capital (CFC), the Constant Gross Domestic Product (GDP), and Investment (I_t), which is the sum of Gross Fixed Capital Formation and Changes in Inventories

The data on Hours Worked used for the analysis come from two different datasets. For the period between 1980 and 1990, the data is obtained from our world in data. For the period between 1991 and 2018, the data is obtained from the OECD. The data on the Working-Age Population, which is defined as the population between 15-64 years old, is sourced from the OECD.

The parameter α is standard from the literature and is set to 0.3. The depreciation rate δ and the initial capital are chosen to match the data. δ is chosen such that the means of $\frac{CFC_t}{Y_t}$ and $\frac{\delta K_t}{Y_t}$ are equal over the entire period. Given any δ we need a value for the initial capital to be able to generate all the stock of capital. So K_0 is chosen such that $\frac{K_1}{K_0} = (\frac{K_{10}}{K_0})^{0.1}$. The date 0 here is 1980. We chose δ and K_0 such that these two equations hold. This gives $\delta = 0.056$. Given the differences in scale, we constructed indexes of the different components of the growth accounting to better visualize their evolution over time. For each variable V we construct its index as $VI_t = V_t * 100/V_0$. The evolution of the different indexes is given in Figure 1.5 for Switzerland and in 1.6 for synthetic Switzerland [10].

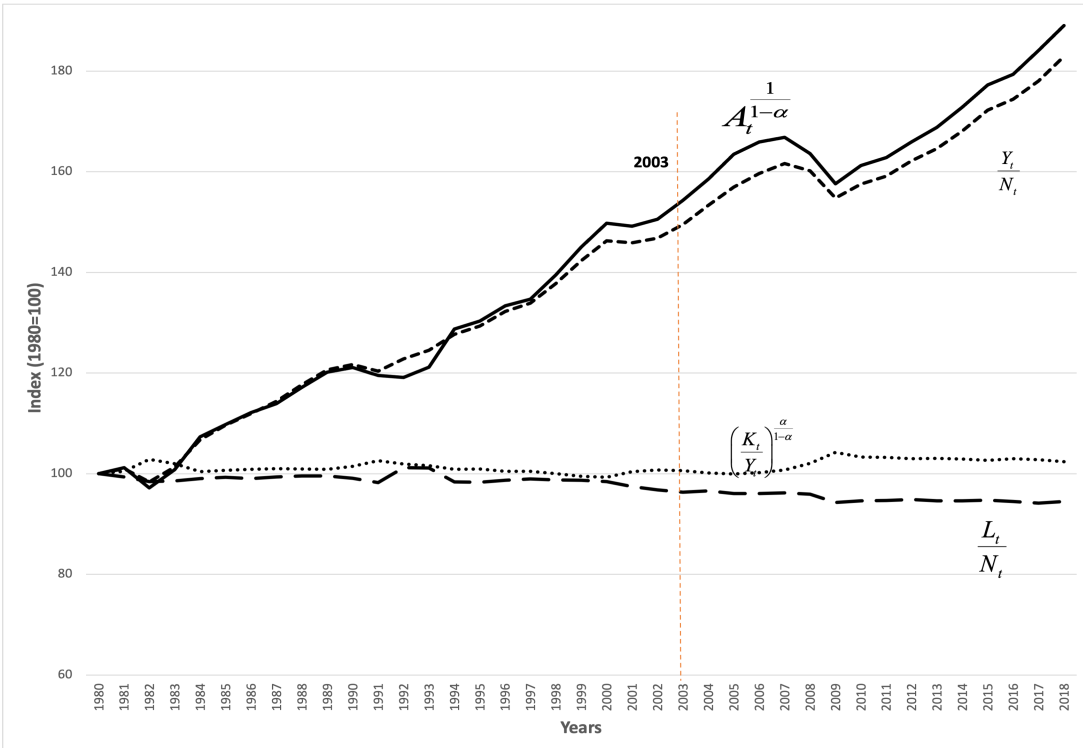
Figure 1.5 – Switzerland's growth accounting



Note: I construct the capital stock K_t using the perpetual inventory method. The working-age population aged 15-64 N_t, hours worked L_t and the GDP in 2015 constant USD Y_t are sourced from the World Development Indicators. A_t represents the Solow residual from the Cobb-Douglass production function.

10. Remind that synthetic Switzerland is the weighted average of Canda (40.2%), US (39.4%), Luxembourg (15.2%) and Norway (5.3%)

Figure 1.6 – Synthetic Switzerland growth accounting



Note: To obtain the different variables for synthetic Switzerland, I first construct each variable for each country and then apply the estimated weights derived from the synthetic control method in the previous section.

The Growth Accounting analysis conducted shows that changes in both Switzerland's and Synthetic Switzerland's economic growth rates are primarily driven by changes in Total Factor Productivity (TFP), rather than changes in labor or capital accumulation. This finding confirms our intuition that changes in economic institutions can impact economic growth by influencing TFP. Furthermore, the analysis reveals an interesting trend where TFP growth was lower than GDP growth in Switzerland prior to the adoption of the BBR in 2003, as depicted in Figure 1.5.

But after the adoption of the BBR in 2003, the growth rate of TFP in Switzerland accelerated significantly and surpassed the growth rate of GDP per working-age person. However, when we examine Figure 1.6, there does not appear to be any significant change in TFP growth in 2003 in the Synthetic Switzerland case. Importantly, the analysis does not indicate a decrease in TFP growth following the BBR adoption, as such a decline would suggest that the estimated effect of the BBR in the Synthetic control analysis was due to a recession in countries included in the donor pool. Furthermore, the study finds that over the period of analysis, the share of capital in GDP and the efficient labor component remained roughly constant.

The results obtained from both the Synthetic Control and Growth Accounting analyses suggest that the adoption of the BBR can impact economic growth by influencing Total Factor Productivity (TFP). This provides insight into how to build a model that can explain the effect of the BBR on growth.

The growth model presented in the following section takes the TFP component, specifically Research and Development (R&D), as the primary driving factor of economic growth. This choice is also supported by the dynamic of R&D spending in Switzerland, as illustrated in Figure A.3 of appendix A.1. This Figure shows that R&D spending in Switzerland has increased significantly since the early 2000s. This is in line with the results of Kehoe et al. (2002) which highlights that government policies that affect TFP can affect growth.

1.1.3.4 Discussion and conclusion of the empirical part

The 2008 Great Recession

It is important to discuss the possible impact of the financial crisis in 2008 since Switzerland is known to be a financial hub. One may argue that the growth experience in Switzerland is amplified by massive net capital inflows due to the financial crisis. But as shown in Yeşin (2015), despite the capital inflows into Switzerland during the financial crisis, there were also significant capital outflows from the country. Indeed foreign investors invested in Switzerland and domestic investors invested outside Switzerland leading to a very volatile net capital inflow (Yeşin, 2015). I also computed the growth rate for Switzerland and its counterfactual before the financial crisis (2008) and after (2009-2018) [see Table 1.1 above]. The results show that Switzerland's growth was much higher before the financial crisis compared to its counterfactual. This suggests actually that the financial crisis might have affected negatively Switzerland's growth more than the counterfactual country. Therefore the concerns suggesting that the estimated growth is biased upward due to the subprime financial crisis may not be valid, and in fact, it seems to be the opposite.

The role of trade and the Swiss franc

Trade can affect an economy's growth since the value of exports can increase due to an improvement in the country's terms of trade. Switzerland's terms of trade have indeed increased after the adoption of the BBR. However, it is crucial to compare this with the Counterfactual's terms of trade. If synthetic Switzerland's terms of trade had been significantly lower than Switzerland's, then terms of trade might have played an important role in Switzerland's trade. As shown in Figure A.5 of appendix A.1, this is not the case. From 2003 to 2009, synthetic Switzerland's terms of trade were above Switzerland's terms of trade [11]. This period coincides with Switzerland experiencing higher growth than its counterfactual. This suggests that if terms of trade had an impact, it was not in favor of Switzerland compared to its counterfactual. It was only in 2015 that Switzerland's terms of trade increased significantly compared to the synthetic one.

Additionally, I used trade openness as a control characteristic to construct synthetic Switzerland, but its weight was negligible (less than 0.15%), indicating that trade played a minimal role in the estimated growth [12]. Switzerland also signed a bilateral free trade agreement with the European Union in 1973, which saw some changes in 2002. However, the critical element to examine is the balance of trade. While the free trade agreement could increase trade, it could also increase imports, making its effect on the balance of trade non-trivial. As shown in Figure A.4 of appendix A.1, we cannot clearly attribute the estimated GDP growth to trade in Switzerland, as both imports and exports have grown simultaneously, with imports often being higher.

It is also important to note that the Swiss franc did not appreciate against the USD in the early 2000s. As depicted in Figure A.7, it even depreciated.

11. Indeed, Canada and Norway have also experienced significant appreciation in their terms of trade. Only Luxembourg's terms of trade declined. However, as shown in the previous robustness test, when Luxembourg is excluded, the results remain valid

12. Trade openness is measured as the sum of exports and imports over GDP.

Endogeneity issue

When making any causal estimation, it is crucial to address potential endogeneity concerns. The first problem might be the reverse causality issue. We could argue that high (or low) growth in GDP could lead to the adoption of the BBR. But, this claim is not supported by the data, as we can see in Figure 1.2, Switzerland's GDP trend was not falling before 2003. In addition, the main reason for the adoption of the BBR in Switzerland was to lower the debt, which justifies why it is sometimes referred to as *the debt brake*.

A second argument that might bias the estimate is the anticipatory effects: the synthetic control estimators may be biased if forward-looking economic agents react in advance of the policy intervention under investigation. If that is the case, one should account for that. A way to deal with this anticipatory effect is to backdate the intervention which has been done in Figure 1.4a. As we can see in that graph the effect of BBR is even larger when we account for the fact that it was voted in 2001.

A third argument is that there should not be spillover effects. We can reasonably assume that there are no interference or spillover effects of the BBR in Switzerland. Indeed, it is less likely that the BBR adopted in Switzerland affected GDPs in other countries in the donor pool (The US, Canada, etc.). Even if that was the case we would have accounted for that in the leave one country out performance in Figure 1.3a. As shown in that graph, there is still a sizeable effect of the BBR whatever the country we take out.

Main empirical takeaways

So far I have shown that the BBR did not prevent growth in Switzerland, contrary to popular wisdom that fiscal rules by constraining the government to borrow can prevent economic growth. It has even led to an increase in the growth of Switzerland making the GDP per capita higher than what it would have been without the BBR, which is in line with Stone (2016), who study the BBRs which constrained states borrowing to only productive investment in the US. I complement my analysis with a growth accounting exercise which reveals that the changes in growth in Switzerland are mainly driven by changes in TFP. After the BBR's adoption in 2003, the TFP growth outperformed the growth of the GDP per working-age person, a pattern not seen before the rule's adoption. Importantly, the effect is not due to a fall in TFP or growth in countries used to construct the counterfactual (synthetic Switzerland). Also as shown in Figure A.3 the R&D spending increased in Switzerland starting in the early 2000s which marks the adoption of the BBR. This suggests that the BBR might have affected Switzerland's growth through its effects on TFP namely the spending in R&D.

Another channel through which the BBR over the business cycle could have affected growth is the fact that it mitigates fiscal policy procyclicality. For a procyclical fiscal policy like the 3% deficit in the Eurozone and WAEMU, when the economy is in recession, the government is constrained to borrow less. Indeed, since the GDP is low (recession), the deficit has a share of GDP increases and can reach more rapidly the 3% deficit limits and therefore constrain government borrowing. This undesirable feature might explain why most of these rules are not respected in practice. A recent study confirms that Switzerland's federal fiscal policy become less procyclical since the BBR over the business cycle adoption (Schaltegger and Weder, 2010).

Besides the fact that I have seriously considered the robustness of the results from the previous empirical strategy and discussed some prominent threats to its validity, a persistent challenge remains concerning the used econometric framework. It assumes that all countries used in the estimation, face the same shocks (or policy reforms) and react similarly to those shocks (or policy reforms) after the BBR. For instance, for the effect to be accurately estimated, Switzerland and synthetic Switzerland are supposed to be affected and respond similarly to the 2008 financial crisis. This is less likely to be the case since Switzerland is a financial hub compared to other countries as discussed in the previous section. So, even though our synthetic control method suggests the BBR impacted Switzerland's growth, the actual effect of 0.95% might be biased due to this reason.

Beyond that, there are some big questions we can't fully answer using this method. Among them, how does the BBR over the business cycle affects people's welfare? Can the BBR work well in other countries and during different economic times? How can it be compared to standard BBRs? To tackle these questions, I built in the second part, a model that can be adapted to other countries. This will help us better understand how our findings could stand outside Switzerland.

1.2 An endogeneous growth model with a present bias government

I start with a simple version of the model without uncertainty and any fiscal rule. The aim is to give intuition by building a model with political friction where a fiscal rule is needed to correct that friction.

1.2.1 Environment

We have a representative consumer from an economy populated by a continuum of infinitely lived citizens. There is a single non-storable consumption good, denoted by c, that is produced using a single factor, labor, denoted by l. There is one public good, denoted by g which is produced from the consumption good. The citizens enjoy the consumption good, invest in their human capital (productivity), benefit from the public good, and supply labor. The representative consumer's preferences are represented by the following per period utility function:

$$U(c_t, l_t, g_t) = log(c_t(1-l_t)^{\mu}) + A_t log(g_t) \tag{1.5}$$

The parameter A_t measures the value of the public good to the citizens at period t (it may be random), and $\mu > 0$ is the elasticity of labor supply. Citizens discount future per period utilities at the factor β. The public good is produced from the consumption good according to a linear technology with a unitary marginal rate of transformation. The consumption good at time t is produced with a linear technology $y_t = z_t \xi_t l_t$. where the product $z_t \xi_t$ determines the economy's overall labor productivity. The variable z_t is interpreted as an economy-wide productivity factor, which is taken as given by the citizens. Basically, z_t captures the productivity from public investment i_t (such as expenditure on research and development, education, public infrastructure, and other productivity-enhancing investment). Let $z_{t+1} = \phi(\frac{i_t}{z_t \xi_t}) z_t$, with $\phi(\frac{i_t}{z_t \xi_t}) = \phi_0.(\frac{i_t}{z_t \xi_t})^{\phi_1}$ a concave increasing function: $\phi_i > 0$, $i = 0,1$ and $\phi_1 < 1$. The function ϕ describes the benefits of public investment. A higher public investment increases next period productivity.

The variable ξ_t is the level of citizens' human capital (productivity). In each period, citizens endogenously determine the level of human capital in the next period, $\xi_{t+1} = \Delta(\frac{s_t}{z_t \xi_t})\xi_t$ by choosing private investment level s_t, which translates into human capital growth according to an increasing concave function $\Delta(\frac{s_t}{z_t \xi_t}) = \Delta_0.(\frac{s_t}{z_t \xi_t})^{\Delta_1}$, $\Delta_i > 0$, $i = 0,1$ and $\Delta_1 < 1$.

There is a competitive labor market; hence, the wage rate in period t is equal to $z_t \xi_t$. The government trades risk-free one-period bonds. Citizens have access to this market. The assets held by a citizen in period t are denoted a_t. The gross interest rate is denoted ρ_t: a unit of consumption worth of bonds at time t yields ρ_t at time $t+1$.

For a given sequence of government policies, citizens' maximization problem in period 0 can be written as:

$$\begin{aligned}
\max_{\{c_t, l_t, s_t, a_{t+1}\}} \quad & \sum_{\text{t}} \beta^t U(c_t, l_t, g_t) \\
\text{subject to} \quad & \frac{a_{t+1}}{\rho_t} + c_t + s_t = (1-\tau_t) z_t \xi_t l_t + a_t + T_t, \\
& \xi_{t+1} = \Delta(\frac{s_t}{z_t \xi_t})\xi_t \;\text{ and }\; z_{t+1} = \phi(\frac{i_t}{z_t \xi_t}) z_t \\
& 0 \le l_t \le 1 \;;\; 0 \le c_t
\end{aligned} \tag{1.6}$$

where τ_t is the tax rate and T_t is the lump-sum transfers from the government. The consumer problem can be solved in closed form. We express the indirect utility from consumption and labor as $u(c^*(p), l^*(p))$, where $p = (\tau, g, i, T)$ is government policies (I abstracted the subscript t to lighten the notations). V is citizen's continuation value, defined recursively as [13] :

$$V(\hat{a}^*) = u(\hat{c}^*(p), l^*(p)) + Alog(\hat{g}) + \beta V(\hat{a}'^*). \tag{1.7}$$

13. The * on variables indicates that they are citizen optimal choice

1.2.2 Public policies

The need for a fiscal rule arises from an exogenous political friction which consists of a present biased government. For several reasons, one should not consider governments as social planners since their objectives may not be perfectly aligned with those of their citizenry. Because governments are seeking popularity (Alesina, 1988; Roubini and Sachs, 1989), they may overspend when in power in order to be reelected (political business cycle and political legacy). Doing so they care more about the present than the future (present bias, Laibson (1997)), spending more and running persistent deficits. In addition, even with the best intentions government spending could actually be inefficient (temptation, self-control, Amador et al. (2006)), and the current government may also not want to follow the rule of previous governments because it doesn't agree with the way these governments acted (political polarization, Alt and Lowry (1994)). Indeed, policymakers apply different policies when in office if they disagree about policy (Wittman, 1983; Calvert, 1985), leading to inefficient policies. The present biased behavior is modeled by modifying the discount factor, making the government more impatient than the citizens. The government discounts at the factor $\beta_g = \alpha\beta$, with $0 \leq \alpha \leq 1$ the present bias parameter.

The government provides a public good g and lump sum transfers T to the citizenry, investing i in the economy. Its revenue comes from linear taxes on labor and bonds b'. The government budget constraint is:

$$\frac{b'}{\rho} + \tau z \xi l = b + g + i + T$$

I divide that constraint by the productivity $z\xi$ and write the government problem as follows:

$$\begin{aligned} V_g(\hat{b}) = & \max_{\{\tau, \hat{g}, \hat{i}, \hat{b}', \hat{T}\}} && \{\mathrm{u}(\hat{\mathrm{c}}^*(\mathrm{p}), \mathrm{l}^*(\mathrm{p})) + \mathrm{A}\log(\hat{\mathrm{g}}) + \beta_g V(\hat{b}')\} \\ & \text{subject to} && Z(p)\frac{\hat{b}'}{\rho} + \tau l^* - \hat{b} - \hat{g} - \hat{I} - \hat{T} = 0 \\ & && \underline{b} \leq \hat{b}' \leq \overline{b} \end{aligned} \tag{1.8}$$

$Z(p) = \frac{z'\xi'}{z\xi}$ is the economy's gross growth rate and it depends on public policies. All the variables denoted by a "hat" are scaled by the economy's productivity $z\xi$ (e.g. $\hat{b} = b/z\xi$,). The scaled model has a steady state which is the balanced growth of the original model. We next define and characterize the equilibrium.

1.2.3 Equilibrium

Definition of Markov Perfect equilibrium

Given b, a Markov Perfect Equilibrium (MPE) is a pair of value functions $V_g(\hat{b})$, $V(\hat{a})$ and a pair of policy functions $p = (\tau(\hat{b}), \hat{g}(\hat{b}), \hat{i}(\hat{b}), \hat{b}'(\hat{b}), \hat{T}(\hat{b}), p_c = (\hat{c}^*(p), l^*(p), \hat{s}^*(p), \hat{a}'^*(p))$ and and interest rates ρ such that:

a. p and $V_g(b)$ solve government problem in (1.8) given p_c, V and interest rate

b. p_c and V satisfy citizen's continuation value in (1.7) given p and interest rate

c. $\hat{b}'(\hat{b}) = \hat{a}'^*(p)$.

1.2.4 Characterization of the Equilibrium

To characterize the equilibrium it is useful to define a key concept in public finance, namely Marginal Cost of Public Fund (MCPF, see Barseghyan and Battaglini (2016); Barseghyan et al. (2013); Battaglini and Coate (2008)). By taxation, the government introduces some distortion into the economy. A measure of that distortion is the Marginal Cost of Public Funds (MCPF). It is the compensating variation for a marginal increase in tax revenues.

In an equilibrium-balanced growth path, a benevolent planner wants to smooth the cost of taxation across time: $MCPF_t^* = MCPF_{t+1}^*$. Does this result still hold in the presence of a political friction economy? The answer is no because there is a wedge between the marginal costs as shown in proposition 1 below.

Proposition 1: In equilibrium,

$$(1 - \varepsilon_\rho(b))MCPF(b) = \alpha MCPF(b') \tag{1.9}$$

Where $\varepsilon_\rho(b) = \frac{\partial \rho(b',b)}{\partial b'} \frac{b'}{\rho(b',b)}$ is the elasticity of interest rate with respect to debt. This elasticity is not zero because the economy is closed and the government debt policy affects the interest rate (the government is not a price taker). The proof is available in the appendix. It is also shown in the appendix that the MCPF is an increasingly convex function of debt.

Equation (1.9) is a generalized Euler equation. It can be interpreted as follows. The left-hand side of this equation is the marginal benefit of debt: by increasing the debt by a unit, tax revenues can be reduced by a unit, inducing a net welfare gain equal to $MCPF(b)$. This term is corrected by $1-\varepsilon_\rho(b)$ because the government is not a price taker. For instance, when $\varepsilon_\rho(b) > 0$ an increase in debt implies an increase in the interest rate, and the corresponding reduction in resources limits the benefit of the increase in debt. For the right-hand side, it can be interpreted as the marginal cost of debt. An increase in debt reduces future resources (with a welfare effect measured by the term $MCPF(b')$) corrected by the political friction parameter.

As we may see, when α is lower (more present bias), the debt b' needed to make the equation hold is high. Then more political friction (present bias), the higher equilibrium level of public debt. This is shown in Figure 1.7.

The following proposition will go further, by showing that without political friction ($\alpha = 1$) the equilibrium level of debt is zero. To do that some definitions are needed.

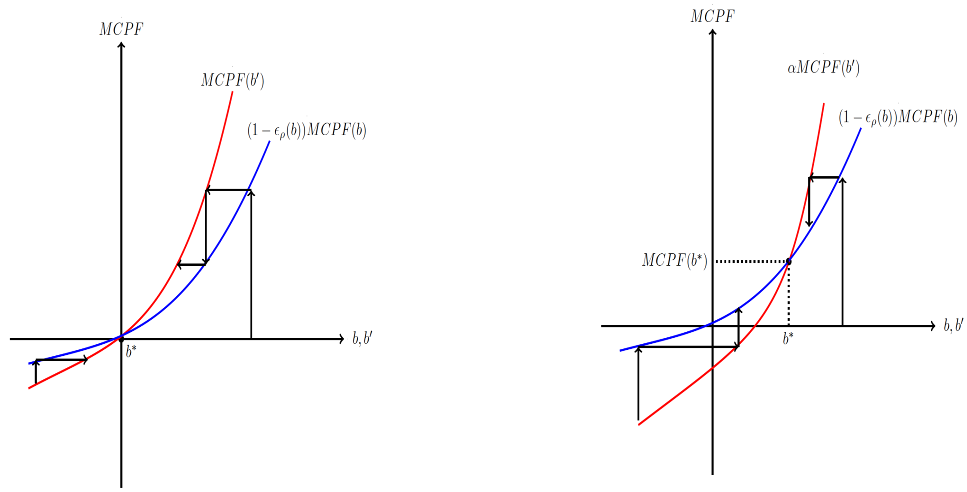
Definitions:

— A balanced growth path is **stable** if there is a neighborhood of b such that b converges to b^* for any initial state b_0 in that neighborhood.

— A balanced growth path is **regular** if it is stable and two conditions are met :(1) debt is positive on the path, i.e. $b^* > 0$ and (2) the interest rate elasticity is positive on the balanced growth path: i.e. $\varepsilon_\rho(b^*) > 0$.

Proposition 2: A balanced growth path is regular only if there is political friction ($\alpha < 1$).

This second proposition demonstrates that the presence of political friction is the only



(a) $\alpha = 1$

(b) $\alpha < 1$

Figure 1.7 – Transitional dynamic

situation that results in positive debt in equilibrium. This justifies the implementation of a fiscal rule to mitigate the bias induced by political friction. Interested readers may refer to the appendix for the proof. These two propositions allow us to determine the transitional dynamics of the debt to the equilibrium, shown in Figure 1.7. Note that the equilibrium is not necessarily unique, but its local property (stability) is preserved and still yields interesting results (Levhari and Mirman, 1980).

Proposition 3: All else equal, an increase in public debt crowds out both private and public investment, thereby exerting a dampening effect on economic growth.

Corollary: The introduction of the BBR by reducing public debt increases economic Growth.

In the next section, I provide a quantitative evaluation of the model, studying the mechanism through which the BBR over the business cycle affects growth and its welfare implications compared to traditional caps on deficit rules.

1.3 Quantitative evaluation

I discipline the above model based on the data for Switzerland. In the next paragraphs, I show the calibration strategy, as well as the validation before presenting the results.

Calibration

I use data on public social expenditure as a share of GDP to measure public good provision. From OECD, social expenditure refers to the provision of cash benefits, goods and services, and tax breaks with social purposes, targeted towards groups such as low-income households, elderly, disabled, sick, unemployed, or young persons. I also use gross domestic spending on Research and Development (R&D) from OECD. The gross domestic spending on research and development (R&D) is the overall amount, including both capital and current expenditures, that resident entities such as research institutes, universities, government laboratories, and companies in a country invest in R&D. This also takes into account the R&D funding that originates from foreign sources. However, any domestic funds that are invested in R&D performed outside the domestic economy are not included in this calculation. This data is used to target private investment and public investment in the model.

Table 1.3 – Calibrated parameters

Parameters	Role	Value	Target/Source	Model	data
ϕ_0	TFP scale parameters	1.016	Av. yearly growth	2.56%	2.42%
Δ_0		1.016			
α	Present bias	0.6	Av. debt/GDP	48.42%	42.62%
ϕ_1	Pub. invest	0.00047	Av. R&D spending	2.43%	2.42%
Δ_1	Priv. invest	0.00075			
β	Discount factor	0.954	BB(2016)		
μ	Elasticity of labor	1.37	BB(2016)		

Note: Data comes from OECD and covers the period 1981-2019. Public debt is from 1990-2003 (before the BBR). Growth is the per capita GDP growth rate based on data from 1960-2002. The average does not change much if we cover all the periods of study up to 2018.

The parameters ϕ_0 and Δ_0 are calibrated to match the balanced growth rate of the model to the average observed Switzerland growth rate over the period 1995-2018. Since the equilibrium level of debt is zero for the social planner, α is calibrated to match the mean of debt/ GDP before 2003. The parameters ϕ_1 and α are chosen to match empirical public investment in $R\&D$ over GDP.

The public spending needs A is stochastic and varies across periods randomly, reflecting shocks such as wars and natural disasters. In terms of the shock structure, we assume that in any period, the economy can be in one of two regimes: "ordinary times" or "extraordinary times". The shocks are discretized using Tauchen (1986)'s method. To have the shock states and the transition matrix I run the following regression $log(g_t) = b + \rho log(g_{t-1}) + u_t$ where the error term u_t is an iid normal distribution. g_t is public spending. Table 1.3 summarizes the calibrated parameters and the targeted values.

Validation

After the calibration presented above, I compare some untargeted moments of the model to their empirical counterparts. Namely the autocorrelation of some key variables, the coefficients of variation which is the standard deviation over the mean, and most importantly the business cycle adjustment factor $k = y^*/y$. Since 2021 the Federal Financial Administration (FFA) has been using a production function approach to compute the potential GDP. The approved methodology by the EU is based on a Cobb-Douglass production function. The description of the methodology is in Havik et al. (2014) and Blondeau et al. (2021). Table 1.4 presents how close the model can replicate k and other untargeted moments.

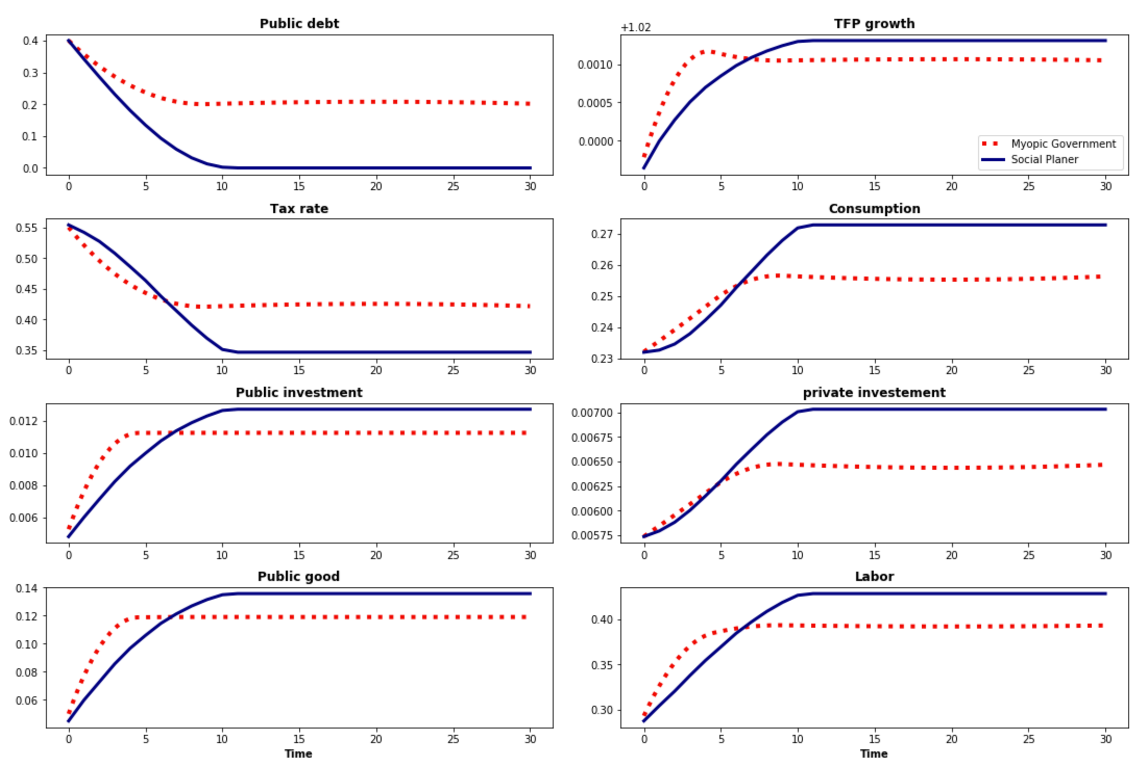
The model's ability to replicate some aspects of GDP behavior is essential, as the central focus of this paper revolves around GDP growth. Despite its simplicity, the model replicates well certain patterns observed in the data. The model is able to closely replicate the average $k = y^*/y$ as shown in Table 1.4. One area where the model excels is in mirroring the autocorrelations of all variables outlined in Table 1.4. The coefficient of variation, obtained by dividing the mean by the standard deviation, measures the level of variability in the data. The model-generated GDP coefficient of variation is fairly close to the one in the data.

Table 1.4 – Model validation

Variable	Data	Model	Ratio (Model/Data)	
$k = y^*/y$	1.005	1.045	1.04	
Variables	**Autocorrelation**		**Coef. of variation**	
	Data	Model	Data	Model
GDP	0.99	0.99	0.26	0.21
Debt	0.93	0.99	0.43	0.22
Public spending	0.98	0.96	0.38	0.14
Total investment in R &D	0.80	0.98	0.85	0.89

Note: I present the autocorrelation, the coefficient of variation (standard deviation*100/mean), and the business cycle adjustment factor k, both for the model and the data. The results from the data are from 1960 to 2002 when available, e.g before the rules' adoption. Note that the average ratio of k is not too sensitive to the choice of the period. Namely before the rules' adoption (1980-2002), after the rule's adoption (2003-2024), or over the whole available sample (1980-2024). The data for k is from Switzerland's State Secretariat for Economic Affairs SECO.

Figure 1.8 – Comparison of social planner and myopic government



Note: The dotted red line represents the model's results with a present-biased (myopic) government. The solid blue line represents the social planner's results, meaning there is no political friction. Here, I'm presenting the scaled version of the model, which has steady states corresponding to the balanced growth path of the original (unscaled) model.

1.3.1 Model's results

Figure 1.8 illustrates the dynamic behavior of the social planner's model, defined has the government without political friction (depicted by the blue line) and the calibrated model for Switzerland (represented by the red line). I present the scaled model here since this model is easy to interpret and its steady state is the balanced growth path of the original model [14]. Starting with the same level of debt which is more than 130% of GDP (which corresponds to 0.4 for the scaled model as can be seen in the top left panel) the social planner's model converges towards zero debt in the balanced growth path. While the myopic government solution converges towards 48% of GDP which is the calibrated value.

In the beginning, the present-biased government experiences a slower decline in debt compared to the social planner, resulting in greater availability of resources. As a result, the present-biased government allocates a higher amount of resources to public investment in research and development (R&D) compared to social planner. Furthermore, the present-biased government implements a lower tax rate compared to the social planner. This lower tax rate has a positive effect on citizens' labor supply decisions, as individuals tend to respond to changes in tax rates by adjusting their work efforts. In this case, the lower tax rate incentivizes individuals to work more, as they can retain a higher portion of their earnings. By working more and being subjected to a lesser tax burden, individuals experience an increase in their disposable income. This allows them to have higher levels of consumption. Additionally, with more resources at their disposal, individuals are able to allocate a greater amount of their income towards private investment in research and development (R&D). The two investments (public and private) in R&D increase the TFP as can be seen in the top right panel of Figure 1.8.

However, in the balanced growth path, the outcomes observed earlier are reversed.

14. The model presented has a share of GDP can be found in the appendix in Figure A.8. However, it is important to be cautious when interpreting these results, as they may appear misleading. For instance, in those graphs, it is noticeable that consumption as a proportion of GDP is higher for the present-biased government (calibrated one) compared to the social planner's model. This apparent discrepancy arises from the lower GDP associated with the present-biased government model in contrast to that of the social planner.

The social planner, being able to eliminate its debt entirely, no longer needs to allocate resources towards debt service. Consequently, it can reduce tax rates, allocate more resources towards public goods provision, and increase investments in research and development (R&D). The lower tax rates provide citizens with an incentive to work more. Additionally, since there are no public bonds available for purchase in the social planner's balanced growth path, citizens direct their investments toward private investment in R&D. This eliminates the crowding-out effect of public debt which is present in the present biased government case. As a result, both government (public) investment and citizen (private) investment in R&D increase relative to the myopic government scenario. This, in turn, drives higher economic growth through improvements in total factor productivity (TFP). Although the difference in the balanced growth path appears small at 0.025%, it becomes significant when considering the cumulative effect over time. Looking at the dynamics of GDP, this difference progressively grows, reaching a substantial 9% disparity after 30 periods, as depicted in Figure A.9.

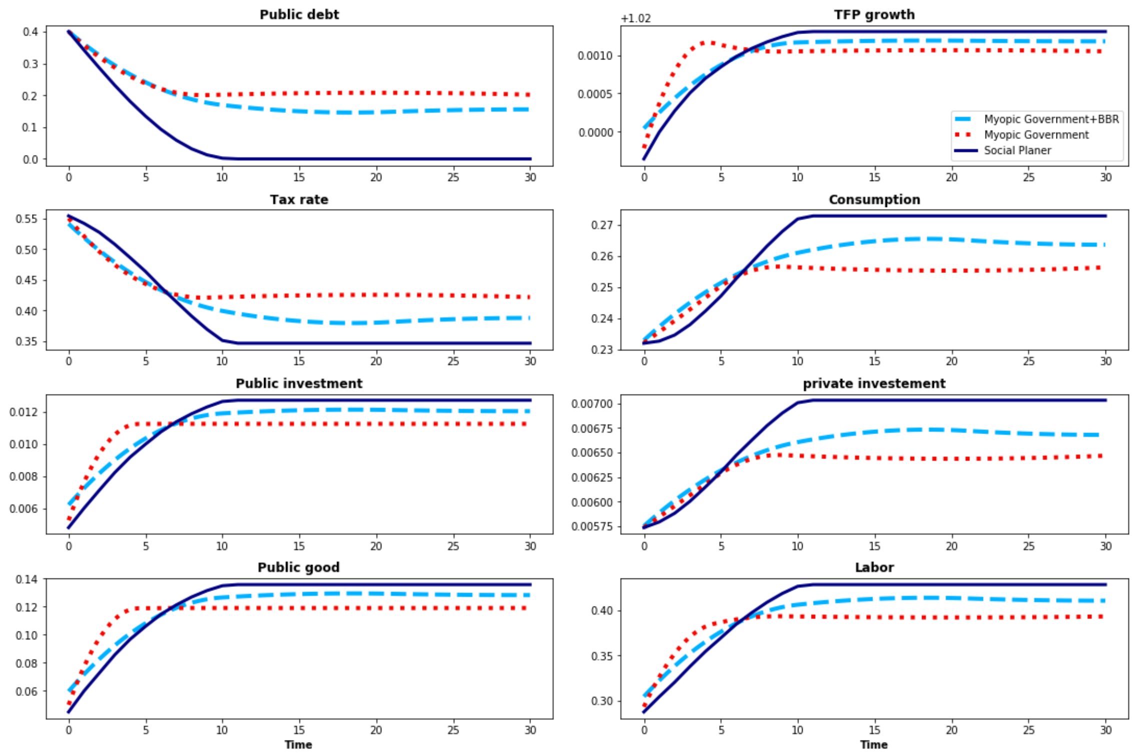
In Figure 1.9 I add to the previous graph a new line (light blue) representing the myopic government on which we impose the BBR. Following the same approach as the empirical section, the BBR is included as follows:

$$G = (\rho - 1)b + g + i + T \leq \frac{y^*}{y}\tau l z \xi = \frac{y^*}{y} R \tag{1.10}$$

Where $(\rho - 1)b$ is the total interest paid on debt, G is the government's total spending and R is the government's revenue. Note also that y and y^* are respectively the real and the potential GDP. In Switzerland, the potential GDP is estimated by the Federal Financial Administration (FFA) using the production function approach adopted by European Union (Havik et al., 2014). In the model, I considered the potential GDP to be the GDP under the social planner, which is the best outcome under current economic circumstances.

The same logic of the previous mechanism works here, namely the crowding-out effect of debt when considering the present biased government (red line). The key message is that the BBR permits the reduction of the inefficiency of the myopic government,

Figure 1.9 – Comparison with the BBR included



Note: The dotted red line represents the model's results with a present-biased (myopic) government. The solid blue line represents the social planner's results, meaning there is no political friction. The dotted blue line represents the myopic government including the Balanced Budget Rule (BBR), which actually represents Switzerland. Here, I'm presenting the scaled version of the model, which has steady states corresponding to the balanced growth path of the original (unscaled) model.

but it does not eliminate all the inefficiency. In terms of quantifiable impact, the implementation of the BBR leads to a gain of 0.0127% in terms of balanced growth. While this Figure may appear modest, it corresponds to a 1% increase in GDP after 10 years. This highlights the positive influence of the BBR in mitigating inefficiencies and driving economic growth, which is in line with the qualitative results of the empirical part.

1.3.2 Comparison to traditional BBRs and Welfare analysis

I now compare the effects of the BBR over the business cycle (new BBR) with those of traditional BBRs. There are two main findings: first, the growth rate under traditional BBRs is lower than that observed under the new BBR; second, while traditional

BBRs reduce welfare, the new BBR increases it. These results can be attributed to two distinct effects: a direct effect and an indirect effect, which are explained in detail below.

Why the growth rate is higher under the new BBR compared to traditional BBRs? As shown in Table 1.5, the imposition of "traditional Balanced Budget Rules (BBRs)", such as the 3% deficit limit (adopted in the European Union (EU) and West African Economic and Monetary Union (WAEMU)) or the 0% deficit limit, can lead to increased growth when starting with a high level of debt [15]. However, the growth achieved under the new BBR is double that of traditional BBRs.

To better understand this result, consider a scenario where the government runs a deficit equal to or greater than 3% of GDP. Suppose further that fiscal pressure or a recession increases the need for public spending [16]. Now let's consider the two fiscal rules: the traditional BBR of 3% deficit limit and the new BBR. Under the traditional BBR, the primary concern is strictly adhering to the deficit limit, regardless of the economic conditions (whether in a recession or an expansion). Despite fiscal pressures, the rule restricts the government's ability to borrow, as the deficit is capped at 3% of GDP. Therefore, to comply with the rule, the government raises taxes and reduces spending on public goods and investments as shown in figure A.11. The reduction in public investment directly impacts economic growth; this is referred to as the **direct effect**. Furthermore, the higher taxes imposed under the traditional BBR reduce citizens' labor supply and disposable income. As a result, private investment declines, which in turn negatively impacts economic growth. This is referred to as the **indirect effect**.

In contrast, the new BBR allows the government to run a higher deficit during a recession (or periods of fiscal pressure), as the deficit is not fixed at a single limit but adjusts according to the severity of the recession. This flexibility enables the government to maintain higher public investment levels and lower taxes (leading to higher private investment) compared to the traditional BBR that limits the deficit irrespective of the economic conditions. Higher public investment (the direct effect) and increased private

15. Exceeding the balanced growth path debt under the present bias government.
16. A recession here can be interpreted as a shock on public spending needs.

investment (the indirect effect) under the new BBR, compared to the traditional BBR, explain why economic growth is greater under the new BBR.

A similar argument explains the welfare result. The welfare measure considered is the Consumption Equivalent (CE) variation. It is the consumption that an individual would require to be equally satisfied with accepting an alternative policy instead of the social planner's. The formal calculation can be found in appendix A.2.5.

The results indicate that the welfare loss associated with traditional rules is higher than that of a myopic government operating without any fiscal rule (see third column in table 1.5). Specifically, as compared to the no rule scenario, the 3% and 0% deficit limits result respectively in welfare losses which are 5.86% and 35% higher [17]. Indeed, although imposing a traditional BBR when starting with high public debt does not yield significant long-term gains, it does alter the government's behavior in the short run, resulting in reduced investments, diminished provision of public goods, and higher taxes (see Figure A.10 in the appendix). With lower provision of public goods, the utility is directly reduced (**direct effect**). The higher taxes, in turn, discourage work and cause a decline in citizens' consumption. Lower consumption reduces welfare further, this is the **indirect effect.** Overall, welfare is negatively affected, even if the growth rate slightly increases under traditional BBR compared to the no-rule scenario. In contrast, the new BBR in addition to exhibiting higher growth as explained earlier also leads to a 7.44% higher welfare compared to the no-rule scenario. There are two main reasons why the welfare is higher for the new BBR. First, the direct effect of higher public good provision and the indirect effect of higher private consumption increase welfare. As it can be seen in figure A.11 private consumption and public good are both higher for the New BBR compared to the traditional one represented by the 3% deficit limit rule. Second, the higher growth under the new BBR further amplifies the increase in welfare.

The finding that traditional BBRs reduce welfare aligns with the results of Stockman (2001). Stockman (2001) studied the welfare effect of a traditional 0% deficit BBR in an exogenous growth model without political friction. They find that the introduction of the BBR leads to 50% lower welfare compared to a Ramsey solution. The results in

17. Obtained as a percentage of the welfare loss of the no Rule scenario.

Table 1.5 – Growth and welfare for different BBRs (in basis points 10^{-2})

Fiscal rules	GDP growth gain relative to No rule	Welfare loss (CE) relative to SP	Welfare gain (loss) relative to no rule (%)
No Rule	0	2.215	0
BBR: 3% deficit	0.615	2.345	-5.86
BBR: 0% deficit	0.658	2.990	-35
BBR over the business cycle	1.276	2.050	7.44

Note: This table presents the differences in growth under various fiscal rules relative to the baseline scenario of a Myopic Government (MG) operating without any rules. It also presents the welfare loss relative to the Social Planner (SP). The welfare measure here is the Consumption Equivalent (CE) variation which represents the proportion of consumption that individuals forego under any alternative policy compared to the Social Planner's policy. In other words, it quantifies the amount of consumption that an individual would require to be equally satisfied with accepting an alternative policy instead of the social planner's policy.

this paper complements this results further by showing that even in a model of political friction - where government policies are inefficient - the cap on deficits BBR can be welfare-reducing compared to the no-rule situation.

1.4 Conclusion

This paper examines the impact of a new Balanced Budget Rule (BBR) on economic growth implemented in Switzerland in 2003. I document that the introduction of the BBR has positively impacted Switzerland's economic growth over the period from 2003 to 2018. Through a growth accounting, I also identified that the primary driver of this growth is total factor productivity (TFP), which includes institutional changes as the adoption of the BBR. Motivated by these empirical findings, I developed an endogenous growth model that incorporates political friction in the form of a present biased government who by accumulating inefficiently high public debt creates a crowding-out effect, limiting resources available for private R&D investment. Additionally, the debt service burden reduces the government's ability to invest in public R&D. The introduction of the BBR into the model reduces the debt burden, thereby mitigating the crowding-out effect and freeing up resources for private investment. Furthermore, the reduced debt service allows for increased public investment in R&D. These combined effects of higher private and public R&D investments contribute to higher economic growth. After calibrating the model to Switzerland, the estimated effect of the BBR is an annual GDP growth increase of 1.27 basis points, compounding to a 1% GDP gain after 10 years.

Furthermore, I find that the new BBR leads to positive welfare gains as opposed to traditional BBRs, such as the 3% deficit limits adopted by the European Union. In fact, the 3% and 0% deficit limits result in welfare losses compared to the no-rule scenario. This finding aligns with Stockman (2001) and may explain why traditional cap on deficit BBRs are challenging to enforce in practice (Reuter, 2019), as they tend to reduce welfare [18].

The new BBR examined in this paper offers some flexibility that is essential in increasing growth and welfare. The fact that the rule adjusts regarding economic conditions (recession or expansion), allowing for borrowing during recessions and saving during booms is important for its ability to effectively respond to various shocks making it an interesting rule if a country wants to adopt a fiscal rule that reconciles growth and welfare objectives.

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18. As shown in Reuter (2019), governments comply with traditional balanced budget rules (BBRs) only 35% of the time, while compliance with debt rules is significantly higher at 88%.

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CHAPTER 2

REEVALUATING THE IMPACT OF REGIONAL TRADE AGREEMENTS IN AFRICA

Fansa Koné*

Abstract- I revisit the effect of Regional Trade Agreements (RTAs) on African intra-trade, finding that they have significantly increased trade by 62 to 77 percent from 1995 to 2019. These figures are lower than most estimates in the literature. I address several issues related to estimating the effects of RTAs, namely the selection bias due to the prevalence of zeros in trade data, the staggered adoption feature of RTAs, and their heterogeneous effects across regions and over time. To deal with these issues, I apply a structural gravity model, a Pseudo Poisson Maximum Likelihood (PPML) method, and a heterogenous robust Difference-in-Differences estimator. The results also indicate that RTAs generally take between five and eight years to have a significant impact on trade.

Keywords: Trade Economics, Regional trade agreement, Gravity regression

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2.1 Introduction

The number of countries adopting Regional Trade Agreements (RTA) in Africa is growing over time, from 6 in 1996 to 35 in 2016 (see figure B.4 in the appendix). Despite this rapid growth in the number of RTA, intra-trade in Africa remains low compared to other regions worldwide. Indeed intra trade is about 18% in Africa while it's around 60% in Europe and Asia (United-Nations, 2022). This raises the question of the effectiveness of RTAs in boosting trade in Africa. This question becomes more relevant given the adoption of a new RTA covering all African countries but Eritrea. Indeed with the recent African Continental Free Trade Area (AfCFTA) adopted in 2021, many studies projected intra-trade in African to increase significantly (Maliszewska et al., 2020; ElGanainy et al., 2023; World Trade Organization, 2023) [1].

However, to the best of my knowledge, although there are some studies focussing on some specific regions in Africa, there is no clear estimates of the overall effectiveness of RTAs prior to AfCFTA implementation, in boosting trade in Africa. This paper investigate that question. In addition, the paper is the first to quantify the timing of the effect of RTAs on trade in Africa.

I demonstrate that existing Regional Trade Agreements (RTAs) in Africa have significantly increased trade by 62 to 77 percent from 1995 to 2019. These results are robust across various estimation strategies addressing common issues such as selection bias due to zero trade data, heterogeneous effects across time and space, and the staggered adoption of RTAs. Previous estimates of the RTA impact on trade in Africa vary widely across studies, likely due to differences in estimation strategies and the specific RTAs considered. The focus is on the average overall effect of RTAs on trade in Africa, which could be important in anticipating the potential impact of the recent African Continental Free Trade Area (AfCFTA) covering all African countries.

To obtain the results, I employ three estimation techniques. I start with the standard structural gravity model by Anderson and Van Wincoop (2003), which, by excluding zero trade data, may be biased due to selection issues arising from this exclusion.

1. (Maliszewska et al., 2020) states that trade could increase by 52% in 2035 and more than double after full implementation of AfCFTA.

To address this, I complement the analysis with Pseudo Poisson Maximum Likelihood (PPML) estimation, which incorporates all sample values, including zeros. Although widely used in the literature, these two previous methods have limitations in estimating the effects of staggered policies such as RTAs. Additionally, they may be biased if the effects of RTAs are heterogeneous over time and space, which is very likely to be the case. To overcome these limitations, we finally use an event study methodology robust to heterogeneous treatment effects, as proposed by Callaway and Sant'Anna (2021). Importantly, the estimates from these three methods are very close to each other: 77 percent for the structural gravity method, 63 percent for the PPML, and 62 percent for the event study. Furthermore, this study estimates the timing of the effect of RTAs in Africa, finding that it takes, on average, five to eight years for an RTA to significantly impact trade after its implementation.

Related Literature

This paper is related to the extensive literature on the effectiveness of RTAs in increasing trade (Carrere, 2006; Baldwin and Taglioni, 2007; Glick and Rose, 2016; de Soyres et al., 2021), with a focus on Africa. Previous estimates of the effect of RTAs in Africa vary widely (Geda and Yimer, 2023; Ngepah and Udeagha, 2018; MacPhee and Sattayanuwat, 2014). This variability can be attributed to differences in the methodologies and the specific RTAs or samples used. In this study, the focus is on the overall effect of RTAs in Africa. It addresses several methodological issues inherent in estimating their effects.

I begin by estimating a structural gravity model as developed by Anderson and Van Wincoop (2003). This model accounts for the inward and outward multilateral resistance (MTR), taking into consideration that trade between two countries is influenced by the relative trade costs of all other trading partners. To capture this, I include importer and exporter fixed effects, which correct for the bias of omitted variables and reflect that changes in trade costs on one bilateral route can affect trade flows on other routes due to relative prices effects. In addition, I include pair dummies to eliminate unobserved time-invariant factors between countries (such as deep-seated historical trust or distrust, informal trade networks that are not documented, and the unofficial influence of diaspora communities on trade patterns), following Baldwin and Taglioni (2007). This methodology allows to isolate the variation in the effects of RTAs over time. Using this empirical specification, I find that the effect of RTAs in Africa, while significant, is lower than most previous estimates. For instance, Ngepah and Udeagha (2018) report effects generally exceeding 100%, whereas our estimates range between 62% and 77%. Unlike Ngepah and Udeagha (2018), who focused on the specific effect of each RTA individually in Africa, we estimate the overall effects of RTAs on trade. Additionally, to account for selection bias due to zeros in trade data, I use a PPML estimation. The OLS estimate is 77%, but accounting for selection bias with PPML reduces this estimate to 63%.

Furthermore, MacPhee and Sattayanuwat (2014) found that the intra-RTA effect for ECOWAS is 128%, while the effect for SADC is 208%. Conversely, the effect for CEMAC was not significant, highlighting the heterogeneity among different RTAs in Africa. Given this evident heterogeneity, to the best of my knowledge, this study is the first to document the overall effect of RTAs on African trade, considering their heterogeneous effects by applying the recent event study methodology developed by Callaway and Sant'Anna (2021). Using this approach, I find an estimated effect of 62%, which is 1% lower than the PPML estimate.

The remainder of this paper is structured as follows. In Section 2.2, I present the data used in the analysis. Section 2.3 presents gravity regressions. Section 2.4 presents the event study and the estimation of the timing of the RTAs on Trade. Finally, Section 2.5 concludes the paper.

2.2 Data presentation

In this section, I present the data source and some descriptive statistics.

2.2.1 Data source

The data come from the data set **Gravity** of `Centre d'études prospectives et d'informations internationales` CEPII (Conte et al., 2022). The main variable of interest is the Regional Trade Agreement (RTA). The World Trade Organization (WTO) recognizes four distinct categories of Regional Trade Agreements (RTAs): Partial Scope Agreements (PSA), Free Trade Agreements (FTA), Customs Unions (CU), and Economic Integration Agreements (EIA). PSAs usually entail the removal of import tariffs in a limited number of sectors, while FTAs generally involve the elimination of import tariffs across most sectors, with each member retaining the ability to enact their own trade policies. Customs Unions, which build upon FTAs, require member states to synchronize their external trade policies and implement a common external tariff. Economic Integration Agreements focus on the liberalization of trade in services. Some examples are Economic Community of West African States (ECOWAS) [2] (wich include West African Economic and Monetray Union (WAEMU, a CU)), Common Market for Eastern and Southern Africa (COMESA) [3], Economic and Monetary Community of Central Africa (CEMAC) [4], etc.

Table 2.1 presents the main variables and their sources in more detail.

2.2.2 Descriptive statistics

Figure 2.1 presents the average trade share of product categories among African countries between 1996 and 2016. I employed a detailed product classification at the two-digit level Word Custom Organization's website. To compute the share, I aggregated the total trade volume for each year across all products and calculated the proportion of each product's trade volume to the total. The findings show that *mineral products*, comprising oil, gas, cement, Cobalt, aluminum, uranium, and other materials, were the products that were the most widely traded between African countries, followed by *electrical equipment, base metals, and chemical products*, each accounting for approximately 9% of total trade. In contrast, the least traded products were collectors' pieces, arms and munitions, and raw hides and skins, which represented less than 0. 5%

2. It's a FTA composed of Cabo Verde; Benin; The Gambia; Ghana; Guinea; Côte d'Ivoire; Liberia; Mali; Niger; Nigeria; Guinea-Bissau; Senegal; Sierra Leone; Togo; Burkina Faso

3. the signatories are: Angola; Burundi; Comoros; Democratic Republic of the Congo; Ethiopia; Eritrea; Kenya; Lesotho; Malawi; Mauritius; Rwanda; Seychelles; Zimbabwe; Sudan; Eswatini; Uganda; Egypt; Tanzania; Zambia

4. Cameroon; Central African Republic; Chad; Congo; Equatorial Guinea; Gabon

Table 2.1 – Variables and their sources

Variable	description	Source
Bilateral trade data	Detailed at 2 digits classification level	WTO Stats
RTA	Dummy equal to 1 if origin and destination countries are engaged in a regional trade agreement of any type within the given year	CEPII(from WTO)
distcap	bilateral distance between capitals, measured in km	CEPII
contiguty	Dummy equal to 1 if countries are contiguous, bilateral	CEPII
comlang_off	Dummy equal to 1 if countries share common official or primary language, bilateral	CEPII
GDP_o	GDP of the origin country, in current thousands US	CEPII(from WDI)
GDP_d	GDP of the destination country, in current thousands US	CEPII(from WDI)

of total trade.

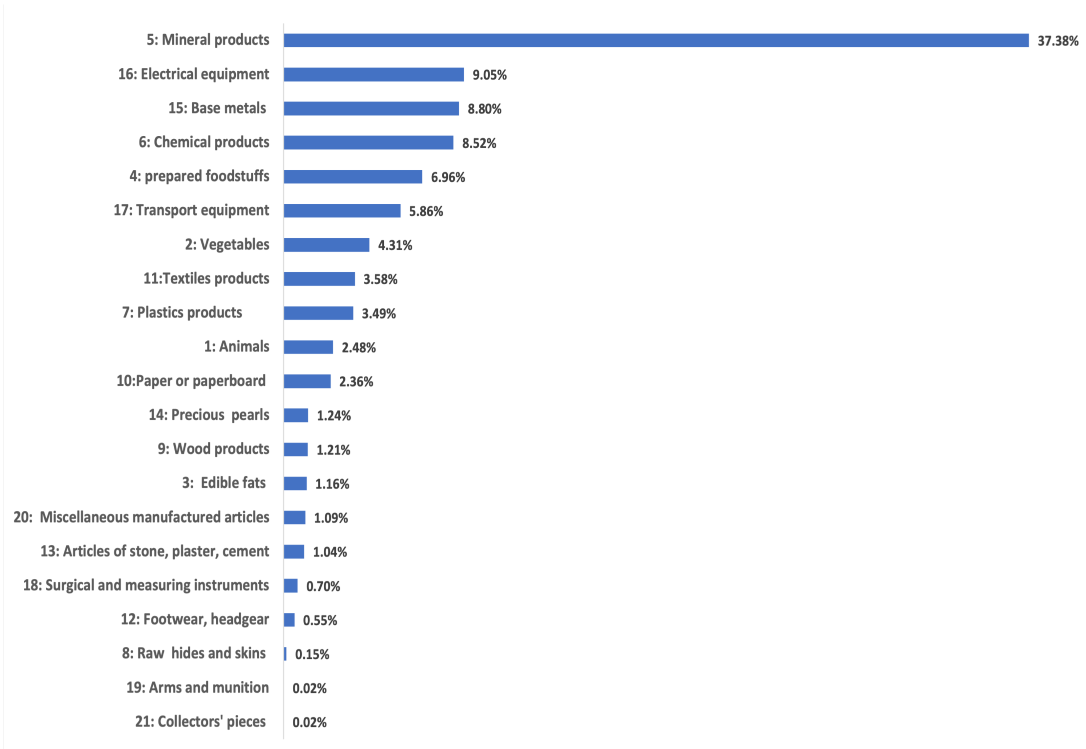
Although being predominantly reliant on raw material exports and suffering from underdeveloped infrastructure, Africa has experienced a significant increase in the number of Regional Trade Agreements (RTAs), from 6 in 1996 to 35 in 2016 (see figure B.4 in the appendix). However, intra-African trade accounted for only 18% of total trade in Africa in 2020, which is strikingly lower compared to Europe and Asia where intra-regional trade constitutes around 60% of their total trade (United-Nations, 2022).

In the following sections, I estimate the effect of RTAs on trade in Africa, taking into account the heterogeneity presented above and also their staggered adoption feature.

2.3 Gravity and PPML Regressions

This section aims to investigate the relationship between trade flows and Regional Trade Agreements (RTAs) among African countries. To analyze this relationship, I employ a structural gravity model based on the influential work of Anderson and Van Wincoop (2003), which incorporates multilateral resistance terms. These terms account for

Figure 2.1 – Intra African trade share by product category



Notes: Average trade among African countries by product over the period 1996-2016

the influence of relative prices among countries that participate in trade. In the model, trade between two countries is not solely determined by their bilateral factors, such as economic size and geographical distance. It also considers the relative prices of other countries involved in trade, which indirectly affect the trade flows between the two countries of interest. These multilateral resistance terms capture the broader economic dynamics at play.

Since the relative prices of countries involved in the trade are unobserved in the available data, we address this by incorporating country-time fixed effects, following Baldwin and Taglioni (2007). These fixed effects serve to capture country-specific and time-specific factors that could influence trade flows. This gives the following specification:

$$Y_{dot} = c + \alpha RTA_{dot} + \beta X_{dot} + b_{dt} + d_{ot} + \gamma_{do} + u_{dot} \ , \forall d, o, t \tag{2.1}$$

where d is the destination (importing) country, o the origin (exporting) country, t denotes the year of the trade. b_{dt}, d_{ot}, and γ_{do} are the destination-time, origin-time, and pairs-fixed effects respectively and u_{dot} is the error term. This is our preferred regression in line with Baldwin and Taglioni (2007) [5]. We also consider regressions where we include alternative fixed effects as shown in table B.2. In Equation (2.1), the dependent variable (Y_{dot}) is the logarithm of imports from country o to the country d in the year t. The variable of interest, RTA_{dot}, is a binary variable equal to 1 when the countries d and o are part of a Regional Trade Agreement (RTA) in year t, and 0 otherwise. The control variables X include several factors that may influence trade flows between the countries. To account for differences in country size, I control for the logarithm of the GDP of the exporting country (ln_gdp_o) and the importing country (ln_gdp_d). I also include a binary variable indicating whether the countries share a common language, and a contiguity variable indicating whether they share a border. Moreover, I control for the effect of distance on trade flows by including the logarithm of the distance between the capitals of the two countries. This is because, as shown in Figure B.3 in the appendix, countries in the same RTA tend to be geographically close. I also tested an alternative measure of distance based on the distance between the most populated cities, and the results were consistent. [6]

To address the possibility of unobservable events that might affect trade flows, we include fixed effects for each year and fixed effects for the exporting and importing countries. We use robust standard errors to account for arbitrary patterns of heteroskedasticity in the data. To address potential correlation within groups, we cluster the standard errors by country pair, as suggested by Moulton (1990). This is because the errors are likely to be correlated within each country pair, regardless of the direction of trade. To enable

5. Specifically, the trade between a pair of countries depends on the prices of all the partners of this pair, which is sometimes referred to as multilateral resistance term. Failing to account for that is what is called the "gold medal error". To correct this error we include the country-time fixed effect. See Baldwin and Taglioni (2007) for further explanation.

6. Note that in some regressions not presented here, I restrict the countries to be around a certain distance. different thresholds have been considered varying from 2,000 km to 10,000 km by step of 1,000km. In all these cases, the results still hold: being part of a RTA increases trade significantly between members relative to non-members. This also means that it's not only because countries are close that they necessarily trade more, being part of the same RTA plays a major role in trade.

clustering, we used the distance which uniquely identifies each country pair. By doing so, we obtain more accurate statistical inferences.

A well-known problem with trade data is zero trade among many countries. Even using aggregate trade data, Helpman et al. (2008) reports that around half of the bilateral trade matrix is filled with zeros, this issue is also true for our data. Such observations are dropped from the OLS model because the logarithm of zero is undefined. However, they are relatively common in the trade matrix, since not all countries trade with all partners every year. Dropping zero observations in the way that OLS does potentially lead to sample selection bias. This makes the Pseudo Poisson Maximum Likelihood (PPML) estimator becoming steadily more popular in the literature since this approach allows us to include observations for which the value of trade is zero (Silva and Tenreyro, 2006). Therefore, I add the PPML estimates in the results presented in Table 2.2 below.

Table 2.2 – Relation between bilateral trade flows and RTA in Africa

	OLS	PPML	OLS	PPML	OLS	PPML	OLS	PPML
rta	1.394***	1.460***	1.268***	1.203***	0.973***	0.734***	0.772***	0.638***
	(0.171)	(0.121)	(0.174)	(0.123)	(0.175)	(0.140)	(0.227)	(0.232)
ln_distcap	-1.949***	-0.155**	-1.632***	-0.106				
	(0.123)	(0.063)	(0.125)	(0.070)				
ln_gdp_o	0.448***	0.110	0.433***	0.077	0.361***	0.140		
	(0.099)	(0.097)	(0.097)	(0.097)	(0.097)	(0.088)		
ln_gdp_d	0.532***	0.716***	0.523***	0.709***	0.516***	0.702***		
	(0.121)	(0.121)	(0.120)	(0.125)	(0.125)	(0.118)		
1 = Common_language			1.014***	0.427***				
			(0.103)	(0.085)				
=1 if contiguous			0.928***	0.551***				
			(0.220)	(0.137)				
Constant	10.141***	1.122	8.327***	1.182	-6.294***	0.520	11.972***	14.873***
	(2.810)	(2.813)	(2.775)	(2.919)	(2.381)	(2.592)	(0.227)	(0.076)
Adjusted R2	0.556		0.573		0.746		0.758	
Obs.	21795.000	35149.000	21795.000	35149.000	21795.000	31534.000	22339.000	23983.000
Years FE	T	T	T	T	T	T	F	F
Destination FE	T	T	T	T	F	F	F	F
Origin FE	T	T	T	T	F	F	F	F
Country Time FE	F	F	F	F	F	F	T	T
Pairs FE	F	F	F	F	T	T	T	T

Note: *The regressions use bilateral trade flows among African countries over the period 1995-2019. Country-time FE stands for origin-time fixed effects (FE) and destination-time fixed effects, which control for each country-specific time-varying factors. We also used robust standard errors and clustered them by country pairs to address potential heteroskedasticity and correlation in the data. The sample for the Poisson regression has been limited to 2000-2019.* * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The results presented in Table 2.2 demonstrate that all of the control variables have the expected signs. Specifically, distance is found to have a statistically significant negative association with bilateral imports, while speaking the same language is positively associated with trade. Similar results were obtained with respect to the GDPs of the countries involved. Moreover, our analysis shows that being part of a Regional Trade Agreement (RTA) leads to a substantial increase in trade, with a predicted rise of 77% (see the seventh column).

One of the main endogeneity issues in our analysis is the potential reverse causality between trade and the adoption of regional trade agreements (RTAs). Trade may lead to the adoption of RTAs, but RTAs may also cause higher trade. To account for this reverse causality, our final regression model in table B.2 includes country pairs fixed effects, origin-time fixed effects, and destination-time fixed effects. By doing so, we are able to compare the effect of changes in RTA on trade for fixed trade partners. Specifically, we estimate the effect of moving from a no-RTA situation to an RTA situation between country pairs instead of comparing countries in RTA to countries not in an RTA. With country time fixed effects, we also account for trends in trade, taking into account the fact that trade could have increased over time even without the RTA. Our results show that the adoption of the RTA is assisted with a significant 77% increase in trade. The estimate for the Poisson model is around 63%. The fact that the Poisson estimate is relatively close to the OLS's suggests that the selection bias it aimed to address may not be severe. It is worth noting that in this regression, we cannot estimate variables that are constant across time in country pairs, such as distance.

Our preferred regression remains the OLS estimates and we would like to interpret the Poisson regression as a robustness check. Indeed, all the zeros are not necessarily zeros because of missing data. Zero is given to any country pair during a specific year where the data is not reported. These "false zeros" could also create a bias. For instance, because before 2000 there was little data available we end up with many zeros which creates collinearity issues when running the Poisson regression with many fixed effects. For this reason, we restrict the sample between 2000 and 2019 for the Poisson regressions. Also given that the Poisson model is sensitive to extremely high values, we eliminate the top 5% trade data in these regressions. Overall the RTA effects estimated under the PPML are close to the OLS estimates.

Other potential problems with the TWFE

Interpreting the TWFE estimator as a causal effect should not be systematic. Indeed TWFE can estimate the Average treatment effect(ATE) if the parallel trend assumption holds and the effect is constant over time and across groups adopting the RTA (De Chaisemartin and d'Haultfoeuille, 2022) [7]. Unlike the first one, the second assumption is less likely to hold in practice because the effect of RTA on trade is certainly heterogeneous across RTAs (Ngepah and Udeagha, 2018). The results should therefore be tested against estimators which are robust to heterogeneous treatment effects. When the constant treatment assumption across time and group fails in a staggered adoption design the TWFE estimator might be biased for two main reasons. (i) The weights of TWFE are decreasing over time. This might be a problem if one believes that the effect of the treatment takes time to materialize. (ii) Some of the weights may be negative, and in that case, even if the effect is positive for a unit, negative weights could lower the whole effect. Or even if the effect for a particular unit is negative, by multiplying by the negative weight we'll have a positive effect (De Chaisemartin and d'Haultfoeuille, 2020). Despite these potential limitations, we should not necessarily reject TWFE estimations but complement them with other estimators (De Chaisemartin and d'Haultfoeuille, 2022), which is the aim of the following section. In addition, event studies allow to test for the parallel trend assumption and to see the dynamic effect of the treatment over time.

2.4 Event study and timing of RTAs effect on trade

Based on the previous criticisms of the TWFE estimator, we use state-of-the-art event study estimators as robustness checks of our previous estimates. Indeed the effects of the regional trade agreement (RTA) on trade is a staggered treatment design with a binary treatment allowing us to use many recent estimators adapted to these circumstances. Here we rely on standard event studies and robust DID estimators for heterogeneous effects. These methods also allow us to estimate the timing of the effect of RTAs on trade.

7. By group we mean countries which have adopted RTA is the same year.

2.4.1 Standard Event study

In equation 2.2 below I specify the standard event study model. Estimating event specification in equation 2.2 provides two key pieces of information not observable in the single-coefficient model presented above in equation 2.1. Firstly, the full set of event leads allows for the inspection of parallel trends in the pre-RTA (or pre-treatment) period. Unbiased estimation of post-event treatment effects relies fundamentally on this assumption. While this does not provide evidence that the units in which the event was adopted and not adopted would have necessarily followed similar trends in the post-RTA (or post-treatment) period it can give an idea of the direction of the potential bias.

Secondly, the policy lags allow for inspection of the temporal nature of treatment effects. This approach allows for a closer inspection of the timing and duration of treatment effects, enabling the identification of potential patterns such as changes in the magnitude or direction of effects over time. Moreover, the analysis can also help to distinguish between transitory and permanent effects, shedding light on the long-term implications of regional trade agreements. By incorporating a temporal dimension into the analysis, the study provides a more comprehensive understanding of the dynamics of the effects of RTAs in Africa, with important implications for policy design and evaluation.

Similar to the approach in Clarke and Tapia-Schythe (2021), I adopt the following specification:

$$y_{dot} = \alpha + \sum_{j=2}^{J} \beta_j (Lag\ j)_{dot} + \sum_{k=1}^{K} \gamma_k (Lead\ k)_{dot} + \mu_{ot} + \lambda_{dt} + F_{od} + X'_{odt}\Gamma + \varepsilon_{dot} \quad (2.2)$$

The dependent variable (Y_{dot}) is the logarithm of imports from country o to the country d in the year t. μ_{ot}, λ_{dt} and F_{od} are origin country time-fixed effects, destination country time-fixed effects, and pair fixed effects, X_{dot} are time-varying controls, and ε_{dot} is an unobserved error term. In equation 2.2, lags and leads to the event of interest are defined as follows:

$$(Lag\ J)_{dot} = 1[t \leq Event - J] \tag{2.3}$$

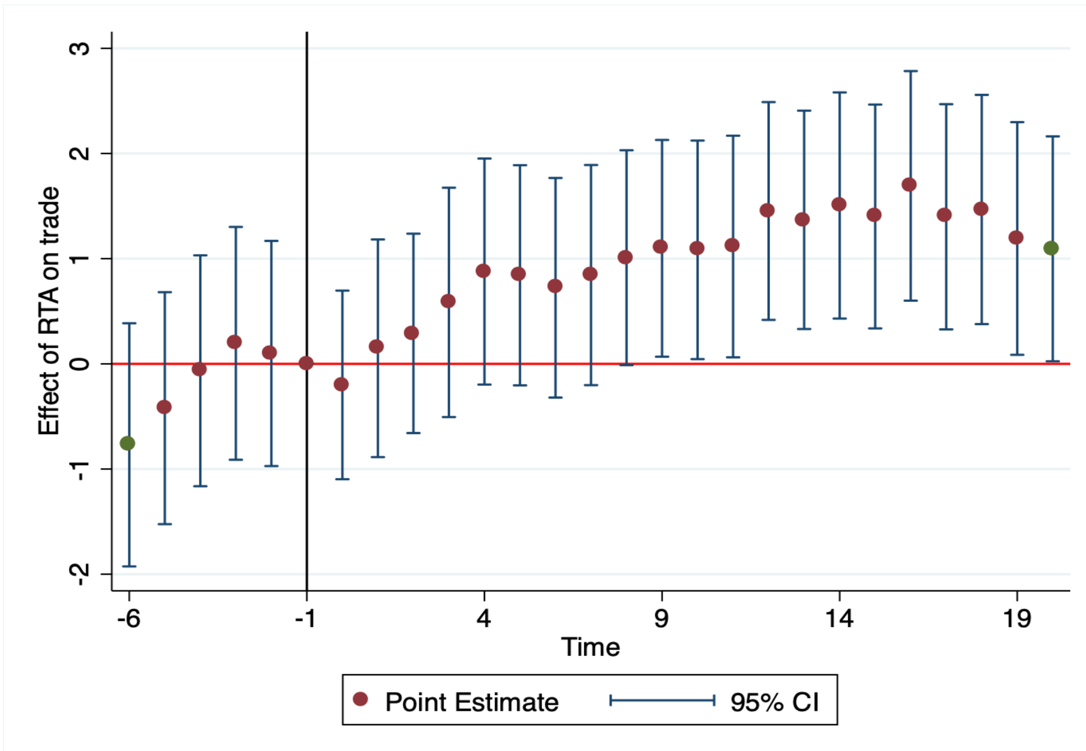
$$(Lag\ j)_{dot} = 1[t = Event - j] \quad j \in 1, \ldots, J-1 \tag{2.4}$$

$$(Lead\ k)_{dot} = 1[t = Event + k] \quad k \in 1, \ldots, K-1 \tag{2.5}$$

$$(Lead\ K)_{dot} = 1[t \geq Event + K] \tag{2.6}$$

Lags and leads are binary variables indicating that the given state was a given number of periods away from the Event of interest. Here the Event of interest is the adoption of the RTA. J lags and K leads are included. As shown in equations 2.3 and 2.6, final lags and leads "accumulate" lags or leads beyond J and K periods. A single lag or lead variable is omitted to proceed without multicollinearity and capture the baseline difference between pairs with RTA and pairs without RTA. It also provides a reference point (the first post-RTA period) against which the effects of the RTA in other periods are measured. In the specification of equation 2.2, this baseline omitted lag is the first one, where j = 1. This means the coefficients of the remaining lead and lag variables represent the difference in trade relative to this baseline period, which is one year before the RTA adoption.

Figure 2.2 – Effect of RTA on imports



Notes: The regression includes origin time, destination time, and pairs fixed effects, this is our preferred regression from the previous gravity part (see equation 2.1). Data are from 2001 to 2019 because of few countries in RTA prior to 2001 (see figure B.4. The horizontal axis presents the time to treatment. Time= -1 is the reference period and means we are evaluating the effect of RTA one year before it has been adopted. the vertical bar around each point displays the confidence interval at 5% level.

The findings of this event study are displayed in Figure 2.2, with the horizontal axis indicating the time before (negative) or after (positive) the adoption of the regional trade agreement (RTA) between two countries. The results reveal a clear pattern, showing no discernible effect of the RTA prior to its adoption (time 0). This finding supports the parallel trend assumption and suggests that the RTA had no significant impact on trade prior to its adoption. Moreover, the results suggest that the effect of the RTA is not immediate, with a positive effect observed only one year after the RTA adoption. However, this effect becomes significant at a 5% level only after eight years following the adoption. This highlights the importance of examining the temporal nature of treatment effects and identifying any dynamics, such as the growth or shrinkage of effects over time, or whether effects are transitory or permanent. Interestingly, the results show that the effect of the RTA increases over time and appears to be permanent, with an increase in trade of more than 150% observed 16 years after the adoption of the RTA. These findings suggest that the RTA has a lasting and positive effect on bilateral trade flows between countries. It is worth noting that while alternative estimation procedures may be preferred to avoid the imbalanced lags and leads observed in this study, the current results provide valuable insights into the temporal dynamics of the impact of RTAs on trade.

But similar to TWFE, Sun and Abraham (2021) show that the coefficients of the regression in equation 2.2 may be biased when the effect is heterogeneous across time or groups. And then testing the parallel trend assumption (or placebo tests) in this setting is not recommended. But the proposed estimator by (Callaway and Sant'Anna, 2021) is robust to heterogeneous treatment effect and is a more suitable model when one is interested in testing the parallel trend assumption De Chaisemartin and d'Haultfoeuille (2022).

In the next subsection, I extend the previous event study by incorporating a robust specification that accounts for the heterogeneous effects of RTAs across both time and groups.

2.4.2 Heterogenous robust DID estimators

The Callaway and Sant'Anna (2021) DID estimator provides a framework to estimate the Average Treatment Effect on the Treated (ATT) for groups that receive treatment at different periods. In our case, the group is a specific Regional Trade Agreement. This method accounts for treatment effect heterogeneity across groups and over time. For a specific RTA first adopted at period g, in calendar time t, the ATT is defined as:

$$ATT(g,t) = E[Y_t(g) - Y_t(0)|G_g = 1] \quad \text{for} \quad t \geq g$$

where Y_t is the outcome of interest at time t, in our case the imports from an origin country to a destination country, $G_g = 1$ if the country pair adopted an RTA for the first time at period g, and $Y_t(g)$ and $Y_t(0)$ are the imports and potential imports from the origin country to a destination country at time t with and without RTA, respectively.

The main assumption underlying this method is the parallel trends assumption, which posits that, in the absence of RTA, the expected change in the imports variable for the treated group (countries adopting RTAs) would have followed the same trend as the control group (countries never adopting RTAs). Formally, for each $t \in \{2, \ldots, T\}$ and $g \in G$ such that $t \geq g$, we assume:

$$E[Y_t(0) - Y_{t-1}(0)|G_g = 1] = E[Y_t(0) - Y_{t-1}(0)|C = 1] \quad \text{a.s.}$$

where $C = 1$ denotes the control group that has never adopted an RTA [8] . The set G represents all possible periods where an RTA has been adopted for the first time. This assumption implies that any difference in the imports between the treated (countries adopting RTAs) and control groups (countries never adopting RTAs), after accounting for the timing of treatment, can be attributed to the RTA adoption.

Using this parallel trends assumption, the ATT can be estimated as:

$$ATT(g,t) = E[Y_t - Y_{g-1}|G_g = 1] - E[Y_t - Y_{g-1}|C = 1]$$

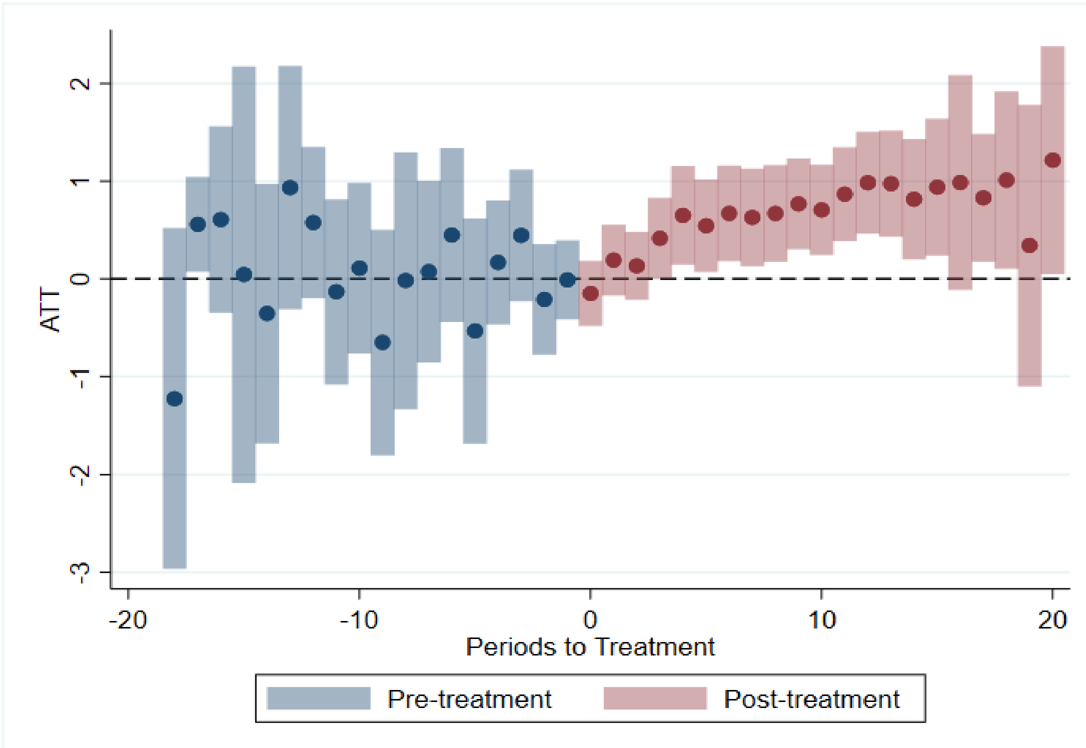
where $E[Y_t - Y_{g-1}|G_g = 1]$ represents the observed change in the outcome for the treated group from just before treatment to time t, and $E[Y_t - Y_{g-1}|C = 1]$ represents the observed change for the control group over the same period. This approach allows for a more flexible and robust estimation of treatment effects when dealing with staggered adoption of treatment across different groups.

The results obtained using this DID estimator, illustrated in Figure 2.3, provide significant insights into the effects of Regional Trade Agreements (RTAs) on intra-African trade over time (the timing effect).

The horizontal axis represents the time before and after the adoption of an RTA between two countries, with negative values indicating the pre-treatment period and positive values indicating the post-treatment period. The vertical axis shows the estimated

8. As a robustness check I used as control groups the not yet treated and the results were similar.

Figure 2.3 – Effect of RTA on imports



Notes: This figure presents the estimation of Callaway and Sant'Anna(2021). The horizontal axis presents the time to treatment. The vertical bars around each point display the confidence interval at 5% level. The overall ATT effect is 62% and is significant at 1% confidence interval level. The estimation is based on data from 1995 to 2019.

effect of the RTA on trade, with the vertical bars around each point representing the 95% confidence interval.

Before the adoption of the RTA, the graph shows no discernible effect on trade, which supports the parallel trends assumption. This indicates that there were no significant differences in trade trends between the treated and control groups [9] prior to the implementation of the RTA. Following the adoption of the RTA, a positive effect on trade is observed one year after the RTA adoption. However, this effect is not immediately significant at the 5% level. The effect becomes statistically significant at the 5% level approximately five years after the RTA adoption, highlighting a delayed but growing impact of the RTA on trade. Over time, the effect of the RTA on trade continues

9. I alternatively used both Never Treated (presented here) and Not yet Treated as control groups, the results are similar.

to increase, indicating a substantial and lasting impact. The aggregated effect is estimated at 62% [10], which means that the adoption of Regional Trade Agreements (RTAs) in Africa has led to an overall increase in trade by 62% over the period 1995 to 2019. This figure is statistically significant at the 1% confidence level, indicating a strong and robust impact of RTAs on enhancing trade flows between the participating countries.

2.5 Conclusion

In this paper, I explore the impacts of Regional Trade Agreements (RTAs) on intra-African trade. Using a structural gravity model, Pseudo Poisson Maximum Likelihood (PPML) estimation, and event studies, I demonstrate that RTAs have significantly increased trade among African countries by 62 to 77 percent from 1995 to 2019. These findings, though lower than most estimates in the existing literature, provide robust evidence of the positive effects of RTAs in enhancing trade in Africa. Furthermore, I document that RTAs take 5 to 8 years before having a significant effect on trade.

Overall, these findings highlight the importance of RTAs in boosting intra-African trade. Based on these results and with the recent implementation of the African Continental Trade Agreement (AfCFTA) on shouldd expect trade to increase further but it could take some time.

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10. A description of the Weighting is presented in Appendix B.1.1, but for more details see Callaway and Sant'Anna (2021).

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CHAPTER 3

TRADE AND SHOCKS TRANSMISSION IN A REGIONAL TRADE AGREEMENTS

Fansa Koné[*] **Régis Kouassi**[†]

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Appendix A

Appendix to chapter 1

A.1 Empirical appendix

Table A.1 – List of countries

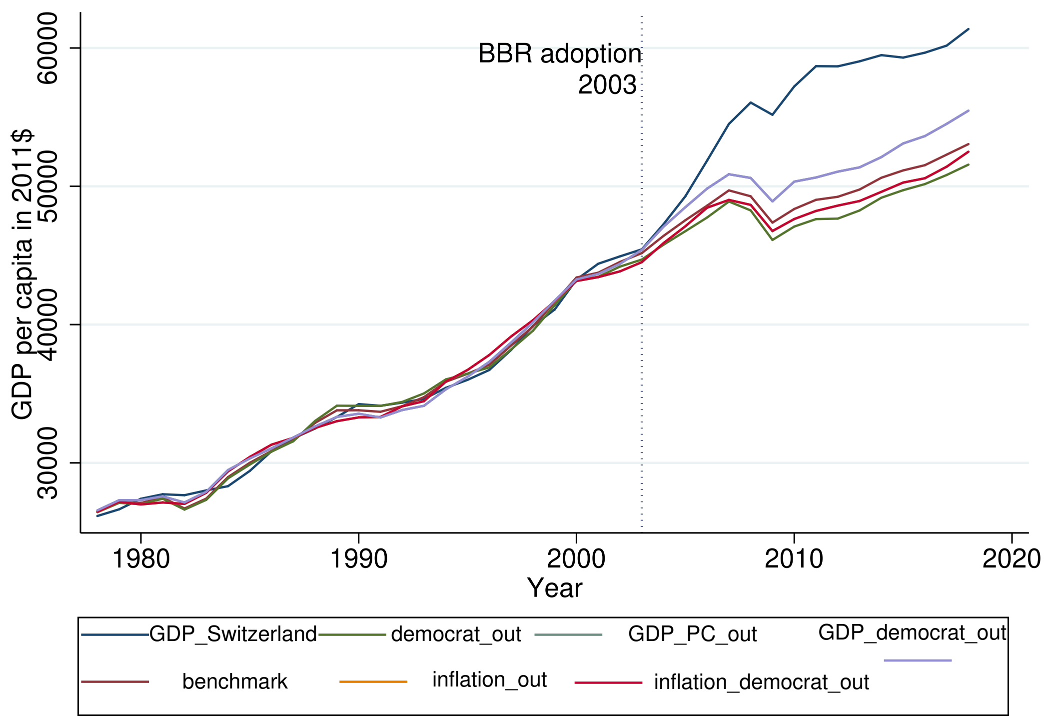
Code	**Country**	**Code**	**Country**	**Code**	**Country**	**Code**	**Country**
US	United States	FIN	Finland	AUS	Australia	GRC	Greece
JPN	Japan	SWE	Sweden	DNK	Denmark	DEU	Germany
AUT	Austria	CAN	Canada	NZL	New Zealand	CHL	Chile
NLD	Netherlands	ESP	Spain	NOR	Norway	KOR	Korea
FRA	France	PRT	Portugal	GBR	United Kingdom	LUX	Luxembourg
BEL	Belgium	MEX	Mexico	CHE	Switzerland		

Source: countries Alpha-3 code
Note: This table presents the list of countries and their corresponding ISO codes. Switzerland is the only country that has adopted the BBR over the business cycle. The other countries will serve to construct Switzerland's counterfactual in terms of GDP per capita.

Table A.2 – Weights for differents leave one donor out in %

Countries	All	US_out	CAN_out	US_CAN_out	NOR_out	LUX_out
USA	39.40	-	61.20	-	58.20	55.80
Canada (CAN)	40.20	48.40	-	-	0	22.60
Luxemburg(LUX)	15.20	51.60	6	44.50	5.70	-
Norway (NOR)	5.30	0	5.30	0	-	9.80
Germany (DEU)	0	0	27.60	0	0	11.80
Denmark (DNK)	0	0	0	55.50	19.30	0
Austria (AUS)	0	0	0	0	16.90	0

Figure A.1 – Leave one variable out performance



Note: Figure A.1 shows how sensitive are the results to a particular variable. So I successively leave the different variables out. The effect still remains. The one where the effect is small is when I leave simultaneously two variables out GDP and democracy `GDP_democrat_out`.

Table A.3 – Variables importance for leave one out in %

Variables	ALL	Democraty out	Inflation Out	GDP out	Inflation and Democraty out	Democraty and GDP out
Democraty	66.20	-	10.45	32.62	-	-
Inflation	30.10	95.68	-	59.51	-	86.81
GDP_pc	2.90	3.70	73.43	-	81.14	-
Labor	0.29	0.02	15.04	5.92	17.09	10.68
Unemployement	0.24	0.54	0.08	0.06	0.87	0.36
Debt_GDP_ratio	0.15	0.05	0.98	1.87	0.88	3.14

Note: Table A.3 shows the importance of the variables for each case presented in Figure A.1.

Figure A.2 – Switzerland GDP gain relative to synthetic Switzerland GDP

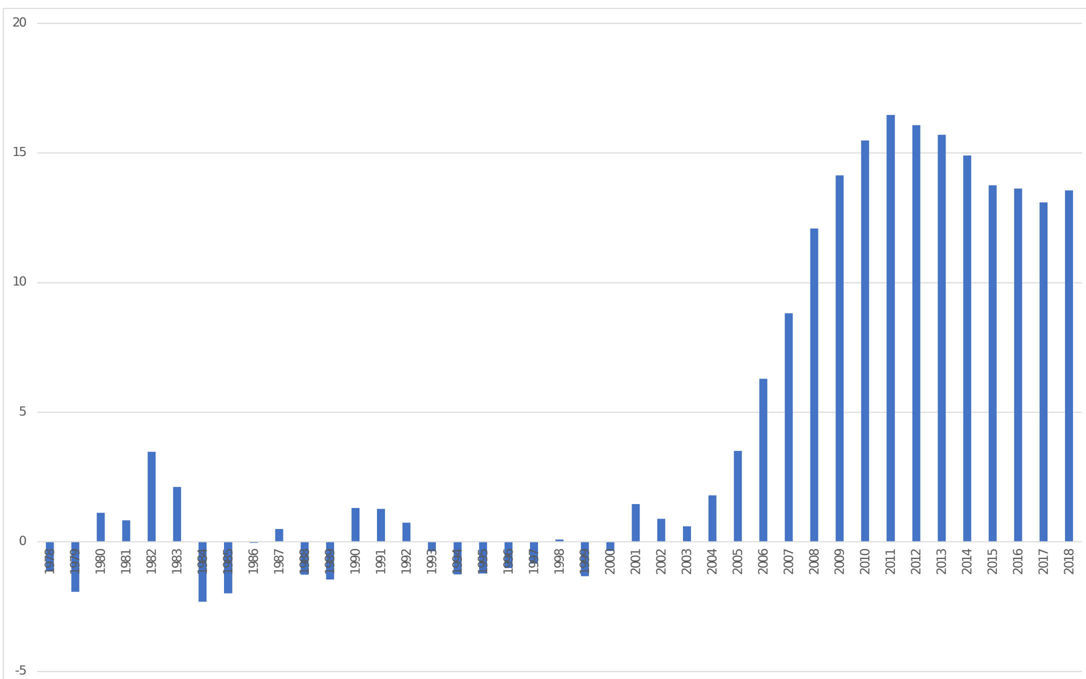
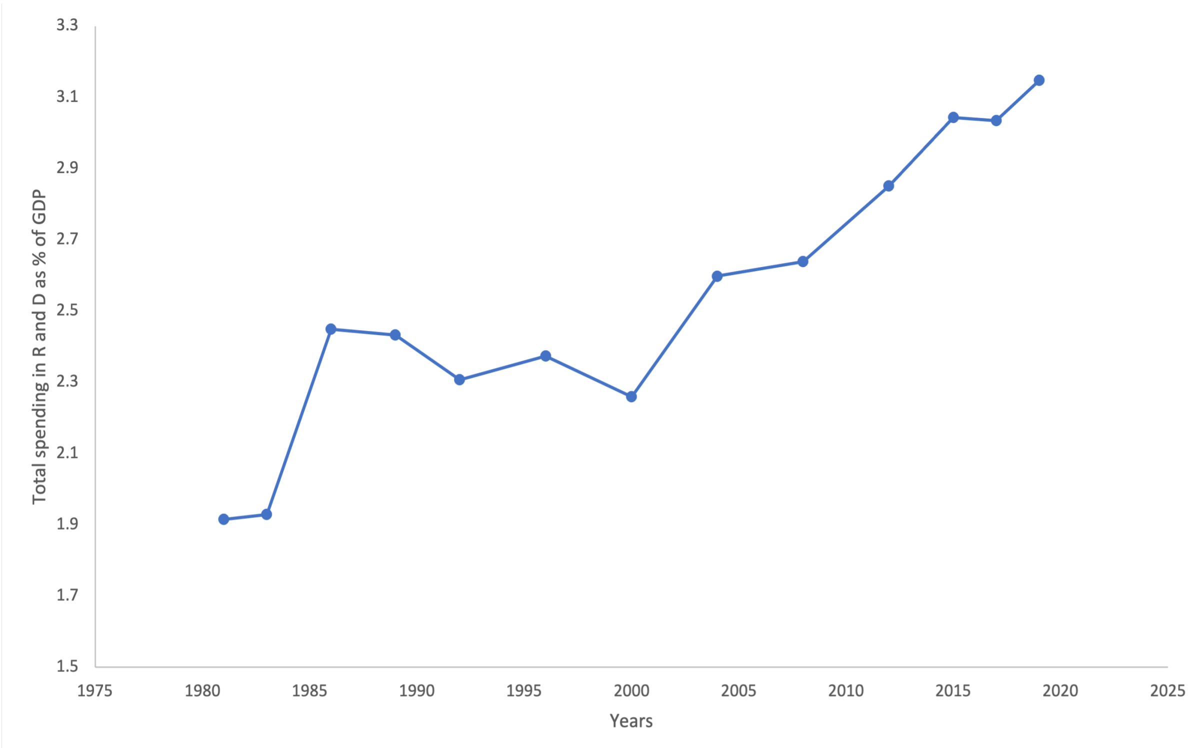
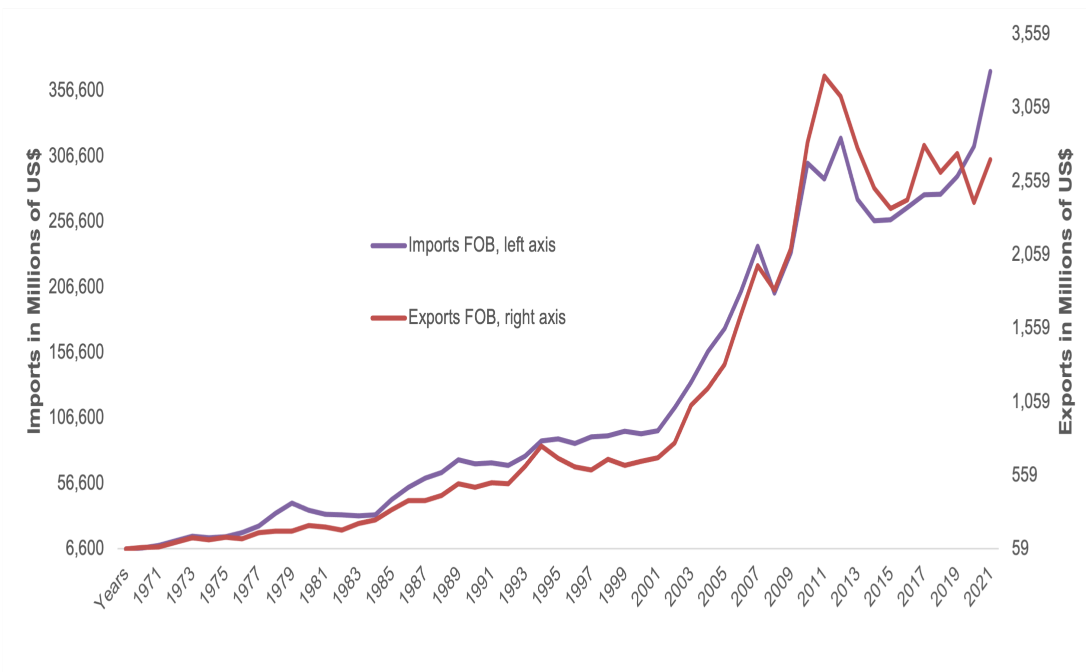


Figure A.3 – Switzerland total spending in Research and Development as a share of GDP



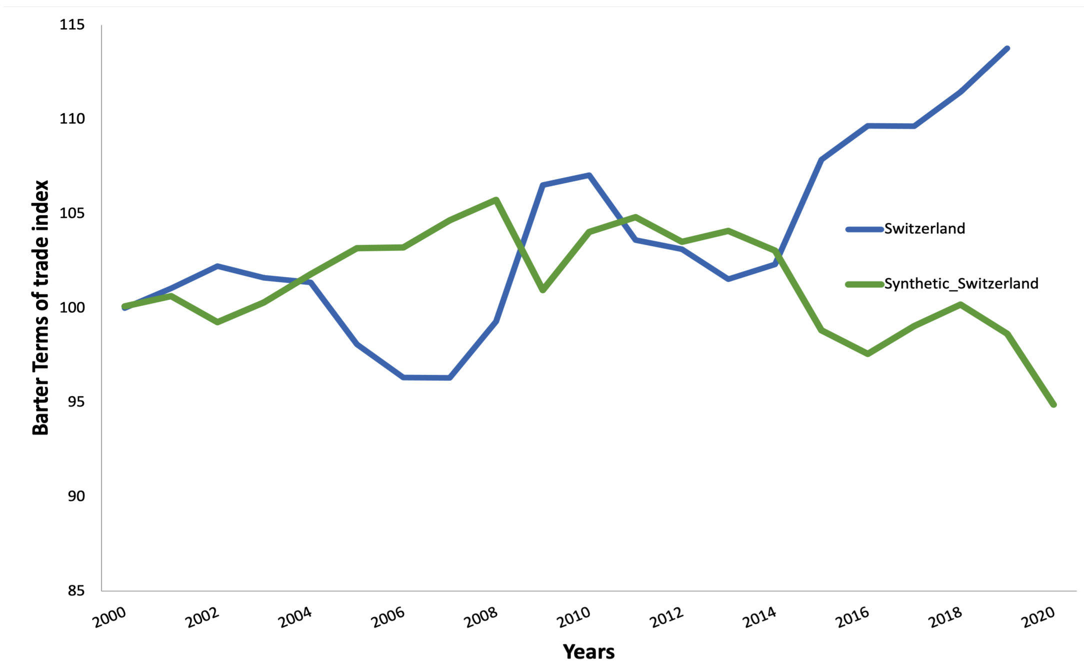
Note: Figure A.2 is showing the evolution of total spending in R&D. Gross domestic spending on R&D is defined as the total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, university and government laboratories, etc., in a country. It includes R&D funded from abroad but excludes domestic funds for R&D performed outside the domestic economy. This indicator is measured in USD constant prices using the 2015 base year and Purchasing Power parties (PPPs) and as a percentage of GDP. The data comes from OECD.

Figure A.4 – Switzerland's imports and exports from and to the rest of the world



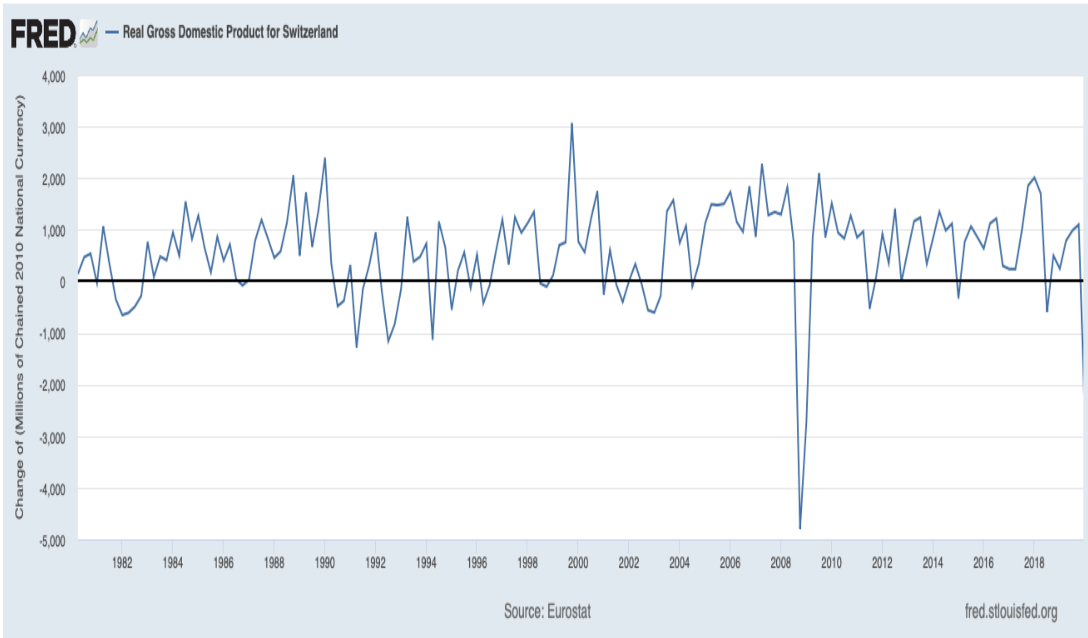
Note: Data is from the IMF Direction Of Trade Statistics (DOTS).

Figure A.5 – Switzerland and synthetic Switzerland terms of trade dynamic since 2000



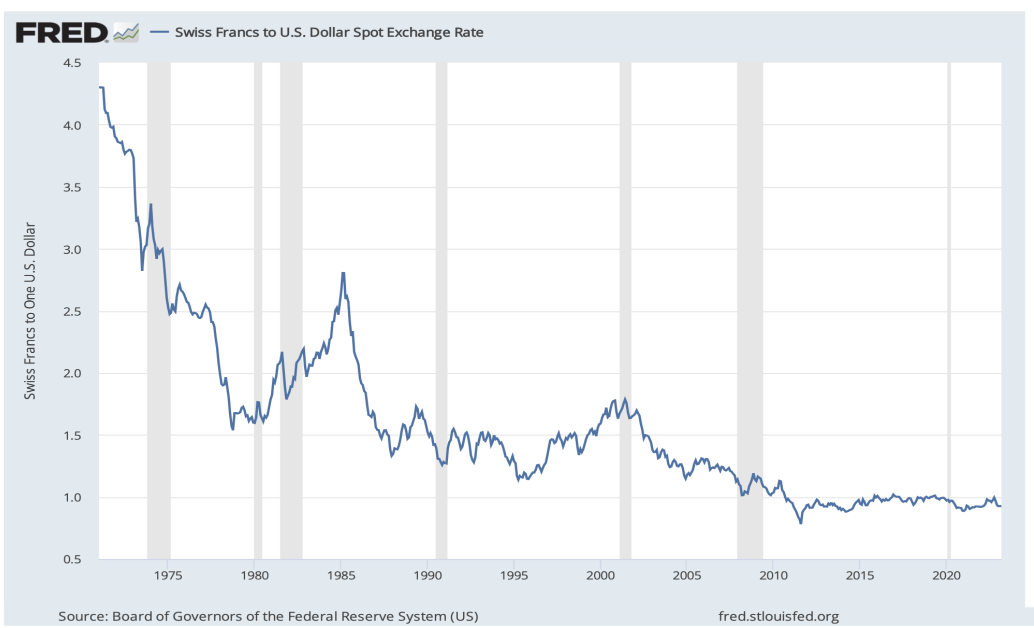
Note: Figure A.5 shows the evolution of Net barter terms of trade index for Switzerland and synthetic Switzerland. Synthetic Switzerland is the weighted average of the US(0.402), Canada(0.39), Luxemburg(0.152) and Norway (0.053). Net barter terms of trade index is calculated as the percentage ratio of the export unit value indexes to the import unit value indexes, measured relative to the base year 2000. Unit value indexes are based on data reported by countries that demonstrate consistency under UNCTAD quality controls, supplemented by UNCTAD's estimates using the previous year's trade values at the Standard International Trade Classification three-digit level as weights. To improve data coverage, especially for the latest periods, UNCTAD constructs a set of average price indexes at the three-digit product classification of the Standard International Trade Classification revision 3 using UNCTAD's Commodity Price Statistics, international and national sources, and UNCTAD secretariat estimates and calculates unit value indexes at the country level using the current year's trade values as weights (From World Bank database)

Figure A.6 – Switzerland change in GDP



Source: Eurostat, Real Gross Domestic Product for Switzerland [CLVMNACSCAB1GQCH], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/CLVMNACSCAB1GQCH, April 11, 2023
Note: Figure A.6 is showing the evolution of the quarterly GDP changes for Switzerland.

Figure A.7 – Switzerland exchange rate



Source: Federal Reserve of St Loius.
Notes: Figure A.7 is showing the evolution of the exchange rate against the USD. The Swiss Franc depreciated around the adoption of the BBR (2003).

A.2 Proofs

A.2.1 Recursive formulation of the citizen's problem

In this part, I show that the citizens' problem can be written in a recursive form with one state variable. The key argument is that when the model is scaled by productivity, the utility is separable in productivity. To make things clear define the scaled variables $\hat{c}_t = c_t/z_t\xi_t$ and $\hat{g}_t = g_t/z_t\xi_t$, then the utility can be written as:

$$u(c_t,l_t,g_t) = log(c_t(1-l_t)^{\mu}) + Alog(g_t)$$
$$u(c_t,l_t,g_t) = log(z_t\xi_t\hat{c}_t(1-l_t)^{\mu}) + Alog(z_t\xi_t\hat{g}_t)$$
$$u(c_t,l_t,g_t) = log(\hat{c}_t(1-l_t)^{\mu}) + A_t log(\hat{g}_t) + (1+A)log(z_t\xi_t)$$

$$\sum_{\text{t}} \beta^t u(c_t,l_t,g_t) = \sum_{\text{t}} \beta^t \left[log(\hat{c}_t(1-l_t)^{\mu}) + A_t log(\hat{g}_t) + (1+A)log(z_t\xi_t)\right]$$

Now focus on the productivity term $z_t\xi_t$, remember :
$z_{t+1} = \phi(\frac{I_t}{z_t\xi_t})z_t = \phi(\hat{I}_t)z_t$ and $\xi_{t+1} = \Delta(\hat{s}_t)\xi_t$

$$
\begin{aligned}
\sum_{\text{t=0}} \beta^t log(z_t \xi_t) &= log(z_0\xi_0) + \beta log(z_1\xi_1) + \beta^2 log(z_2\xi_2) + \beta^3 log(z_3\xi_3) + \ldots \\
&= log(z_0\xi_0) + \beta log\left[\phi(\hat{I}_0)\Delta(\hat{s_0}) z_0\xi_0\right] + \beta^2 log\left[\phi(\hat{I}_1)\Delta(\hat{s_1}) z_1\xi_1\right] + \beta^3 log(z_3\xi_3) + \ldots \\
&= log(z_0\xi_0) + \beta log\left[\phi(\hat{I}_0)\Delta(\hat{s_0}) z_0\xi_0\right] + \beta^2 log(z_1\xi_1) + \beta^2 log\left[\phi(\hat{I}_1)\Delta(\hat{s_1})\right] + \\
&\beta^3 log(z_3\xi_3) + \ldots \\
&= log(z_0\xi_0) + \beta log(\left[\phi(\hat{I}_0)\Delta(\hat{s_0}) z_0\xi_0\right] + \beta^2 log(\left[\phi(\hat{I}_0)\Delta(\hat{s_0}) z_0\xi_0\right] + \beta^2 log\left[\phi \hat{I}_1)\Delta(\hat{s_1})\right] + \\
&\beta^3 log(z_3\xi_3) + \ldots \\
&= log(z_0\xi_0) + \beta log(\left[\phi(\hat{I}_0)\Delta(\hat{s_0}) z_0\xi_0\right] + \beta^2 log(\left[\phi(\hat{I}_0)\Delta(\hat{s_0}) z_0\xi_0\right] + \beta^2 log\left[\phi \hat{I}_1)\Delta(\hat{s_1})\right] + \\
&\beta^3 log\left[\phi(\hat{I}_2)\Delta(\hat{s_2}) z_2\xi_2\right] + \ldots \\
&= log(z_0\xi_0) \sum_{\text{t=0}} \beta^t + log\left[\phi(\hat{I}_0)\Delta(\hat{s_0})\right] \sum_{\text{t=0}} \beta^{t+1} + log\left[\phi(\hat{I}_1)\Delta(\hat{s_1})\right] \sum_{\text{t=1}} \beta^{t+1} + \\
&log\left[\phi(\hat{I}_2)\Delta(\hat{s_2})\right] \sum_{\text{t=2}} \beta^{t+1} + \ldots \\
&= \frac{1}{1-\beta} log(z_0\xi_0) + \frac{\beta}{1-\beta} log\left[\phi(\hat{I}_0)\Delta(\hat{s_0})\right] + \frac{\beta^2}{1-\beta} log\left[\phi(\hat{I}_1)\Delta(\hat{s_1})\right] + \\
&\frac{\beta^3}{1-\beta} log\left[\phi(\hat{I}_2)\Delta(\hat{s_2})\right] + \ldots \\
&= \frac{log(z_0\xi_0)}{1-\beta} + \left[\frac{\beta}{1-\beta}\right] \sum_{\text{t=0}} \beta^t log\left[\phi(\hat{I}_t)\Delta(\hat{s}_t)\right]
\end{aligned}
$$

Replace this expression in the utility function to get:

$$
\begin{aligned}
\sum_{\mathrm{t}} \beta^t u(c_t, l_t, g_t) &= \sum_{\mathrm{t}} \beta^t \left[log(\hat{c}_t(1-l_t)^{\mu}) + Alog(\hat{g}_t)\right] + (1+A)\sum_{\mathrm{t=0}} \beta^t log(z_t \xi_t) \\
&= \sum_{\mathrm{t}} \beta^t \left[log(\hat{c}_t(1-l_t)^{\mu}) + Alog(\hat{g}_t)\right] + (1+A)\frac{log(z_0\xi_0)}{1-\beta} + \\
&\quad (1+A)\left[\frac{\beta}{1-\beta}\right]\sum_{\mathrm{t=0}} \beta^t log\left[\phi(\hat{I}_t)\Delta(\hat{s}_t)\right] \\
&= (1+A)\frac{log(z_0\xi_0)}{1-\beta} + \\
&\quad \sum_{\mathrm{t}} \beta^t \underbrace{\{log(\hat{c}_t(1-l_t)^{\mu}) + Alog(\hat{g}_t) + (1+A)\left[\frac{\beta}{1-\beta}\right] log\left[\phi(\hat{I}_t)\Delta(\hat{s}_t)\right]\}}_{\widetilde{u}(\hat{c}_t, l_t, \hat{s}_t, \hat{g}_t, \hat{I}_t)} \\
&= (1+A)\frac{log(z_0\xi_0)}{1-\beta} + \sum_{\mathrm{t}} \beta^t \widetilde{u}(\hat{c}_t, l_t, \hat{s}_t, \hat{g}_t, \hat{I}_t)
\end{aligned}
$$

Note that $\widetilde{u}$ is a derivable concave increasing function. The constant term could be neglected. We have then a standard optimization problem on the consumer side. Now let's pose the problem in a recursive form :

Citizens problem is 1.6 can be written as : given $\hat{a}_0$,

$$
\begin{aligned}
\max_{\{\hat{c}_t, l_t, \hat{s}_t, \hat{a_{t+1}}\}} \quad & \sum_{\mathrm{t}} \beta^t \widetilde{u}(\hat{c}_t, l_t, \hat{s}_t, \hat{g}_t, \hat{I}_t) \\
\text{subject to} \quad & \phi(\hat{I}_t)\Delta(\hat{s}_t)\frac{\hat{a}_{t+1}}{\rho_t} + \hat{c}_t + \hat{s}_t = (1-\tau_t)l_t + \hat{a}_t + \hat{T}, \\
& 0 \leq l_t \leq 1 \ ; \ 0 \leq \hat{c}_t
\end{aligned}
\tag{A.1}
$$

This standard problem can be solved for, we will get the consumer solutions as reaction functions to government's policies $p = (\tau_t, g_t, I_t, T_t, b_t)$. Denotes the solutions with a $*$. Hence the citizen value function is:

$$
V(z_0, \xi_0, a_0) = \sum_{\mathrm{t}} \beta^t u(c_t^*(p), l_t^*(p), g_t) = (1+A)\frac{log(z_0\xi_0)}{1-\beta} + \sum_{\mathrm{t}} \beta^t \widetilde{u}(c_t^*\hat{(}p), l_t^*(p), s_t^*\hat{(}p), \hat{g}_t, \hat{I}_t)
$$

$$
V(z_0, \xi_0, a_0) = (1+A)\frac{log(z_0\xi_0)}{1-\beta} + \widetilde{V}(\hat{a}_0)
$$

Note that $\widetilde{V}_0$ depends only on one state variable and can be written in a recursive form as follow:

$$\widetilde{V}(\hat{a}_0) = \widetilde{u}(\hat{c}_t^*(p), l_t^*(p), \hat{s}_t^*(p), \hat{g}_t, \hat{I}_t) + \beta \widetilde{V}(\hat{a}_1^*) \tag{A.2}$$

Given the citizen's value function V, the government solves the following problem:

$$\begin{aligned}
V_g(\hat{b}) = \max_{\{\tau,\hat{g},\hat{I},\hat{b}'\}} \quad & \{\tilde{\mathrm{u}}(\hat{\mathrm{c}}^*(\mathrm{p}), \mathrm{l}^*(\mathrm{p}), \hat{\mathrm{s}}^*(\mathrm{p}), \hat{\mathrm{g}}, \hat{\mathrm{I}}) + \alpha\beta V(\hat{b}')\} \\
\text{subject to} \quad & \phi(\hat{I})\Delta(\hat{s}^*)\frac{\hat{b}'}{\rho(\hat{b}')} + \tau l^* - \hat{b} - \hat{g} - \hat{I} - \hat{T} = 0 \\
& \underline{b} \leq b' \leq \overline{b}
\end{aligned} \tag{A.3}$$

A.2.2 Proof of proposition 1

Proof of proposition 1: It comes from the government's first-order condition. To simplify notations, let's ignore the hats on the different variables, but keep in mind that we are solving the scaled model. The proof will be done in four steps. Let define $B(b;p) = \frac{\rho(b')}{\Delta(S)\Phi(I)}(b+g+I+T-\tau l)$. Then the government constraint can be written as $b' - B(b;p) = 0$, with $p = (\tau, g, I, T, b')$.

1. First define Marginal cost of Public Fund as $MCPF(b) = \frac{V_\tau(b;p)}{B_\tau(b;p)}c(p)$ (From BB(2016))
2. Show that the Lagrange multiplier can be written as $\lambda(b) = \frac{V_\tau(b;p)}{B_\tau(b;p)}$

   Note $V^g(b;p)$ the objective function of government problem:

$$\begin{aligned}
V^g(b;p) &= \widetilde{u}(c^*(p), l^*(p), s^*(p), g, I) + \alpha\beta V(b') \\
V^g(b;p) &= \widetilde{u}(c^*(p), l^*(p), s^*(p), g, I) + \beta V(b') - \beta V(b') + \alpha\beta V(b') \\
V^g(b;p) &= V(b;p) + \beta(\alpha - 1)V(b')
\end{aligned}$$

   Considering this equation and the second definition of government budget constraint, the FOC with respect to τ gives: $V_\tau(b;p) - \lambda B_\tau(b;p) = 0$ [1], which is

1. Not that $V(b)$ depends on p, wich contains τ

$\lambda(b) = \frac{V_\tau(b;p)}{B_\tau(b;p)}$

3. Show that $V'(b) = \dfrac{\partial V(b;p^*)}{\partial b} = -\lambda(b)$. Writte the langrangian as:
$L(b;p) = \widetilde{u}(c^*(p), l^*(p), s^*(p), g, I) + \alpha\beta V(b') + \lambda\left[\phi(I)\Delta(s^*(p))\frac{b'}{\rho(b')} + \tau l^*(p) - b - g - I - T\right]$

   By the envelop theorem: $\left[\dfrac{\partial V^g(b;p)}{\partial b}\right]_{p=p*} = \left[\dfrac{\partial V(b;p)}{\partial b}\right]_{p=p*} = \left[\dfrac{\partial L(b;p)}{\partial b}\right]_{p=p*} = -\lambda(b)$

4. Use the first order condition (FOC) of the government problem with respect to b' and combined it with consumer FOC to get the characterization of the balanced growth path.

$$
\begin{aligned}
b' : \alpha\beta V'(b') + \lambda\phi(I)\Delta(s^*(p))\left[\frac{\rho(b') - b'\dfrac{\partial\rho(b')}{\partial b}}{\rho(b')^2}\right] &= 0\\
\alpha\beta V'(b') + \lambda\frac{\phi(I)\Delta(s^*(p))}{\rho(b')}\left[1 - \frac{b'}{\rho(b')}\frac{\partial\rho(b')}{\partial b}\right] &= 0\\
\alpha\beta V'(b') + \lambda\frac{\phi(I)\Delta(s^*(p))}{\rho(b')}\left[1 - \varepsilon_\rho(b')\right] &= 0\\
-\alpha\beta\lambda(b') + \lambda\frac{\phi(I)\Delta(s^*(p))}{\rho(b')}\left[1 - \varepsilon_\rho(b')\right] &= 0
\end{aligned}
$$

The last equation uses 3 (from the previous point). From consumer intertemporal Euler equation: $\frac{\phi(I)\Delta(s^*(p))}{\rho(b')} = \beta\frac{C}{C'}$ (see the details of derivation below).

   Then we have

$$
\begin{aligned}
(1 - \varepsilon_\rho(b'))\beta C(p)\lambda(b) &= \alpha\beta C'(p')\lambda(b')\\
(1 - \varepsilon_\rho(b'))MCPF(b) &= \alpha MCPF(b')\ \square.
\end{aligned}
$$

Let's solve the consumer problem given governments policies p. From the consumer perspective, the problem can be written as : (remember that $\Delta(\hat{s}_t) = \Delta_0\hat{s}_t^{\Delta_1}$)

$$
\begin{aligned}
\max_{\{\hat{c}_t, l_t, \hat{s}_t, \hat{a_{t+1}}\}} \quad & \sum_t \beta^t \{log(\hat{c}_t(1-l_t)^{\mu}) + Alog(\hat{g}_t) + (1+A)\left[\frac{\beta}{1-\beta}\right] log\left[\phi(\hat{I}_t)\Delta(\hat{s}_t)\right]\} \\
\text{subject to} \quad & \phi(\hat{I}_t)\Delta(\hat{s}_t)\frac{\hat{a}_{t+1}}{\rho_t} + \hat{c}_t + \hat{s}_t = (1-\tau_t)l_t + \hat{a}_t + \hat{T}, \\
& 0 \le l_t \le 1 \ ; \ 0 \le \hat{c}_t
\end{aligned}
\tag{A.4}
$$

Note λ_t the Lagrange multiplier at period t, the first order conditions are:

$$
\begin{aligned}
\hat{c}_t : \frac{\beta^t}{\hat{c}_t} &= \lambda_t \quad (1) \\
l_t : \frac{\beta^t \mu}{1-l_t} &= \lambda_t(1-\tau_t) \quad (2) \\
\hat{s}_t : \beta^t(1+A)\frac{\beta}{1-\beta}\Delta_1 &= \lambda_t(\hat{s}_t + \frac{\hat{a}_{t+1}}{\rho_t}\Delta_1\Phi(\hat{I}_t)\Delta(\hat{s}_t)) \quad (3) \\
\hat{a}_{t+1} : \lambda_t \frac{\Delta(\hat{s}_t)\Phi(\hat{s}_t)}{\rho_t} &= \lambda_{t+1} \quad (4) \\
\text{Ressouce constraint (scaled):} \qquad \hat{c}_t + \hat{s}_t + \hat{I}_t + \hat{g}_t &= l_t \quad (5)
\end{aligned}
$$

(1) and (4) gives the intertemporal Euler Equation: $\beta\frac{\hat{c}_t}{\hat{c}_{t+1}} = \frac{\Delta(\hat{s}_t)\Phi(\hat{I}_t)}{\rho_t}$ and (1) and (2) gives the intra-temporal equation: $\hat{c}_t = \frac{(1-l_t)(1-\tau_t)}{\mu}$.

Combining equations (1)-(5), and the budget constraint the solutions are:

$$
\begin{aligned}
l_t^* &= \frac{(1-\Delta_1)(\frac{1-\tau_t}{\mu} + \hat{g}_t + \hat{I}_t + \hat{T}_t) + \Delta_1(\frac{1-\tau_t}{\mu})\left[(1+A)\frac{\beta}{1-\beta}+1\right] - \Delta_1(\hat{a}_t + \hat{T}_t)}{(1-\Delta_1)(1+\frac{1-\tau_t}{\mu}) + \Delta_1(\frac{(1-\tau_t)}{\mu})\left[(1+A)\frac{\beta}{1-\beta}+1\right] + \Delta_1(1-\tau_t)} \\
c_t^* &= \frac{(1-\tau_t)\left[(1-\Delta_1)(1-\hat{g}_t-\hat{I}_t-T) + \Delta_1(1-\tau_t+\hat{a}_t+T)\right]}{(1-\Delta_1)(\mu+1-\tau_t) + \Delta_1(1-\tau_t)\left[(1+A)\frac{\beta}{1-\beta}+1\right] + \mu\Delta_1(1-\tau_t)} \\
\hat{s}_t^* &= l_t - \hat{c}_t^* - \hat{I}_t - \hat{g}_t - T \\
\hat{a}_{t+1}^* &= \left[\frac{(1-\tau_t)l_t^* + \hat{a}_t + T - \hat{c}_t^* - \hat{s}_t^*}{\Delta(\hat{s}_t^*\Delta(\hat{I}_t)}\right]\rho_t
\end{aligned}
$$

Here I show that $MCPF(b')$ is a convex increasing function (Te be added)

A.2.3 Proof of Proposition 2

Proof of proposition 2: I show it by contraposition: suppose there is no political friction, $\alpha = 1$, at the equilibrium balanced growth $b = b' = b^*$ and from equation 1.9 (proposition 2) we have $1 - \varepsilon_\rho(b^*) = 1$ which gives $b^* = 0$.

A.2.4 Proof of Proposition 3

Proposition 3: All else being equal, an increase in public debt tends to crowd out both private and public investment, thereby exerting a dampening effect on economic growth.

Proof.
Let define: $F(\hat{s}_t(\hat{a}_{t+1}), \hat{a}_{t+1}) = \phi(\hat{I}_t)\Delta(\hat{s}_t)\frac{\hat{a}_{t+1}}{\rho_t} + \hat{c}_t + \hat{s}_t - (1-\tau_t)l_t - \hat{a}_t - \hat{T}$

$$F(\hat{s}_t(\hat{a}_{t+1}), \hat{a}_{t+1}) = 0 \text{ is consumer's budget constrain.}$$

$$\hat{s}_t{}'(\hat{a}_{t+1}) = -\frac{F_{a_{t+1}}}{F_{s_t}} = -\frac{\phi(\hat{I}_t)\Delta(\hat{s}_t)}{\rho_t}/(1+\Delta_1\phi(\hat{I}_t)\Delta(\hat{s}_t)/\hat{s}_t$$

$$\hat{s}_t{}'(\hat{a}_{t+1}) = -\frac{\phi(\hat{I}_t)\Delta(\hat{s}_t)}{\rho_t}\frac{\hat{s}_t}{1+\Delta_1\phi(\hat{I}_t)\Delta(\hat{s}_t}$$

$$\hat{s}_t{}'(\hat{a}_{t+1}) \leq 0$$

Similarly, one can easily show that $\hat{I}_t{}'(\hat{a}_{t+1}) \leq 0$, with strict inequality if and only if $\hat{s}_t$ and $\hat{I}_t$ are positive, this is the case particularly in the balanced growth path.

A.2.5 Definition of the Welfare measure

The Consumption Equivalent (CE) variation is formally defined as follows. Suppose a benchmark solution is denoted by C^b, let's say in our case the social planner's solution.

And let C^p be the solution under an alternative policy, for instance, the BBR. Let w denote the welfare gain/loss under the alternative policy, w solves:

$$\begin{aligned}
U(C^p) &= U((1+w)C^b) \\
&= \sum_{\text{t}} \beta^t u((1+w)c_t^b) \\
&= \sum_{\text{t}} \beta^t log((1+w)c_t^b) \\
&= \sum_{\text{t}} \beta^t log(1+w) + \sum_{\text{t}} \beta^t log(c_t^b) \\
&= \frac{log(1+w)}{(1-\beta)} + \sum_{\text{t}} \beta^t log(c_t^b) \\
&= \frac{log(1+w)}{(1-\beta)} + U(C^b)
\end{aligned}$$

Which gives $w = exp([U(C^p) - U(C^b)] * (1-\beta)) - 1$. A negative value means that the alternative policy reduces the welfare.

A.2.6 Additional External links to data

Fred: data on public investment and government consumption

BEA: definition of public consumption and investment

A.2.7 Quantitative appendix

Figure A.8 – Transitional dynamic for the model as share of GDP

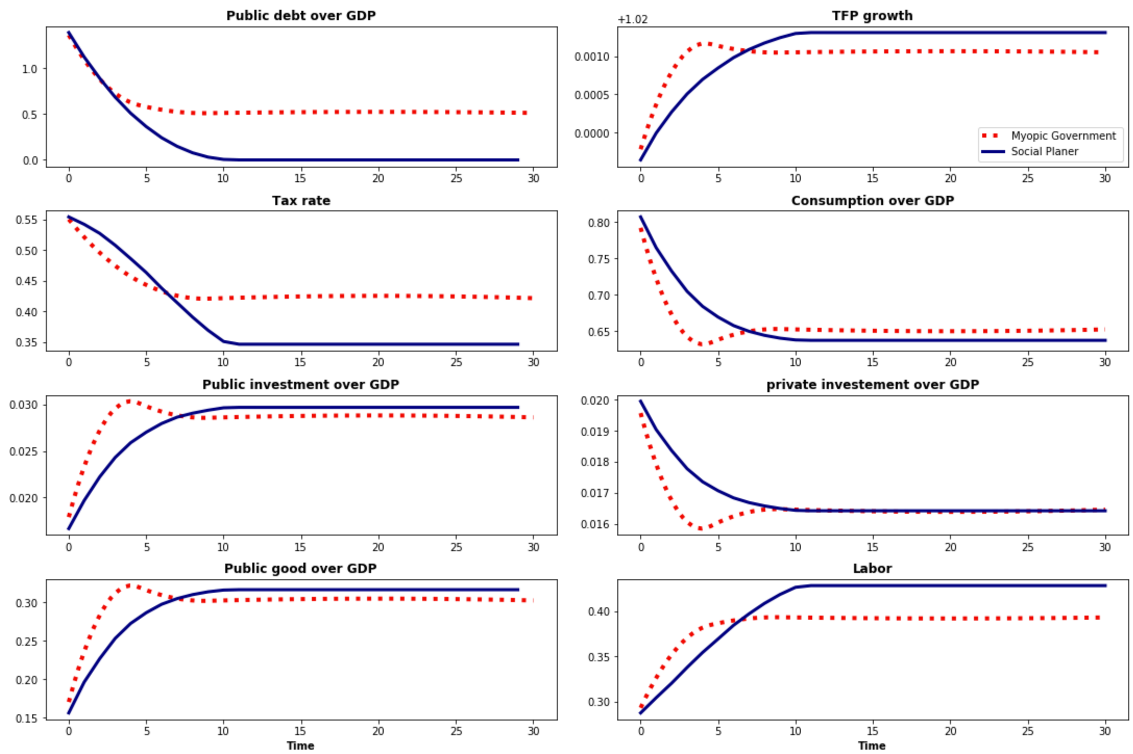


Figure A.9 – Comparison of social planer and myopic government

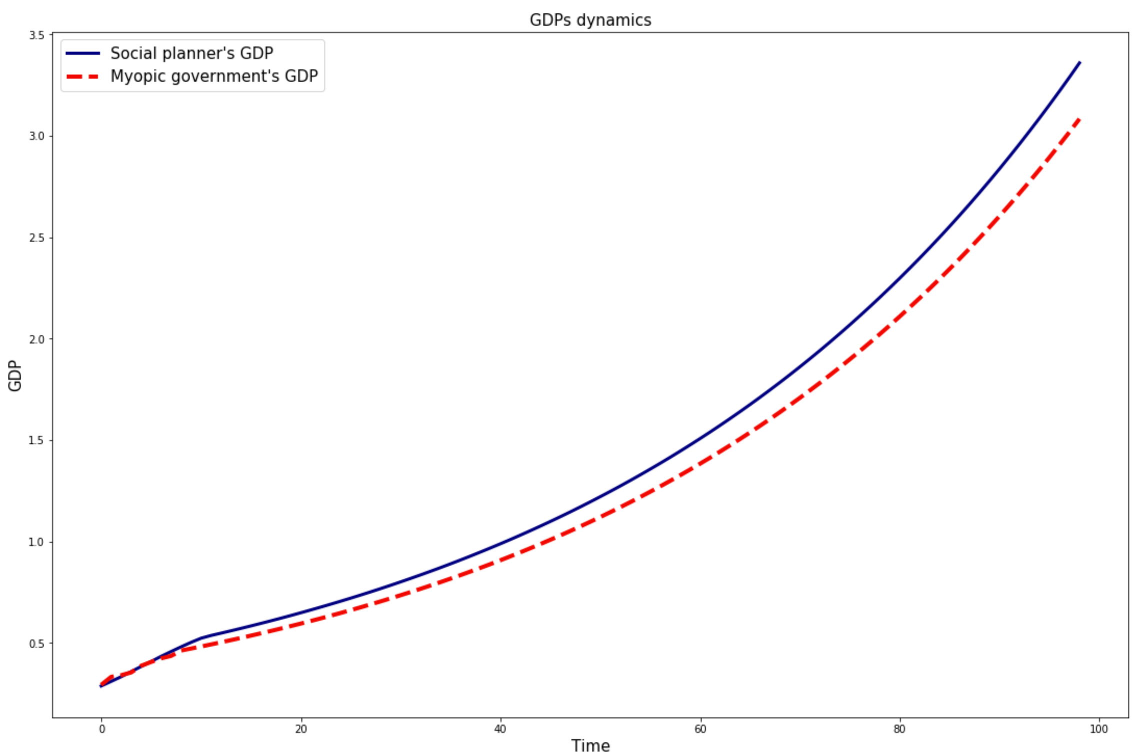


Figure A.10 – Model dynamic with 3% deficit limit BBR

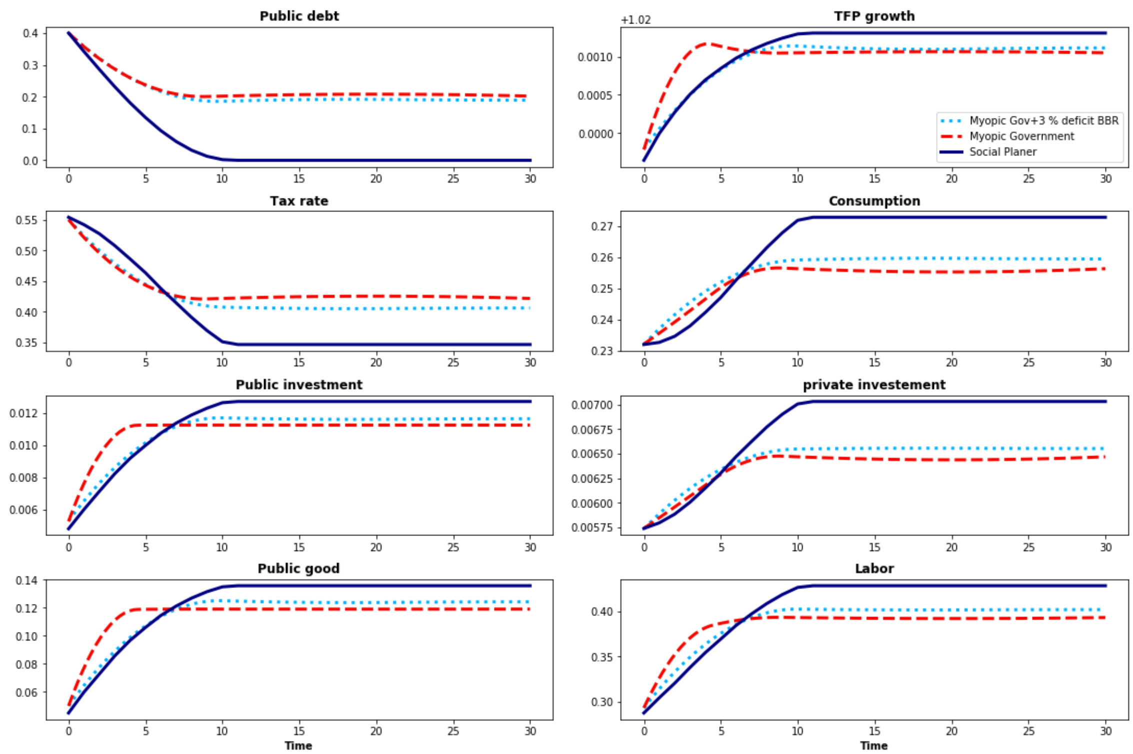
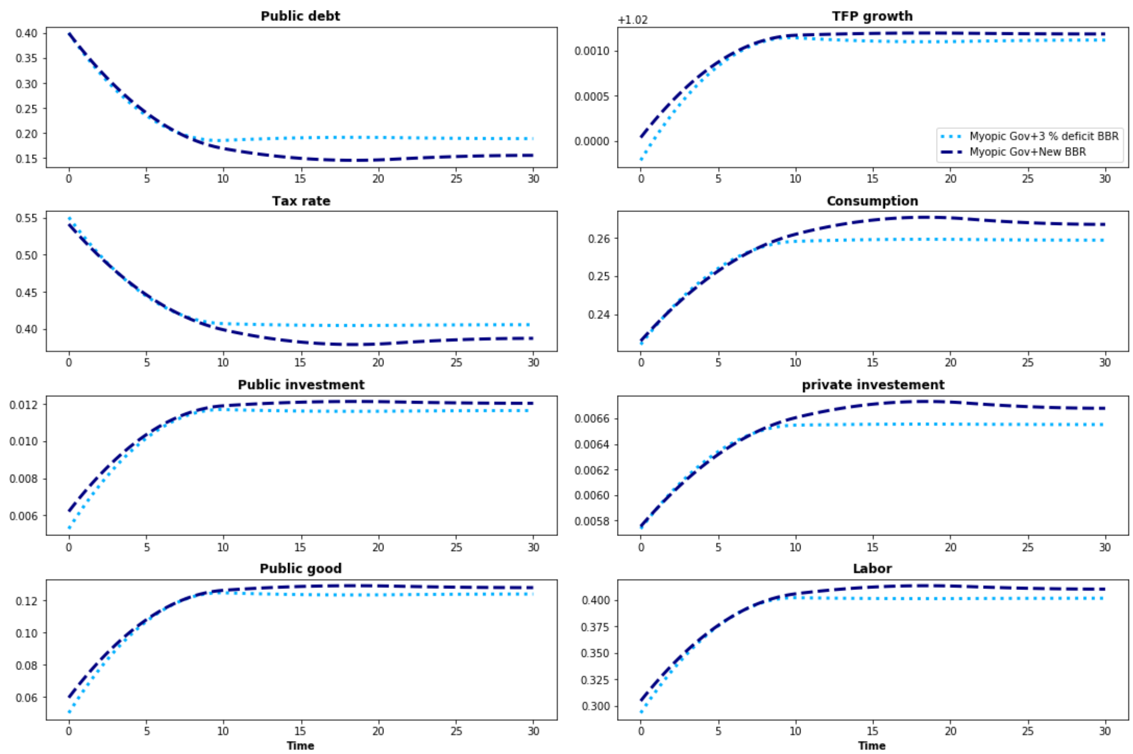


Figure A.11 – Comparison of the New BBR with traditional 3% deficit limit BBR



Appendix B

Appendix to chapter 2

B.1 Trade flows and Regional Trade Agreement (RTA)

Table B.1 – Relation between bilateral trade flows and RTA in Africa

	(1)	(2)	(3)	(4)
rta	1.417***	1.318***	0.891***	0.560**
	(0.206)	(0.211)	(0.180)	(0.252)
ln_distcap	-1.833***	-1.575***		
	(0.157)	(0.162)		
ln_gdp_o	0.359***	0.354***	0.280**	
	(0.112)	(0.109)	(0.108)	
ln_gdp_d	0.597***	0.594***	0.579***	
	(0.140)	(0.139)	(0.143)	
1 = Common official or primary language		0.868***		
		(0.138)		
=1 if origin and destination are contiguous		0.680***		
		(0.253)		
Constant	9.939***	8.148***	-1.965	12.662***
	(2.755)	(2.777)	(2.763)	(0.623)
Adjusted R2	0.546	0.558	0.744	0.763
Obs.	15525.000	15525.000	15525.000	15841.000
Years FE	T	T	T	F
Destination FE	T	T	F	F
Origin FE	T	T	F	F
Country Time FE	F	F	F	T
Pairs FE	F	F	T	T

The regressions use bilateral trade flows among African countries from 1995-2019. Here we keep countries with data available in at least 12 years over the 24. The results of the OLS are stable and close to the benchmark of around 60 % even if we keep at least 5, 10, or 12 years. The Poisson regression is much more unstable. Indeed the presence of many fixed effects increases the collinearity between regressors which could lead to spurious estimates **?**. *Therefore we rely more on the OLS when we vary the sample and the fact that the estimates are consistent gives evidence that the OLS is a good estimator in this case. Country-time FE stands for origin-time fixed effects (FE) and destination-time fixed effects, which control for each country-specific time-varying factors. We also used robust standard errors and clustered them by country pairs to address potential heteroskedasticity and correlation in the data.*

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B.2 – Relation between bilateral trade flows and RTA in Africa

	(1)	(2)	(3)	(4)	(5)	(6)
rta	2.146***	1.394***	1.268***	1.325***	0.973***	0.772***
	(0.174)	(0.171)	(0.174)	(0.190)	(0.175)	(0.227)
ln_distcap	-1.351***	-1.949***	-1.632***	-1.602***		
	(0.096)	(0.123)	(0.125)	(0.133)		
ln_gdp_o	1.070***	0.448***	0.433***		0.361***	
	(0.038)	(0.099)	(0.097)		(0.097)	
ln_gdp_d	0.854***	0.532***	0.523***		0.516***	
	(0.041)	(0.121)	(0.120)		(0.125)	
1 = Common official or primary language			1.014***	0.980***		
			(0.103)	(0.106)		
=1 if origin and destination are contiguous			0.928***	0.983***		
			(0.220)	(0.218)		
Constant	-7.402***	10.141***	8.327***	25.902***	-6.294***	11.972***
	(1.228)	(2.810)	(2.775)	(1.175)	(2.381)	(0.227)
Adjusted R2	0.410	0.556	0.573	0.579	0.746	0.758
Obs.	21795.000	21795.000	21795.000	22339.000	21795.000	22339.000
Years FE	T	T	T	F	T	F
Destination FE	F	T	T	F	F	F
Origin FE	F	T	T	F	F	F
Country Time FE	F	F	F	T	F	T
Pairs FE	F	F	F	F	T	T

The regressions use bilateral trade flows among African countries over the period 1995-2019. Country-time FE stands for origin-time fixed effects (FE) and destination-time fixed effects, which control for each country-specific time-varying factors. We also used robust standard errors and clustered them by country pairs to address potential heteroskedasticity and correlation in the data.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B.1.1 Weighting Mechanism to aggregate the ATTs

Here we presents how we aggregates the Average Treatment Effects on the Treated (ATTs) across different groups that receive treatment at different times.

Group-Specific ATT Estimation

First, the ATT for each group g at each time t is estimated. Formally, for a group g treated at time g in period t:

Table B.3 – Poisson estimation: dependent var $bilateral\_import\_ij$

	(1)	(2)	(3)	(4)	(5)
rta	2.012***	0.980***	0.805***	0.790***	0.670***
	(0.318)	(0.161)	(0.201)	(0.212)	(0.237)
ln_distcap			-0.765***	-0.760***	-1.245***
			(0.151)	(0.152)	(0.111)
1 = Common official or primary language			0.699***	0.672***	
			(0.206)	(0.208)	
=1 if origin and destination are contiguous			0.849***	0.884***	
			(0.253)	(0.274)	
ln_gdp_o			0.497***		0.476***
			(0.133)		(0.125)
ln_gdp_d			0.006		0.005
			(0.142)		(0.139)
Constant	16.502***	19.253***	14.334***	23.539***	19.151***
	(0.242)	(0.111)	(3.793)	(1.211)	(3.384)
Obs.	22339.000	22213.000	21795.000	22339.000	21795.000
Years FE	T	F	T	T	T
Destination FE	F	F	T	T	T
Origin FE	F	F	T	T	T
Pairs FE	F	T	F	F	F

Notes: The third and fifth regressions are Poisson Pseudo-Maximum Likelihood Estimators. Adding GDP of origins and destinations doesn't change the results much and their coefficient has expected signs.

$$ATT(g,t) = E[Y_t(g) - Y_t(0)|G_g = 1]$$

where $Y_t(g)$ and $Y_t(0)$ are the potential outcomes with and without treatment, respectively.

Aggregation Over Event Time

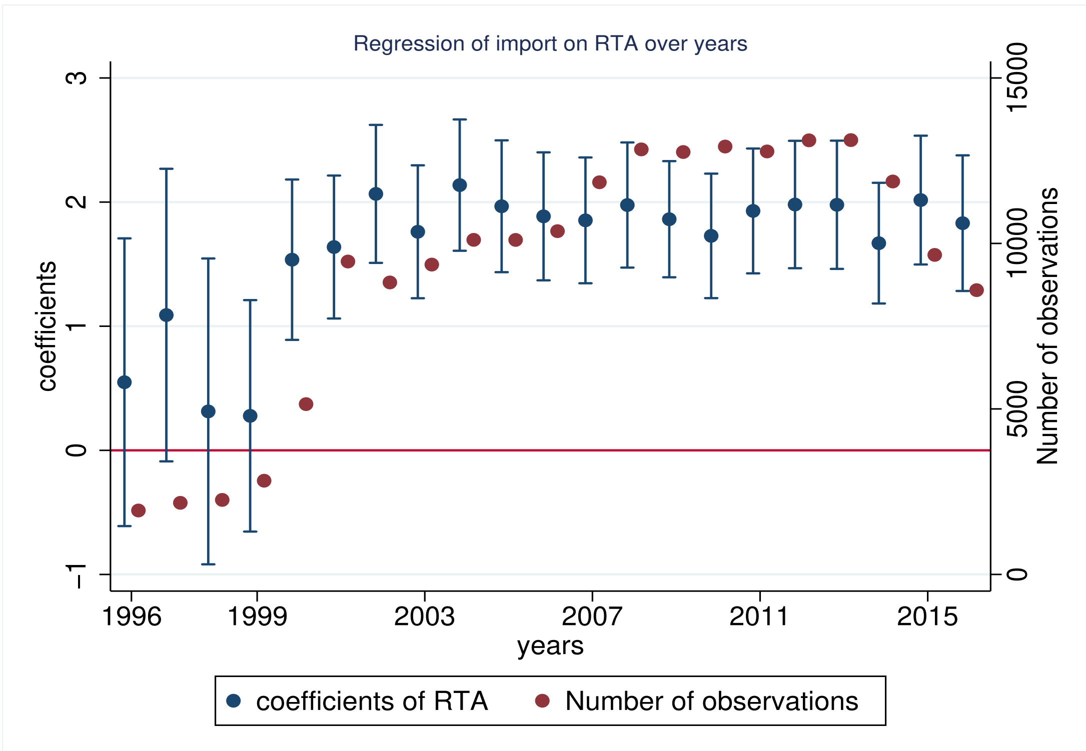
Event time k is defined as $k = t - g$, the difference between the calendar time t and the treatment time g. The goal is to aggregate ATTs for the same event time k across different groups.

Let's denote the number of units (e.g., country pairs) in group g as N_g. The overall ATT at event time k can be formulated as:

$$ATT(k) = \frac{\sum_{g \in G_k} N_g \cdot ATT(g, g+k)}{\sum_{g \in G_k} N_g}$$

where G_k is the set of groups that have event at time k. This formula represents a

Figure B.1 – Imports on RTA over time, with all controls



Notes: This figure presents the dynamic of the coefficient over time. We note that before 2000, we did not have a significant effect, which can be explained by a few observations. Indeed, there were only a few RTAs (around 10, see figure B.4) which started around the same period, so their effect was not instantaneous. But after 2000 the effect of RTA on trade is positive, significant, and relatively stable over time.

weighted average of the ATTs for event time k, with weights N_g proportional to the group sizes.

Overall Aggregated ATT

To get the overall aggregated ATT across all event times, we further aggregate the event time-specific ATTs:

$$ATT = \frac{\sum_{k \in K} W_k \cdot ATT(k)}{\sum_{k \in K} W_k}$$

where:

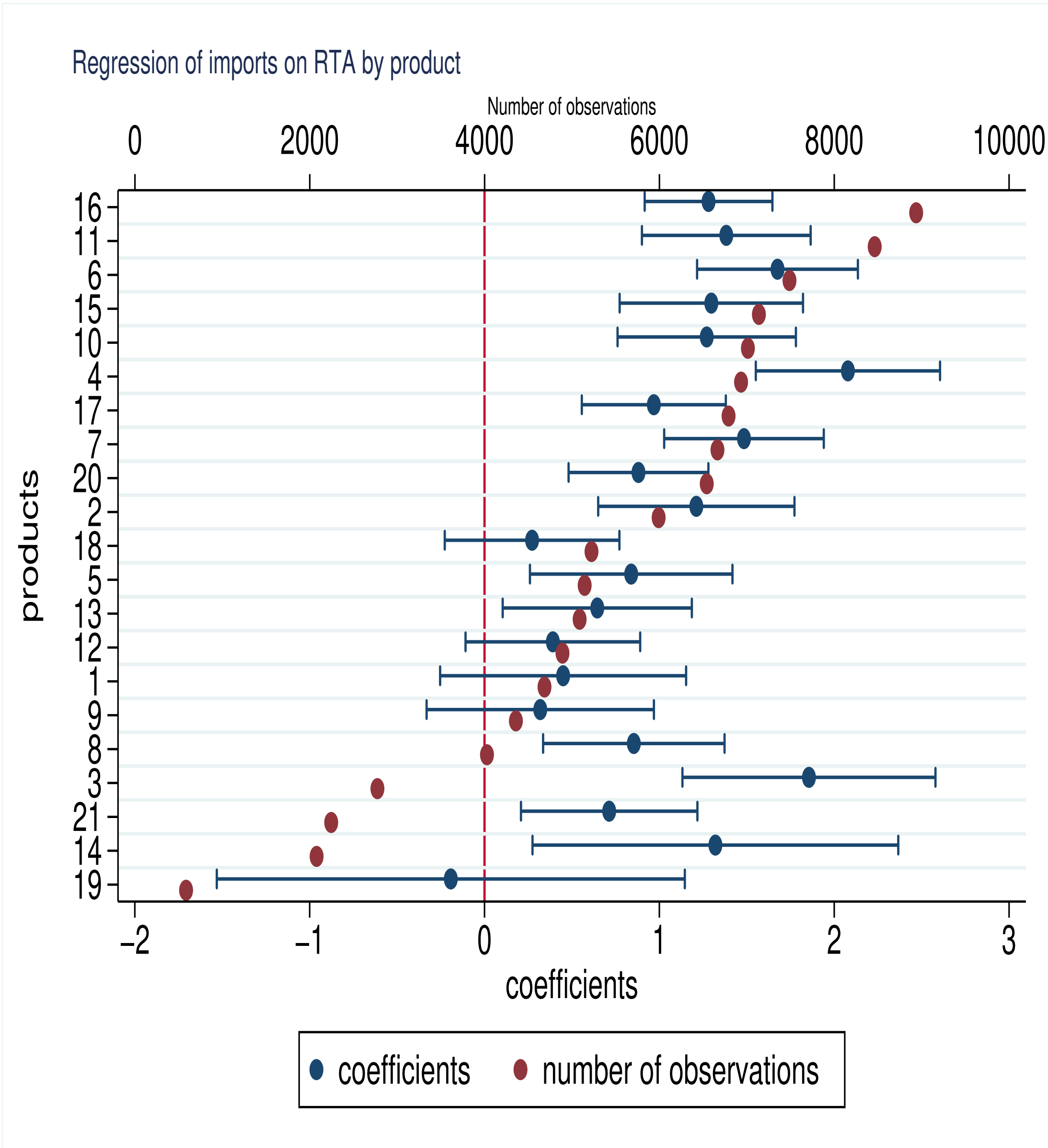
— K is the set of all event times.

— W_k is the total weight for event time k, typically the sum of the weights of all groups at that event time:

$$W_k = \sum_{g \in G_k} N_g$$

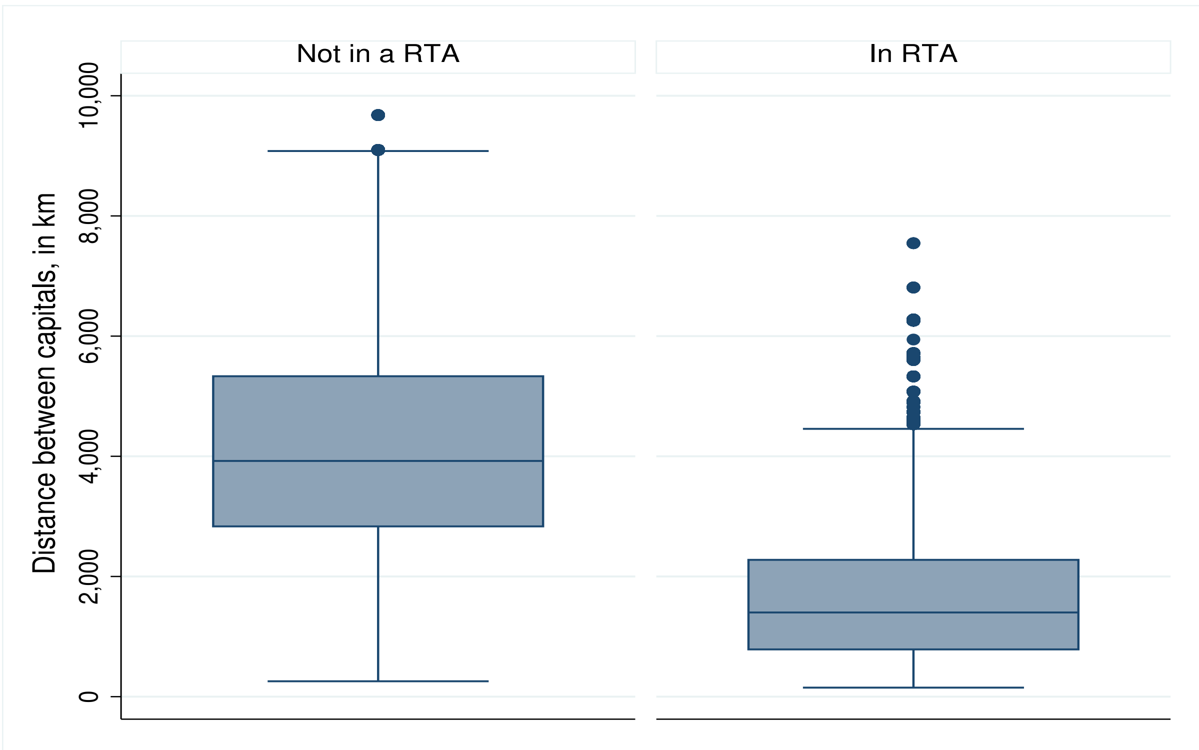
Thus, the overall ATT is a weighted average of the event time-specific ATTs, with the weights reflecting the combined sizes of the groups contributing to each event time. The weighting mechanism ensures that larger groups and more frequently observed post-treatment periods contribute more to the overall effect. This approach leverages the flexibility of the Difference-in-Differences (DID) estimator to handle treatment effect heterogeneity and staggered treatment adoption across different groups and times.

Figure B.2 – imports on RTA by product, with all controls



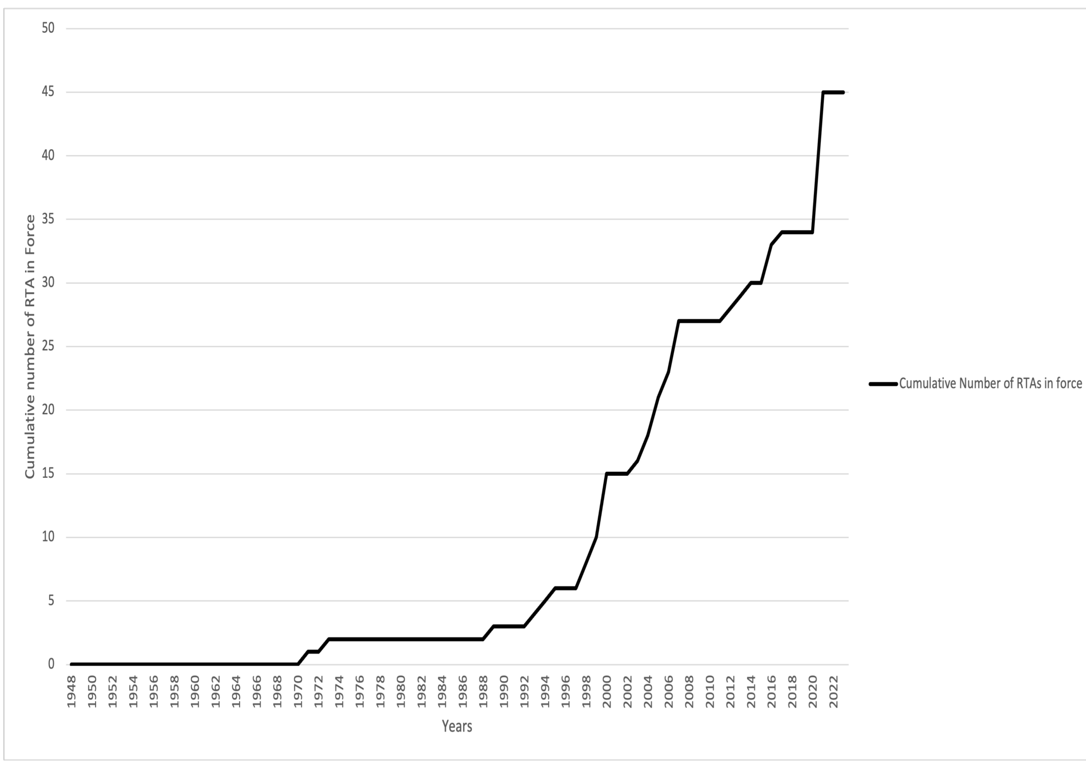
Notes: This figure presents regressions by product category. Besides arms and munition (which have few data), for all the products RTA has the right sign and is significant for 16 products out of 21. See figure 2.1 for the labels of the produts).

Figure B.3 – box plot of distance by RTA



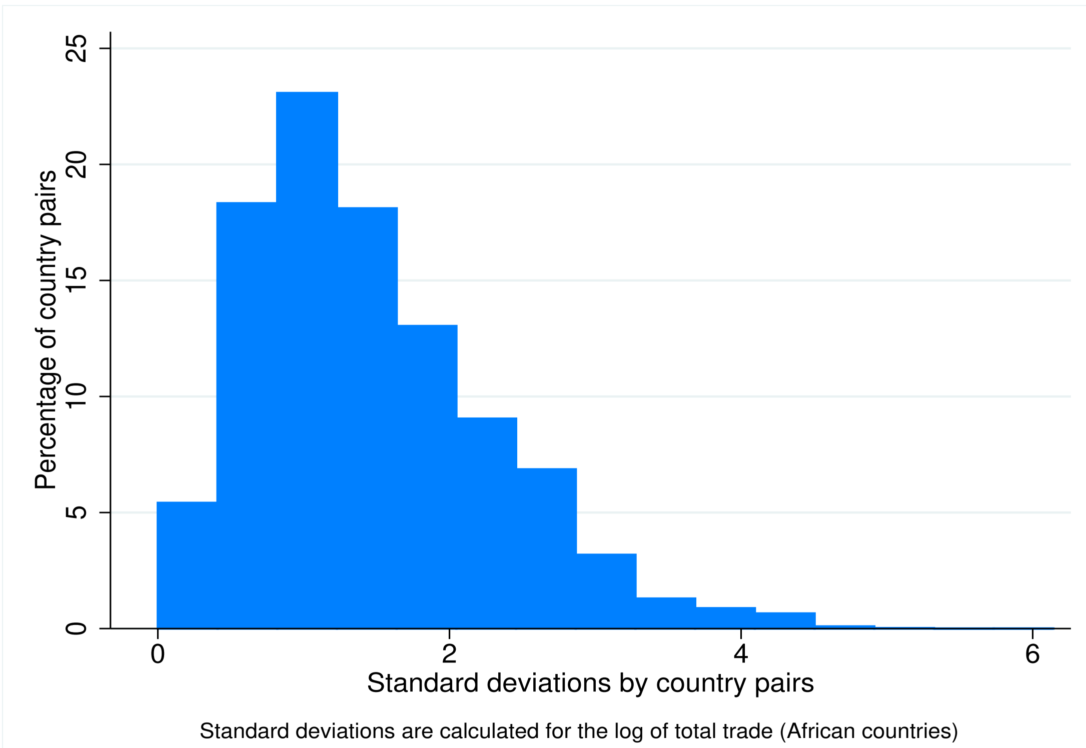
Notes: This box plot displays the distance between countries in an RTA compared to countries not in an RTA. As it can be seen, countries in an RTA are closer to each other.

Figure B.4 – cumulative numbers of RTA among African countries



source :WTO

Figure B.5 – standard deviations of bilateral imports across pair of countries



Notes: This graph presents standard deviations of bilateral imports by pairs of countries. When we also do the same exercise for the most exchanged products "mineral products", we get similar results.

Appendix C

Appendix to chapter 3

C.1 tibgbvbn