

UNIVERSITÉ D'ORLÉANS

**ÉCOLE DOCTORALE SCIENCES DE LA SOCIÉTÉ : TERRITOIRES, ÉCONOMIE
ET DROIT (SSTED)**

Laboratoire d'Économie d'Orléans

THÈSE présentée par :

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soutenue le : **21 Novembre 2025**

pour obtenir le grade de : **Docteur de l'Université d'Orléans**

Discipline/ Spécialité : **ÉCONOMIE**

Essays on Fiscal Policy, Climate Change, and Financing for Development

Essais sur la politique budgétaire, le changement climatique et le financement du développement

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DIEU MERCI!

HOMMAGE À MON PÈRE ET MA MÈRE !

« Face aux défis du changement climatique, la responsabilité commande d’agir maintenant pour sauver le futur »

LISTE DES ACRONYMES ET DES ABRÉVIATIONS

TABLE 1 – LISTE DES ABRÉVIATIONS

Variables	Description	Source
OMM	Organisation Mondiale Météorologique	ABRÉVIATIONS
COP	La Conférence des Parties est l'organe décisionnel suprême de la Convention	ABRÉVIATIONS
GIEC	Groupe d'experts intergouvernemental sur l'évolution du climat	ABRÉVIATIONS
IDE	Investissements Direct Étrangers	ABRÉVIATIONS
SPEI rules	Standardized Precipitation-Evapotranspiration Index	ABREVIATIONS
CRU	Climate Research Unit	ABREVIATIONS
OCDE	Organisation de coopération et de développement économiques	ABRÉVIATIONS
FMI	Fonds Monétaire International	ABRÉVIATIONS
CO ₂	carbon dioxide	ABREVIATIONS
CAI	Climatology Assisted Interpolation	ABREVIATIONS
GDP	Gross domestic product	ABREVIATIONS
GDP per capita	the sum of gross value added by all resident producers in the economy plus any product taxes (less subsidies) not included in the valuation of output, divided by mid-year population	ABREVIATIONS
FMI	Fonds Monétaire International	ABRÉVIATIONS
ODA	Official Development Assistance	ABREVIATIONS
NDC	Paris Climate Agreement	ABREVIATIONS
NDC	Nationally Determined Contributions	ABREVIATIONS
GI	Green Investment	ABREVIATIONS
UNCTAD	UN Trade and Development	ABREVIATIONS
GHG	Greenhouse gas emissions	ABREVIATIONS
LDC	Least-Developed Countries	ABREVIATIONS
ND-GAIN	The Notre Dame Global Adaptation Initiative	ABREVIATIONS

REMERCIEMENTS

Avant tout propos, je tiens à dire toute ma reconnaissance, ma gratitude et mon admiration à l'endroit de mes Directeurs de thèse Xavier GALIEGUE et Djamel KIRAT qui depuis trois ans ont accepté diriger mes travaux de recherche. C'est un honneur pour moi de les avoirs comme encadrants. J'ai particulièrement apprécié l'esprit de rigueur, le suivi régulier et la bienveillance qui ont animé nos échanges durant ces trois années. C'est véritablement une chance pour moi de vous avoir comme Directeurs de thèse. J'exprime ma profonde gratitude à tous les membres du jury, pour avoir pris leur temps afin de lire ce document et accepté de composer le jury, ce qui témoigne leur intérêt pour cette thèse. Je souhaite également exprimer mes remerciements et ma reconnaissance à Alexandru MINEA qui a été pour moi un catalyseur et une inspiration. J'exprime aussi toute ma gratitude à Jean-Louis COMBES pour sa disponibilité et ses orientations qui ont été pour moi très utiles. Mes remerciements à l'ensemble du personnel du Laboratoire d'économie d'Orléans (LEO) pour tout le soutien, l'attention et les orientations. Qu'ils reçoivent toute ma gratitude et ma reconnaissance. Grâce à vous, mes périodes de travail au LEO ont été agréables et remplies de bons souvenirs. Je souhaite remercier particulièrement Christophe HURLIN pour son esprit d'ouverture, sa compréhension et son soutien manifesté à mon égard afin de faciliter le bon déroulement de mes travaux de recherche. Je tiens à remercier chaleureusement le Directeur d'AFRITAC Centre (FMI) Philippe EGOUME pour sa compréhension, sa disponibilité et le soutien qu'il m'a apporté pendant les deux dernières années pour la réussite de la thèse. Par la même occasion, j'adresse mes remerciements à l'ensemble des collègues d'AFRITAC Centre pour l'attention, les orientations et le soutien à mon égard. A Sandrine ROLAH, celle qui m'accompagne et partage ma vie depuis bientôt trois ans, je voudrais lui témoigner toute ma gratitude, mon attachement et ma reconnaissance. Elle a été d'un grand soutien et réconfort pendant ces années de thèse. Je remercie du fond du cœur mes amis Aya IDRISSE ALADJI, Bao-wé BAMBE, Bélem AHMED ALY, Ulrich DOAMBA, et Michel NDAYIKEZA avec lesquels j'ai passé des très bons moments. Leur soutien et motivation ont été pour moi un véritable catalyseur. Dans le même élan, je tiens à exprimer mes remerciements à tous mes camarades de promotion de Magistère économie du développement de l'école d'économie de Clermont-Ferrand (CERDI). Mes remerciements vont également à l'endroit de tous mes collègues de bureau du LEO et du CERDI : Asbath ALASSANI, Yacouba COULIBALLY, Ben VIERA, Dorian BALVIR, Chantale OWECCI, Rachid PAFADNAM, Richard PENG-D-WENDE. Leurs conseils et attentions ont été d'une grande importance pour moi. Merci d'avoir fait de mes journées au bureau une réussite quotidienne sur le plan humain, académique et professionnelle. J'adresse mes remerciements à CAMPUS France et plus particulièrement à l'Ambassade de France au Tchad pour l'octroi de la bourse d'études durant ma thèse. Ce soutien financier m'a particulièrement aidé à bien réaliser mes activités de recherche. J'en suis reconnaissant. Je souhaiterais adresser ma profonde gratitude et reconnaissance envers l'Université d'Orléans et le Ministère Français de l'Enseignement Supérieur et de la Recherche car pendant ma thèse, j'ai bénéficié d'un bon

cadre d'études et d'une bonne qualité de formation. Durant ces trois années de thèse, j'étais très impliqué dans la vie associative. J'ai été tour à tour Président de l'association des élèves, étudiants et stagiaires tchadiens de Clermont Ferrand et Président de l'Union des Associations des Etudiants Tchadiens de France. Cette expérience m'a permis d'être au service de mes compatriotes résident en France. Cela m'a également permis de me détendre et d'apprendre davantage sur la gestion des Hommes. Je voudrais exprimer ma reconnaissance à tous les étudiants tchadiens de France pour le choix porter sur ma modeste personne pour diriger ces deux associations. Ces expériences m'ont permis de développer davantage les capacités organisationnelles et la rigueur qui sont également important dans le cadre de la thèse. Je rends hommage à mon Père Wandi DASSIDI et ma Mère Fourira JEANNETTE (décédée en octobre 2020) pour tous les bienfaits et le soutien multiforme qu'ils n'ont cessé de m'apporter depuis ma naissance. Qu'ils reçoivent ici, l'expression de ma reconnaissance, ma gratitude et ma fierté. Cette thèse est entièrement dédiée à ma Mère, à tous mes proches décédés (Daniel HINIMA DASSIDI, Aimée VIKAMA GOUNDOUL, BALSSOUNA, Nassour GOUNDOUL, etc.) pendant ces cinq dernières années. Mes remerciements à tous mes Oncles (Ada DAMBA, Ngolona GOUNDOUL, Moussa DASSIDI, Vikama GOUNDOUL, Baba DINA, Fimbassou DASSIDI, Moulna DASSIDI, Désiré WIQUET, Ayambi DASSIDI, Bangtouna WIQUET, Amibel WIQUET, etc.) ; mes tantes (Eldjima WANA , Kadoufa WANA Lucienne, Djivira WIQUET, etc.), mon grand-Père maternel Wiquet OIVERE, mes sœurs (Fatimatou DASSIDI, Houssouna et Hassanié DASSIDI, Minda DASSIDI, Solange DASSIDI, Khadidja DASSIDI, Haoua DASSIDI, Achta HALINA Anne-Marie, Bintou DASSIDI, Tchangopa DASSIDI, Laira DASSIDI, Fitoua DASSIDI), mes frères (Mansour DASSIDI, Douksouna DASSIDI, Foksia GOUNDOUL, Kalvick GOUNDOUL, Laaya GOUNDOUL, Issa DASSIDI, Abdelkerim DASSIDI, Dawia DINA, Tocksouna GOUNDOUL, Malambassa DASSIDI, Fabrice DAMBA, Ndafogo DAMBA, Djoufssou DAMBA, Soussia DASSIDI, Lohamou DASSIDI, etc.) pour tout le soutien moral et les conseils pendant ces années de recherche.

RÉSUMÉ

Les effets du changement climatique font peser des menaces réelles sur les conditions de vie de l'Homme. Dans les pays en développement, ces effets sont encore plus prononcés en raison de la forte vulnérabilité et de la faible capacité de ces pays à y faire face. Ainsi, cette thèse se propose de contribuer à la littérature existante en présentant quatre chapitres afin d'analyser le lien entre le changement climatique, la politique budgétaire et le financement du développement dans les pays en développement. Dans le premier chapitre, nous nous penchons sur l'effet du changement climatique sur la pauvreté et interrogeons la capacité des dépenses publiques à atténuer ces effets. Les résultats indiquent que le choc climatique aggrave les conditions socio-économiques, donc la pauvreté. Cet effet est mis en évidence par la relation positive et significative entre le choc climatique et la pauvreté. Les résultats suggèrent également que l'utilisation des dépenses publiques permet d'atténuer les effets du choc. Ce chapitre met aussi en lumière des facteurs clés de résilience, donc d'atténuation du choc, tels que les dépenses sociales et de santé. Le deuxième chapitre s'intéresse à l'analyse de la relation entre les règles budgétaires et les Investissements Directs Étrangers (IDE). Il en ressort que l'adoption des règles budgétaires par les pays en développement permet d'augmenter les IDE, nécessaires au financement du développement. Plus intéressant encore, en dehors des règles sur les dépenses, les autres types de règles budgétaires, à savoir celles sur le revenu, le ratio d'endettement, le déficit et l'inflation, contribuent à attirer davantage d'IDE. Dans le troisième chapitre, nous menons une réflexion sur la relation entre l'adoption des règles budgétaires et le financement vert. Les résultats montrent que l'adoption de règles budgétaires permet d'attirer plus d'investissements verts. Le dernier chapitre met en évidence le lien entre le choc climatique et la notation de la dette souveraine, puis interroge l'efficacité de la politique budgétaire dans l'atténuation des effets du choc sur cette notation. Très souvent, cette notation souveraine correspond à l'évaluation de la solvabilité de chacun de ces pays par les agences de notation. Elle permet de mesurer la capacité du pays à mobiliser des ressources externes pour le financement du développement. Les résultats montrent que le choc climatique affecte négativement et significativement la notation de la dette souveraine. En présence du choc, l'adoption des règles budgétaires permet d'atténuer cet effet sur la notation.

Mots clés : Changement climatique, chocs climatiques, pauvreté, règles budgétaires, pays en développement, Investissements Directs Etrangers, financement vert.

Classifications JEL : Q54 ; I30 ; I32 ; I38 ; C23 ; E43 ; E62 ; F41 ; O11 ; Q56 ; E60 ; E62 ; Q5 ; C33 ; F21

SUMMARY

The effects of climate change pose real threats to human living conditions. In developing countries, this effect is even more pronounced due to the high vulnerability and low capacity of these countries to cope with it. Thus, this thesis aims to contribute to the existing literature by proposing four chapters to analyze the link between climate change, fiscal policy, and development financing in developing countries. In the first chapter, we look at the effect of climate change on poverty and we question the capacity of public spending to mitigate the effects. The results indicate that the climate shock worsens socio-economic conditions, therefore poverty. The effect is captured by the positive and significant relationship between the climate shock and poverty. The results also suggest that the use of public spending helps to mitigate the effects of the shock. The results of this chapter also highlight key factors of resilience, therefore shock mitigation such as social and health spending. Chapter 2 focuses on the analysis of the relationship between fiscal rules and Foreign Direct Investment (FDI). It emerges from this chapter that the adoption of fiscal rules by developing countries helps increase FDI, which is necessary to finance development. More interestingly, apart from expenditure rules, other types of budgetary restrictions, namely rules on income, debt ratio, deficit, and inflation, contribute to attracting more FDI. Subsequently, in the third chapter, we reflect on the relationship between the adoption of fiscal rules and green financing. The results of this chapter show that the adoption of fiscal rules helps attract more green investment. The last chapter highlights the link between climate shock and sovereign debt rating and then questions the effectiveness of fiscal policy in mitigating the effects of the shock on this sovereign rating of developing countries. Very often, this sovereign rating is the assessment of the solvency of each of these countries by rating agencies. It measures the country's ability to mobilize external resources to finance development. The results show that climate shock negatively and significantly affects sovereign debt rating. In the presence of the shock, the adoption of the fiscal rules helps to mitigate the effect of the shock on this rating.

Keywords : Climate change, climate shocks, poverty, fiscal rules, developing countries, Foreign Direct Investment, green financing.

JEL classifications : Q54 ; I30 ; I32 ; I38 ; C23 ; E43 ; E62 ; F41 ; O11 ; Q56 ; E60 ; E62 ; Q5 ; C33 ; F21

Essais sur le changement climatique, la politique budgétaire et le financement du développement

Introduction générale

0.1 Contexte et justification

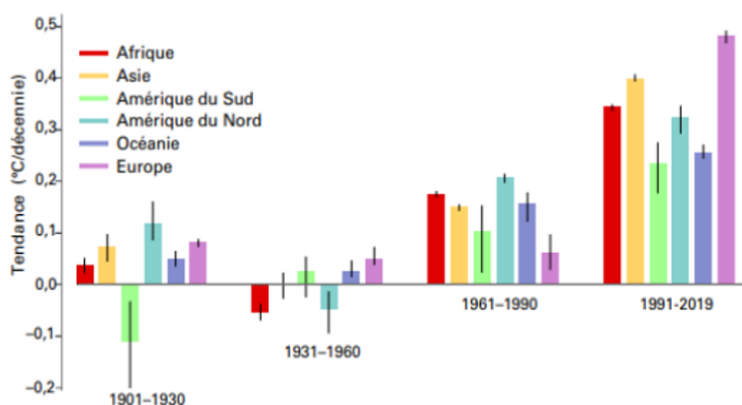
Le changement climatique est sans nul doute l'un des grands défis du XXI^{ème} siècle. Ses impacts affectent quasiment tous les secteurs du développement notamment l'économie, l'écosystème, la santé, l'agriculture, etc. Les pays en développement sont particulièrement affectés par ce fléau en raison de leur forte exposition aux aléas climatiques (les inondations, la désertification, la sécheresse, la chaleur) compte tenu de leur faible capacité d'adaptation, manque d'infrastructures adéquates, la situation géographique, etc. Les plus vulnérables face aux effets du changement climatique sont les pays qui émettent moins de gaz à effet de serre. Ces pays subissent de plein fouet des conséquences disproportionnées et peinent également à mobiliser des ressources pour y faire face. En 2021, le rapport du Groupe d'experts intergouvernemental sur l'évolution du climat (GIEC, 2021) a également montré la vulnérabilité des pays en développement face au changement climatique alors qu'ils sont responsables d'une partie très faible des émissions de gaz à effet de serre. L'économie et le changement climatique sont liés car le changement climatique n'est pas uniquement un problème environnemental, mais également lié à la gouvernance internationale, la justice sociale et le choix des politiques économiques. Dans les pays en développement, la situation est souvent complexe car ils sont à la fois confrontés à plusieurs défis importants (climat, performance économique et bien-être de la population). Les pays en développement se retrouvent non seulement devant une panoplie de défis mais sont également dépourvus de moyens pour y faire face. La politique budgétaire joue un rôle crucial dans la gestion du changement climatique. Elle est un instrument clé dans la réponse des États aux enjeux du changement climatique. Les gouvernements des pays en développement doivent allouer des ressources financières importantes pour atténuer les effets du changement climatique, tout en soutenant les processus de développement économique et social. La gestion des finances publiques, la redistribution des ressources et la mise en place de mécanismes fiscaux adaptés deviennent des priorités pour intégrer les préoccupations climatiques dans les stratégies nationales. Cependant, la gestion budgétaire dans ces pays se trouve confrontée à plusieurs défis. D'une part, la pauvreté, les inégalités et la faiblesse des institutions limitent les capacités des gouvernements à mobiliser les ressources nécessaires. D'autre part, les enjeux climatiques nécessitent des investissements massifs dans des secteurs tels que l'énergie, l'agriculture, les infrastructures résilientes et la protection de l'environnement. Dans ce contexte, les pays en déve-

loppement doivent revoir leurs priorités budgétaires, opter pour des choix difficiles et développer des mécanismes de financement innovants et adaptés à leurs spécificités. Les effets du changement climatique affectent le monde entier et non un pays ou une communauté de manière isolée. En plus d'être confrontés à des défis économiques et sociaux, les pays en développement voient souvent leur vulnérabilité être exacerbée par des catastrophes naturelles. Les travaux de (Jones et al., 2019) montrent que la pauvreté, les inégalités sociales et la gouvernance fragile rendent ces pays particulièrement vulnérables aux changements climatiques. La lutte contre le changement climatique mérite une attention particulière, une mobilisation internationale et fait surtout appel à un sursaut de chacun et de tous afin de réussir collectivement. Ainsi, plusieurs conférences, initiatives et institutions ont été mises en place afin de permettre une prise de conscience globale et accroître une forte mobilisation des moyens. Le réchauffement climatique a fait l'objet d'une mobilisation internationale, grâce à l'expertise acquise par le GIEC à travers ses différents rapports, et aux différentes COP qui ont suivi la Conférence de Rio et le protocole de Kyoto, etc. Chaque année une Conférence des parties (COP) est organisée afin de suivre l'évolution des émissions de gaz à effet de serre dans le monde et de fixer des objectifs ambitieux pour limiter le réchauffement climatique. Depuis 1995, on dénombre 30 COP qui ont été organisées dont la dernière a eu lieu cette année à Belém au Brésil. La COP la plus emblématique reste celle (COP21) organisée à Paris en 2015 qui a permis d'aboutir à un nouvel accord international sur le climat, l'accord de Paris, applicable à tous les pays. Il vise à maintenir le réchauffement mondial à 1,5-2°C, par rapport aux niveaux préindustriels, conformément aux préconisations du Groupe d'experts intergouvernemental sur l'évolution du climat (GIEC). La question du défi climatique et du financement du développement est au cœur des préoccupations des pays en développement car le financement du développement durable a toujours été un enjeu majeur pour les pays en développement, mais le changement climatique ajoute une nouvelle dimension à cette problématique. Les coûts associés à l'adaptation au changement climatique, à la transition énergétique et à la gestion des catastrophes naturelles sont colossaux. Les ressources nationales ne suffisent pas toujours, et les pays en développement dépendent largement de l'aide internationale, des investissements privés et des financements multilatéraux pour financer leurs actions climatiques. Les mécanismes de financement climatique, tels que le Fonds vert pour le climat ou les programmes de financement des Nations Unies, ont été mis en place pour soutenir les pays en développement. Toutefois, l'accès à ces fonds reste un défi, notamment en raison des exigences techniques et administratives, des processus complexes de négociation et de l'incertitude sur les montants alloués. De plus, la question de la responsabilité historique des pays industrialisés dans la crise climatique complique les discussions autour du financement climatique.

0.2 Motivations et problématiques

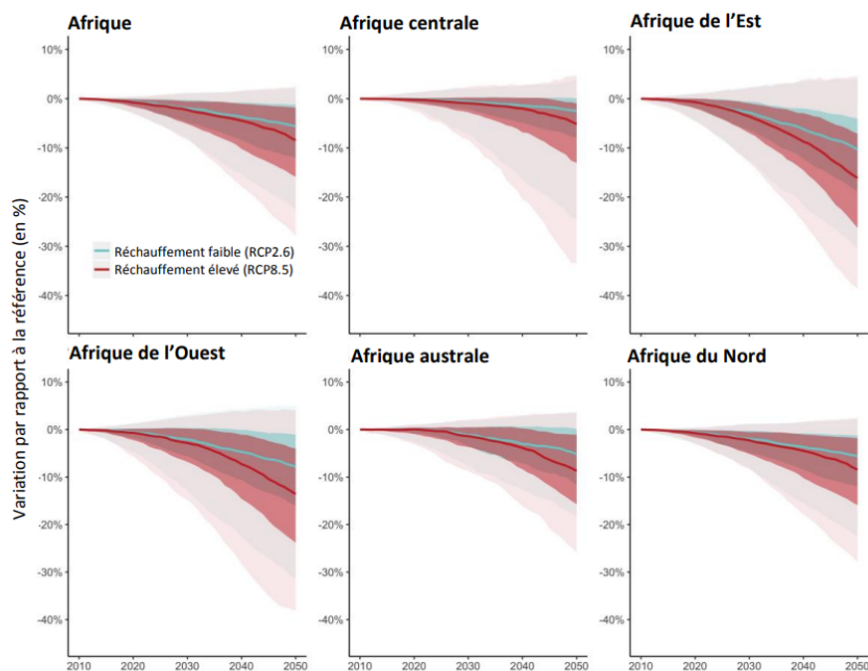
Cette thèse se donne pour mission d'analyser le lien entre le changement climatique, la politique budgétaire et le financement du développement. Cette analyse a le mérite d'être car elle

aborde l'un des défis majeurs auxquels sont confrontés de nombreux pays : faire face aux effets du changement climatique tout en essayant de maintenir la trajectoire de la prospérité économique. L'objectif principal de cette thèse est d'explorer les liens entre la politique budgétaire, le financement du développement et le changement climatique dans les pays en développement. Plus précisément, il s'agira de comprendre comment les pays en développement peuvent intégrer la dimension climatique dans leur politique économique tout en assurant un financement durable pour leur développement. Selon les Nations Unies, les changements climatiques désignent les variations à long terme de la température et des modèles météorologiques. Il peut s'agir de variations naturelles, dues par exemple à celles du cycle solaire ou à des éruptions volcaniques massives. Les effets du changement climatique affectent la gestion de la politique budgétaire dans la mesure où les pays sont obligés de faire usage des instruments de la politique budgétaire afin de contenir les effets de l'instabilité climatique, donc financer la résilience face au changement climatique. La politique budgétaire quant à elle fait référence à l'ensemble des mesures prises par un gouvernement et entraînant des conséquences sur le niveau et la composition de ses recettes et de ses dépenses. A chaque fois qu'un pays fait face à une instabilité climatique, il utilise le levier de la politique budgétaire pour faire face à cette situation ; cela place la politique budgétaire au cœur de la riposte au changement climatique. De même, les pays sont à la fois confrontés aux enjeux climatiques et de développement ; d'où la nécessité de trouver le juste milieu entre le développement et la réponse aux défis climatiques. Tel est l'une des aspirations de cette thèse. Cette thèse vise à contribuer à la compréhension des liens complexes entre le changement climatique, la politique budgétaire et le financement du développement dans les pays en développement. En offrant une analyse approfondie des défis et des solutions potentielles, elle espère fournir des pistes concrètes pour une gestion plus efficace des ressources financières et une meilleure intégration des enjeux climatiques dans les stratégies de développement. Notre travail se focalise sur les pays en développement. Le choix de cette partie du monde n'est pas aléatoire mais est justifié par trois raisons : premièrement, ces pays sont identifiés comme des pays où les impacts du changement climatique sont les plus prononcés à cause de leur vulnérabilité. Deuxièmement, ces pays émettent le moins de dioxyde de carbone (donc dégradent le moins la couche d'ozone) mais sont les plus grandes victimes de l'instabilité climatique. Enfin, ces pays se caractérisent par leur faible capacité de mobilisation des ressources pour faire face aux enjeux climatiques et également de développement. Au-delà du caractère vulnérable des pays en développement, il faut noter que ces pays (zone Afrique, Amérique du sud et Asie) ont globalement connu une augmentation de la température à un taux comparable aux autres continents mais un peu plus rapidement depuis le début du 20-ème siècle (Voir figure 1).



Source : Organisation Météorologique Mondiale, 2019

Parmi les pays en développement, les pays d'Afrique subsaharienne sont ceux qui subissent le plus les effets du changement climatique (GIEC). Le GIEC montre aussi que ces pays se sont réchauffés de plus de 1°C depuis 1901, avec une augmentation des jours de canicule et des vagues de chaleur. La figure 2 montre la variation du PIB par habitant à la suite du réchauffement continu de la planète d'ici 2050 selon les prévisions d'ECA (United Nations Economic Commission for Africa).



Source : United Nations Economic Commission for Africa (ECA)

Le choix de l'Afrique (dans l'illustration) se justifie par le fait que c'est la partie du monde qui fait le plus face aux conséquences du changement climatique, donc plus vulnérable. Le graphique ci-dessus présente la situation de l'ensemble des pays africains. Il fait également une projection sur trois décennies à partir de 2010 pour les pays des cinq régions, pour des scénarios à réchauffement faible (en bleu) et à réchauffement élevé (en rouge). La zone grisée représente l'intervalle

de confiance statistique de 50% , alors que la zone rosée indique celui de 95% . Les effets négatifs du changement climatique sur la performance économique de l’Afrique vont retarder la dynamique de développement économique de cette région. Au regard des arguments développés ci-haut, il est donc plus que jamais nécessaire de s’intéresser à la problématique du climat, de faire des enjeux climatiques et de leur implication dans la politique budgétaire et le financement du développement une priorité. Ainsi, notre thèse se propose de discuter des questions suivantes dans les différents chapitres qui la compose :

Quel est l’impact du changement climatique sur la pauvreté dans les pays en développement ? Les dépenses publiques sont-elles efficaces pour contenir l’effet des chocs climatiques sur la pauvreté dans les pays en développement ?

Quel est l’effet des règles budgétaires sur les investissements directs étrangers (IDE) dans les pays en développement ?

Quel est l’effet des règles budgétaires sur les investissements verts dans les pays en développement ? et quel type de règle permet de plus favoriser les investissements verts ?

Quel est le lien entre le changement climatique et la notation de la dette souveraine ?

0.3 Méthodologie, contributions et organisation de la thèse

Le changement climatique et ses conséquences socio-économiques sur la performance économique des pays (et le bien-être des populations) constituent des sujets de préoccupation mondiale ([Van Gameren et al., 2014](#)). Même si le changement climatique est un phénomène mondial, les effets de l’instabilité climatique varient en fonction de la position géographique, des dispositions naturelles, et des capacités financières et économiques de chaque pays à faire face à cette instabilité. Chaque année, les conséquences du changement climatique telles que l’érosion, les inondations, les cyclones, les sécheresses, etc. continuent de dégrader les conditions socio-économiques des ménages avec leurs lots de désolation et de malheurs. Déjà mal en point sur le plan économique, les pays en développement se retrouvent être les plus impactés par le phénomène du changement climatique et peinent à mobiliser davantage de ressources pour atténuer ses effets ([Ericksen et al., 1993](#)). Les coûts financiers et économiques des conséquences de l’instabilité climatique sont particulièrement élevés pour les pays en développement, plus particulièrement pour les ménages pauvres. D’où la nécessité d’analyser l’impact socio-économique du changement climatique et l’apport de la politique budgétaire dans l’atténuation des effets de l’instabilité climatique ([Savage et al., 2009](#)). Cet apport de la politique budgétaire contribue à renforcer la résilience des pays et améliore les conditions socio-économiques des ménages. Cette thèse est d’abord motivée par la compréhension des mécanismes par lesquels le changement climatique affecte l’activité économique des pays en développement. Ensuite, elle s’intéresse aux effets du changement climatique sur les conditions socio-économiques

de la population des pays en développement. Enfin, elle est également motivée par les différentes implications de politiques économiques pour une amélioration de la résilience des populations face au changement climatique. Cette thèse contribuera à la littérature existante en apportant des innovations méthodologiques et empiriques à travers les quatre chapitres qui portent tous sur les pays en développement. À travers ces chapitres, nous analyserons les questions liées à la pauvreté, le changement climatique et le financement du développement. Le premier chapitre s'intéresse dans un premier temps à l'impact du changement climatique sur les conditions socio-économiques (la pauvreté). Dans un deuxième temps, il abordera la question du rôle des instruments de la politique budgétaire dans le processus d'adaptation et d'atténuation des effets du changement climatique. Enfin, il mène une analyse comparative de l'efficacité des différents instruments de politiques économiques en termes d'impact sur la résilience des ménages. Le deuxième chapitre analyse le lien entre l'adoption des règles budgétaires et les Investissements Direct Étrangers (IDE). Les enjeux du financement du développement des pays en développement nécessitent une forte mobilisation des ressources et les IDE restent l'un des leviers importants pour mieux financer le développement. Le troisième chapitre se focalise sur le verdissement des règles budgétaires et le financement du changement climatique. Les questions du financement du changement climatique et la réduction de la pauvreté sont de nos jours, des sujets de préoccupation mondiale, d'où l'urgence d'adapter les politiques économiques afin qu'elles répondent aux défis et améliorent le bien-être de la population. De façon claire, il est question de faire le lien entre les règles budgétaire, la crédibilité, l'accès aux fonds verts et l'apport pour le financement du changement climatique. Le dernier chapitre met en évidence le lien entre le choc climatique et la notation de la dette souveraine. Dans les lignes qui suivent, nous présentons le résumé de chaque chapitre qui inclut la motivation, la méthodologie, la contribution, les résultats et les implications de politiques économiques qui en découlent.

Le **premier chapitre** s'intéresse à l'analyse de l'impact du changement climatique sur la pauvreté. Plusieurs articles ont identifié les facteurs par lesquels le changement climatique agit sur les conditions socio-économiques des ménages. Les travaux de ([Slingo et al., 2005](#), [Hoddinott and Kinsey, 2001](#), [Burke et al., 2015](#)) identifient l'agriculture, la santé et les conflits comme principaux canaux par lesquels le changement climatique affecte la pauvreté. En dehors de ces canaux, le niveau des prix pourrait également être un facteur important de transmission des effets de l'instabilité climatique sur les conditions socio-économiques des populations. Le choix des pays en développement pour ce chapitre est motivé d'abord par le fait qu'ils font face régulièrement aux effets du changement climatique. Leurs populations sont souvent exposées aux catastrophes naturelles. Ensuite, ces pays présentent les mêmes caractéristiques que les autres pays (affectés) car ils connaissent une volatilité macroéconomique plus élevée en raison d'une moindre diversification économique, ce qui accroît leur vulnérabilité aux chocs climatiques. Enfin, ces pays ont quasiment tous mis en place des politiques visant à renforcer la résilience des populations à la suite des chocs climatiques. Deux principales hypothèses sont testées dans ce chapitre : La première hypothèse indique que

le choc climatique augmente la pauvreté des ménages et la deuxième est relative à l'idée selon laquelle l'utilisation des instruments de politique budgétaire lors d'un choc atténue les effets du changement climatique. Les pays en développement sont particulièrement vulnérables aux effets du changement climatique et peinent à mobiliser des ressources pour faire face à ses effets. D'où l'importance d'analyser l'impact du changement climatique sur les conditions socio-économiques des ménages et les conditions d'une utilisation optimale des instruments de la politique budgétaire pour renforcer leur résilience. Ce chapitre apporte trois contributions majeures à la littérature existante : La première contribution est relative à l'analyse des effets du changement climatique sur les conditions socio-économiques des ménages. La deuxième contribution réside dans l'identification des caractéristiques qui exacerbent et renforcent la résilience des ménages face au changement climatique. La troisième contribution majeure est la définition d'une règle de dépense publique récurrente et robuste contre les catastrophes naturelles (choc climatique, etc.), les fluctuations des prix des produits de base et les revenus de subventions. Le choc climatique est la variable d'intérêt. Il est mesuré par le choc de température et le choc de précipitation. Les données des variables de Température et de Précipitation, et le SPEI (Standardized Precipitation-Evapotranspiration Index) proviennent de Climate Research Unit (CRU TS version 4.04). C'est la plus grande base de données pour les travaux sur le changement climatique et ses conséquences économiques. En effet, les données géolocalisées brutes du CRU TS se réfèrent à une grille de 0,5° de latitude et de longitude (environ 50X50 km à l'équateur). Chaque cellule de la grille contient une donnée climatique pour chaque mois couvrant la période 1901-2021. La variable dépendante est mesurée par l'incidence de la pauvreté (1,90\$). L'objectif est de capter les effets du changement climatique. Plusieurs tests d'hétérogénéité sont effectués en distinguant les effets selon la taille des relances économiques, leurs compositions, le niveau de développement des deux pays et la qualité des institutions. Les résultats suggèrent que les chocs de température et de précipitations augmentent la pauvreté, donc entraînent une dégradation des conditions socio-économiques des ménages. La mise en place des filets de sécurité sociaux (financés à travers les dépenses sociales et la dette) devrait atténuer les effets des chocs climatiques et réduire la pauvreté.

Le **deuxième chapitre** analyse l'effet des règles budgétaires sur les investissements directs étrangers (IDE). Les IDE sont des leviers importants pour financer le développement. La création d'un environnement propice pour attirer les IDE est l'une des conditions nécessaires pour mobiliser ce type de financement. Nous utilisons la méthode entropy balancing pour analyser le lien de causalité.

En termes de contributions, nous contribuons à la littérature existante à travers l'étude des effets des règles budgétaires sur les IDE dans les pays en développement. Sur le plan empirique, nous enrichissons la littérature existante en utilisant la méthode d'entropy balancing de ([Hainmueller, 2012](#)). D'autres méthodes comme les Propensity Score Matching (PSM) de Rosenbaum et Rubin (1983) sont utilisées en tests de robustesse. Cette étude apporte une nouvelle contribution dans la mesure où elle permet d'analyser la capacité des différents types de règles budgétaires à attirer les

investissements étrangers. Cette analyse se distingue également des autres travaux en apportant des preuves empiriques sur les canaux par lesquels les règles budgétaires affectent les IDE. Enfin, cette étude apporte une nouvelle contribution en termes d'implication de politiques économiques afin de mieux attirer les IDE pour financer le développement.

Nous trouvons des résultats clés avec des implications politiques de grande portée : dans un premier temps, les résultats sont robustes et montrent que l'adoption des règles budgétaires augmente les IDE. Le ratio du déficit public par rapport au PIB, la notation des dettes souveraines à long terme en devise et le ratio de l'encours de la dette extérieure à court terme sont les canaux de transmission par lesquels les règles budgétaires affectent les IDE. L'effet des règles est amplifié en présence d'un niveau élevé du climat des affaires, de la performance économique, d'une meilleure structuration du secteur agricole et industriel. En revanche, cet effet est atténué en présence des rentes minières (pétrole et gaz) et d'un taux d'intérêt réel de l'économie élevé.

Le **troisième chapitre** analyse le lien entre les règles budgétaires et les investissements verts. Les règles budgétaires ont pour objectif d'accroître la discipline budgétaire, la crédibilité de la gestion budgétaire et faciliter la mobilisation des ressources sur le marché financier pour le développement. Les effets du changement climatique annihilent des années de progrès économiques et dégradent les conditions de vie des populations. Le choix des pays en développement pour ce chapitre se justifie également dans ce chapitre par le niveau élevé de leur volatilité macroéconomique en raison de la faible diversification de leurs économies ; ceci accroît leur vulnérabilité aux chocs du terme de l'échange, des prix des produits de base et des catastrophes naturelles. Aussi, ces pays sont confrontés à des baisses plus importantes de la performance économique à la suite d'une catastrophe naturelle par rapport aux pays développés. En plus, le cadre budgétaire par défaut dans les pays en développement faisant face aux chocs climatiques est procyclique car ces pays ont de facto une règle d'équilibre budgétaire avec une capacité d'emprunt limitée : leur volatilité des revenus entraîne la volatilité des dépenses. Les données sur les investissements verts proviennent de la base de données de l'OCDE. Les données sur les règles budgétaires proviennent de la célèbre base « Fiscal rules dataset » du Fonds Monétaire International (FMI). Les autorités en charge de la politique budgétaire ont également du mal à s'adapter aux chocs macroéconomiques et climatiques en raison du manque de données macroéconomiques et climatiques actualisées, ce qui réduit la portée des mesures anticycliques. L'instabilité climatique oblige les pays à adapter le dispositif budgétaire pour mieux faire face à ses effets. D'où l'importance d'analyser les effets des règles budgétaires sur les investissements verts afin d'accroître le financement du changement climatique dans le but de renforcer la résilience des pays et améliorer les conditions de vie des populations déjà vulnérables. En effet, l'adoption des règles budgétaires facilite non seulement l'accès et la mobilisation des ressources mais envoie un signal sur la volonté des pays de bien gérer leur politique budgétaire. De nombreux travaux tels que ([Barnes et al., 2012a](#) ; [Cottarelli, 2020](#) ; [Darvas and Anderson, 2020](#)) ont étudié la possibilité de verdir les règles budgétaires en période de choc climatique dans les pays

développés mais très peu d'études se sont intéressées sur la nécessité de verdir les règles budgétaires dans les pays en développement. D'où l'importance de faire cette étude pour ces derniers. La première contribution majeure de ce chapitre est qu'il apporte une preuve empirique sur le lien entre l'adoption des règles budgétaires et l'accès au financement vert. Si l'adoption des règles budgétaires favorise l'accès au fonds vert, il y a un effet de complémentarité avec les autres types de financement. Cependant, si l'adoption des règles budgétaires diminue l'accès aux fonds verts, il y a un effet de substitution entre les financements verts et les autres types de financement car cette diminution d'accès (au financement vert) pourrait se faire au profit d'autres types de financement. La deuxième contribution de ce chapitre réside dans l'identification des types de financement à mobiliser en période de chocs climatiques et les conditions de leur utilisation optimale. La troisième contribution est relative aux implications de politiques économiques. En effet, ce sont des dépenses publiques qui ont des effets favorables sur l'environnement. Ce sont ces types d'investissements qui pourraient être exclus du calcul du déficit en cas de verdissement des règles budgétaires. Sur le plan empirique, la variable dépendante est captée par les financements verts et la variable d'intérêt est mesurée par les règles budgétaires. Il s'agit d'une variable qui indique 1 si un pays adopte au moins une règle et 0 sinon. La principale méthode adoptée dans ce chapitre pour analyser les effets de l'adoption des règles sur les investissements verts est la méthode « entropy balancing » qui est une méthode innovante d'analyse d'impact. Les résultats de ce chapitre montrent le lien positif et significatif entre l'adoption des règles budgétaires et les financements verts. Les résultats indiquent les types de règles budgétaires qui sont les plus pertinents et mobilisable pour financer la résilience face au changement climatique et son apport pour la réduction de pauvreté.

Le **dernier chapitre** analyse l'effet causal des chocs climatiques sur les notations de la dette souveraine d'une part et analyser dans quelle mesure les règles budgétaires peuvent atténuer ces effets d'autre part. Nous avons déterminé le lien entre le changement climatique et les notations de la dette souveraine en utilisant la méthode des variables instrumentales. En utilisant la méthode d'équilibrage d'entropie pour les traitements continus, nous avons déterminé la capacité de l'adoption de règles budgétaires à atténuer l'effet d'un choc climatique sur les notations de la dette souveraine des pays. Les résultats montrent que les chocs climatiques (de température) ont un impact négatif significatif sur les notations de la dette souveraine. Outre les règles de dépenses, les autres types de règles (recettes, dette et déficit) atténuent les effets d'un choc de température sur les notations de la dette souveraine des pays.

Chapter I

Climate change and poverty in developing countries : The role of public expenditure¹

HISGUIMA DASSIDI Crépin²

Abstract

This study analyses the effect of climate change on poverty in developing countries. Using a sample of 67 countries, we use the fixed-effects panel model to analyze the causal effect of climate instability on poverty. Two hypotheses are tested in this study. The first states that climate shocks increase poverty, and the second relates to mitigating the effects of climate shocks through public expenditures and external financing. First, the results are robust and show that climate instability increases poverty. Second, health and social spending and official development assistance mitigate the negative impact of a climate shock. In contrast, the results suggest no significant effect of remittances on poverty in the presence of the shock. Finally, an in-depth analysis shows that countries with more fiscal space before the shock can better cope with climate shocks than countries with less fiscal space.

1. This study was presented at the Africa Health Conference held from Saturday, February 18, 2023, to Sunday, February 19, 2023, at Harvard University, Boston. This article was also presented at the “Money, Structural Transformations and Public Policies” conference held on November 29-30 and December 1, 2023 at the University of Tours.

2. We want to take this opportunity to thank from the depths of our hearts Xavier GALIEGUE, Senior Lecturer in Economics at the University of Orléans, Djamel KIRAT, Senior Lecturer in Economics at the University of Orléans, and Bao-wé BAMBE, Ph.D in Economics for their advice and guidance in the framework of this study. We want to express our gratitude and appreciation to them.

Introduction

Climate change and poverty are significant issues of concern to policymakers. Climate change poses a significant risk to the process of reducing household poverty because it undermines the progress and development efforts of countries, particularly developing countries, which are generally the most vulnerable (OCDE, 2002). It is one of the major problems of the 21st century (Van Gameren et al., 2014). It is characterized by climatic variability or instability and is then illustrated by a cumulative and long-term degradation of the environment. Climate change is manifested by an increase in greenhouse gas concentrations (CO₂ emissions, NO₂, etc.), leading to a change in the climate system through abrupt changes in temperature and precipitation. The impact of climate change requires decision-makers to consider two essential and complementary concepts : adaptation and mitigation. Adaptation to climate change is now an essential condition for development. Like most countries worldwide, developing countries are not spared the effects of climate change. The consequences of climate change are increasingly being felt in social, economic, and environmental sectors. Climate change impacts put human lives and livelihoods at risk (Leichenko and Silva, 2014; Hallegatte and Rozenberg, 2017). Adaptation anticipates the effects of climate change, and limits its damage by acting on the various factors that can limit their magnitude. It includes strategies, initiatives, and measures aimed at reducing the vulnerability of natural and human systems to the effects of climate change (Van Gameren et al., 2014). Although climate change affects the entire planet, it is essential to note that its impact varies from region to region. The direct effects of climate variability are felt through the increase in cold and scorching seasons, rising sea levels, etc. Indirect effects are felt through certain types of disease, malnutrition, etc. Indirect effects are felt through certain types of disease, malnutrition, etc.

By affecting households' living conditions and livelihoods, climate shocks directly impact their poverty levels and can lead to underemployment of production factors. This is even more true in developing countries (Guivarch and Taconet, 2020) characterized by high vulnerability and resilience to shocks and where households suffer from deficiencies in national insurance systems. In this context, many studies highlight the negative impact of climate shocks on growth, poverty levels, and inequalities (Leichenko and Silva, 2014; Diwakar and Lacroix, 2021; Hallegatte et al., 2014; Azzarri and Signorelli, 2020; Hallegatte et al., 2018). It should also be recalled that despite significant progress in recent decades, poverty remains one of the significant challenges in developing countries. It is even more true for certain regions such as sub-Saharan Africa, where almost 41% of the population lives below the international poverty line³. Finally, the Covid-19 pandemic and the war in Ukraine raise fears that the situation could deteriorate further in developing countries, potentially leading to a drastic increase in the number of poor people in these countries.

3. World Bank Report, 2018

Fiscal policy plays a vital role in poverty reduction through public expenditure. Several countries devote a large part of their public expenditure to poverty reduction (Roberts, 2003; Lofgren and Robinson, 2008). This expenditure is often directed toward development projects that improve the population's living conditions. In the presence of climate shocks, several countries can set up social safety net programs to mitigate the effects of the shock. These programs are one of the first responses the state puts in place to strengthen the resilience of populations affected by the shock. Several economic studies show the importance of public spending in reducing poverty (Fan et al., 2000; Fan and Zhang, 2008; Pack, 1998; Ivanic and Martin, 2014; Mehmood and Sadiq, 2010). The 1980s and 1990s saw the emergence of new forms of poverty, thus broadening the scope and framework of analysis of this concept. These new forms of poverty have given a multidimensional character to this phenomenon which has become the primary concern of international financial institutions, (Mondiale, 1990; Loisy, 2000). In developing countries, poverty remains one of the major challenges, particularly in Africa. For example, there are more poor people in Africa today than in 1990. Two out of five adults are illiterate, and violence is increasing⁴. The number of people living in extreme poverty has increased considerably in recent years due to crises such as Covid 19, climate change, etc. Although the poverty rate has decreased over the last ten years in developing countries, the challenges to eradicating this phenomenon, which degrades the socio-economic conditions of the population, remain immense.

This article is linked to two streams of literature. The first stream examines the impact of climate change on poverty. The second stream is related to the literature that questions the role of public policies' role in coping with external shocks, including public expenditure. Many studies show that climate change increases household poverty (Leichenko and Silva, 2014; Hallegatte and Rozenberg, 2017; Hallegatte et al., 2014). Hope Sr (2009) analyses the link between poverty and climate change and discusses potential adaptation policies to mitigate the impact of climate change on poverty in Africa. Climate change has a strong link to poverty because, as it affects economic activity, it also affects household activity and can lead to the underemployment of factors of production. Climate variability, while impacting household incomes and assets, contributes to the deterioration of their socio-economic conditions, thus aggravating their vulnerabilities. This is especially true for the poorest households, which are more likely to be severely affected by the impacts of climate change. Climate change risks aggravate household poverty and increase vulnerabilities because they threaten the livelihoods and social well-being of vulnerable households (Laurent and Zwickl, 2022; Leichenko and Silva, 2014). The World Bank estimates that 100 million people in South Asia and sub-Saharan Africa are at risk of falling back into poverty because of the effects of climate change (Hallegatte, 2016; Baarsch et al., 2020). Reducing the effects of climate change is a way to promote sustainable development worldwide and improve the socio-economic

4. According to the World Bank's 2016 Africa Poverty Report

conditions of poor households. In line with the demonstration of the link between poverty and climate change, [Laurent and Zwickl \(2022\)](#) show that "poor countries and poorest households are the most vulnerable to the impacts of climate change." In the second stream, [Diwakar and Lacroix, 2021](#) and [Leichenko and Silva, 2014](#)) demonstrate the different policies that must be implemented to strengthen people's resilience to the effects of climate change and thus reduce poverty.

Although several studies ([Hallegatte and Rozenberg, 2017](#); [Leichenko and Silva, 2014](#); [Skoufias et al., 2011](#); [Hertel et al., 2010](#)) analyze the link between poverty and climate change, very few have focused on the effects of climatic shocks on poverty; hence the interest in distinguishing from existing work by analyzing the impact of climate shocks on poverty and the contribution of public expenditure in mitigating the effects of climate shocks in developing countries. The analysis, therefore, consists of answering the following questions : How effective is public expenditure in containing the effect of climate shocks on poverty in developing countries ? This study focuses on developing countries because of the high level of poverty in these countries and their continued exposure to the effects of climate change.

We make the following contributions to the literature : First, we assess the effect of climate shocks on poverty on a panel of 67 developing countries from 1998-2016, using the panel fixed effects model. The results show that climate instability increases poverty. Next, we examine the role of social expenditures, notably social protection, and health, in the presence of these shocks. The results suggest that health and social spending and official development assistance mitigate the negative impact of a climate shock. Finally, an in-depth analysis suggests that countries with more budgetary space before the shock can better cope with climate shocks than countries with less budgetary space.

The rest of the study is structured as follows : section 1.1 presents a review of the theoretical and empirical literature. The section 1.2 presents theoretical identification of transmission channels. The section 1.3 presents developing countries' temperature, rainfall, and poverty trends. Section 1.4 presents the data. Sections 1.5 and 1.6 present the identification strategy and the main results. Sections 1.7 and 1.8 present some sensitivity tests and discuss the validation of the transmission channels. Finally, the last section concludes the study.

1.1 Review of the literature

Since the early 1990s, the economic literature has extensively studied the link between climate change and poverty. The studies of ([Seaman et al., 2014](#); [Mertz et al., 2009](#); [Hope Sr, 2009](#); [Sanchez, 2000](#)) are considered to be pioneering work as they show for the first time, to our knowledge, the existence of a formal link between climate change and poverty in developing

countries, suggesting that the climate instability worsens the socio-economic conditions of households, and thus poverty. Several other empirical studies have subsequently supported the results of these studies. For example, the World Bank's 2010 World Development Report also directly links poverty and climate change. Then it shows that climate change increases poverty worldwide, particularly in developing countries. In the same vein, (Hallegatte, 2016; Barrett and Swallow, 2006; Hallegatte et al., 2018) find that the effects of climate change on the poor are "dramatic" because poor households, given their economic conditions and therefore lacking savings, are highly exposed to the effects of climate change. Furthermore, these studies argue that the link between poverty and climate change is a two-way street : "poverty is one of the main factors that explain household vulnerability to climate shocks, and it is this very vulnerability that keeps people in poverty." The study shows that the poor are most likely to be exposed to natural shocks, such as climate shocks and climate-related stressors. Therefore, the authors suggest that a so-called "environmental income" would help reduce the vulnerability of the poorest households to natural shocks and strengthen their resilience. In the same vein, the works of Hallegatte and Rozenberg (2017) show that increased climate vulnerability is associated with increased poverty. It is even more true for African economies, characterized by a high dependence on the agricultural sector and a high vulnerability to climate shocks and natural disasters. The author shows that climatic instability positively affects poverty. Intending to build the resilience of poor households to Climate Shock, Diwakar and Lacroix (2021) while analyzing the link between climate shocks and poverty persistence using a multivariate regression model, show that climate shocks prolong household poverty and suggest that ensuring a supportive financial environment for households can help mitigate the main factors that keep households permanently poor in the presence of the climate shock.

Another strand of literature examines the link between public expenditure and poverty. Indeed, public expenditure is an instrument of fiscal policy to influence the economic conditions of a country in order to achieve economic and social objectives, including reducing poverty and inequality. The studies of (Fan et al., 2000; Fan and Zhang, 2008; Pack, 1998; Ivanic and Martin, 2014; Mehmood and Sadiq, 2010) analyses the link between public expenditure and poverty and shows the importance of public expenditure in reducing poverty. Indeed, public expenditure helps to finance projects and public policies that aim to improve the socio-economic conditions of the population. The contribution of this study to the existing literature lies in the use of health and social expenditure (which are components of public expenditure) to mitigate the effects of climate shock on poverty. Roberts (2003)⁵ shows that public expenditure can affect growth and poverty reduction in two ways : on the one hand, it can increase the performance of the economy and therefore impact on poverty. On the other hand, it can increase the opportunities for the poor to

5. In the same vein, the world bank in its 2005 report shows the importance of public expenditure on poverty reduction

contribute to the growth process, notably through human capacity building and reducing transaction costs. Empirical work has examined the impact of public expenditure on poverty. For example, the study of [Fan \(2004\)](#) examine the effects of different types of public expenditure on agricultural performance and rural poverty in Uganda. Public health spending did not significantly impact agricultural productivity growth or rural poverty reduction. In contrast, [Fan and Zhang \(2008\)](#) find that social spending (including health spending) is essential in reducing poverty. Finally, in the same vein, [Sasmal and Sasmal \(2016\)](#) shows that efficient use of public expenditure makes it possible to improve the living conditions of the poor. This contribution requires efficient use of public expenditure to improve the living conditions of the poor. Other work ([Leppänen et al., 2017](#)) shows that climate shocks reduce public spending. This decrease in public expenditure negatively influences poverty reduction through decreased development projects and public policy funding. On the other hand, [Collier et al. \(2008\)](#) highlights the contribution of public expenditure in financing adaptation to the effects of climate change.

Poverty makes poor households more vulnerable and exposed to the effects of climate change. [Leichenko and Silva \(2014\)](#) describe poverty as a factor that increases the propensity of households to be exposed to climate-related shock and stress. Although climate change is not the only cause of poverty, they identify direct and indirect channels through which the effects of climate change on household poverty manifest themselves. Regarding direct channels, they identify food prices and the agricultural production chain as climate change, while increasing climate volatility also contributes to increased poverty in households. The study shows that indirect channels such as socio-economic conditions and the quality of institutions play a significant role in transmitting the effects of climate change on poverty. Poverty reduction is the most effective strategy for reducing the impacts of climate change on the poor, according to the study, as it will make the poor and other marginalized people less vulnerable and more resilient to the effects of climate change ([Leichenko and Silva, 2014](#)).

Understanding the impacts of market-based climate policies is crucial to designing economically efficient and socially acceptable climate change mitigation policies is important ([Ohlendorf et al., 2021](#)). [Friend and Moench \(2013\)](#) analyze the extent to which development policy concerns for poverty reduction and social justice can be reflected in theories and practices for addressing the effects of climate change. The authors propose using a theory of resilience to help better understand the particularities of household climate vulnerability. Very often, the word resilience or the adoption of a policy of resilience to the effects of climate change is used as a buzzword rather than an existing conceptual framework for addressing climate change. The study ([Diwakar and Lacroix, 2021](#)) discusses potential adaptation and mitigation policies to mitigate the effects of climate change on poverty. Mitigation measures, specifically income-enhancing and price-stabilizing measures, have an essential effect on poverty reduction in developing countries ([Hertel and Rosch,](#)

2010). Similarly, The study of Hallegatte (2016) proposes combining resilience measures (in favor of the most affected populations) and disaster preparedness systems.

1.2 Theoretical identification of transmission channels

Based on the existing literature, we identify the channels through which public spending can affect poverty in the presence of climate shocks. Climate instability can increase vulnerability and risks to households in developing countries. Given this, adaptation to climate change becomes a fundamental necessity if there is the hope of "addressing" the vulnerability of poor households and ultimately achieving "equitable" growth. Indeed, the climate shock affects households and reduces agricultural production (Ivanic and Martin, 2014; Hertel and Rosch, 2010; Hallegatte et al., 2018). For the producer, there is a drop in production and, in turn, a drop in income. For the consumer, there is an increase in the price of food products, and this increase in the general price level reduces the consumer's purchasing power. In the absence of a compensatory policy, the rise in prices will harm the consumer basket and ultimately lead to income inequality Alvarado and Gasparini (2015) and deteriorating socio-economic conditions (poverty) (Watts et al., 2017; Watts et al., 2015; Lohmann and Lechtenfeld, 2015). Most developing countries (DCs) are net importers of goods and services but still produce some agricultural products (sorghum, maize, millet, etc.). In the presence of climate shock in the exporting country, the effect of the climate shock will be small on the agricultural production of the developing countries because the shock does not impact their agricultural production. However, it could increase prices in the importing countries (DCs) because of the scarcity of products in the exporting country. On the other hand, if climate shock occurs in the country importing goods and services, the shock will be felt more in the importing country, resulting in a drop in agricultural production. The use of public expenditure can contribute to reducing poverty in the presence of climatic shocks

Agricultural production : This is a critical factor in climate change affecting poor households as they spend much of their income to ensure food security. Thus, a climate shock severely impacts agricultural production and ultimately exposes poor households to the risk of worsening their vulnerability and overall socio-economic conditions. The studies of Ivanic and Martin (2014) reveal that the poor spend up to 62 % of their income on food (Hertel and Rosch, 2010; Hertel et al., 2010). The mechanism is explained by the fact that : In the face of low supply, farm demand for production is inelastic, and therefore if the climate shock is widespread, the effects of climate change on poor households will pass through food security issues. The studies of Hallegatte et al. (2018) also identify food security as one of the main transmission channels for the effects of climate change on household poverty. However, the linkage works both ways.

Inequality plays a vital role in mediating the effects of climate shocks on poverty because climate shocks increase inequality, and inequality, in turn, increases poverty among the population

(Alvaredo and Gasparini, 2015). The use of public expenditure can help mitigate the effects of climate shocks.

Social expenditure : this is one of the factors by which public power acts to reduce the effect of climatic instability on the population. Social spending can improve the well-being of the population by acting on both poverty and climate change. In the presence of climate instability, social expenditures are even more important because they help to mitigate the effects on the population.

It is therefore clear that public spending can affect poverty in the presence of climate change through agricultural production, inequality, and social spending.

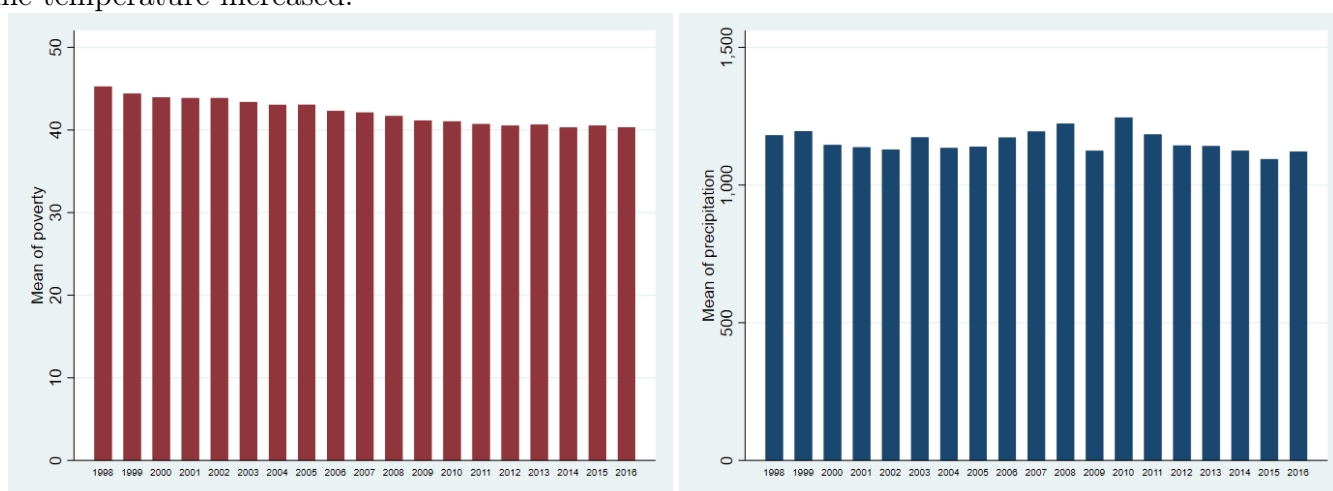
1.3 Trends in poverty, precipitation, and temperature between 1998-2016

The three figures below represent trends in average poverty, precipitations, and temperature over the study period (1998-2016). Throughout the study period, we see that poverty decreases (see graph 1). This could be due to the massive investment in poverty reduction by developing countries (Jalilian and Kirkpatrick, 2002). Concerning this, we are only interested in measuring monetary poverty. More specifically, we measure the incidence of poverty. The second reason for the decline in the poverty rate could be the massive commitment of international financial institutions to make the fight against poverty in developing countries their priority. This choice can help channel significant resources toward poverty reduction. The third reason could be the economic performance of developing countries during the study period. Indeed, developing countries have made significant economic progress. This progress has resulted in a considerable increase in national wealth, thus making it possible to also fight against poverty. Although enormous efforts have been made to reduce poverty, more efforts are needed because of the immense challenge of eradicating this phenomenon.

Precipitation refers to drops of water or ice crystals that form after condensation and agglomeration in clouds. These drops become too heavy to remain suspended in the air and fall to the ground or evaporate. Figure 2 shows that precipitation increased from 1998 to 1999. This corresponds to an increase in meteors over this period. After 1999, precipitation decreases until 2002 and increases slightly in 2003. After 2003, there is a decrease in precipitation over one year. From 2004 to 2008, precipitation increased. The period from 2008 to 2009 was marked by a decrease in precipitation, while between 2009-2010, there was an increase. After 2010, precipitation decreased until 2015 before increasing slightly in 2015. In short, over the period 1998-2016, precipitation decreased slightly. Climate instability is manifested by periods of instability, with significant social and health consequences.

Temperature, on the other hand, manifests itself in periods of rising and falling temperatures. A considerable increase in temperature could lead to lower agricultural yields and exposure to diseases such as meningitis, heat wave, etc. The evolution of the temperature is globally unstable over the study period. Between 1998 and 2000, the temperature dropped. From 2000 to 2002, the temperature increases slightly. There is an increase in temperature over the period from 2002 to 2010. This trend decreases in 2011 before increasing again until 2016. Countries such as Niger and Sudan are mainly at the origin of this increase because in isolation, their temperatures are higher compared to the rest of the countries.

In sum, it can be seen that poverty and precipitation decreased on average over the study period while temperature increased.



Poverty and precipitation trends over the period 1998-2016 in developing countries. Source : Author's calculation. Data : World Bank and CRU (Climate Research Unit).



Temperature trend over the period 1998-2016 in DCs Source : Author's calculation, CRU (Climate Research Unit).

1.4 Data

1.4.1 Description of the database

1.4.1.1 Measuring poverty

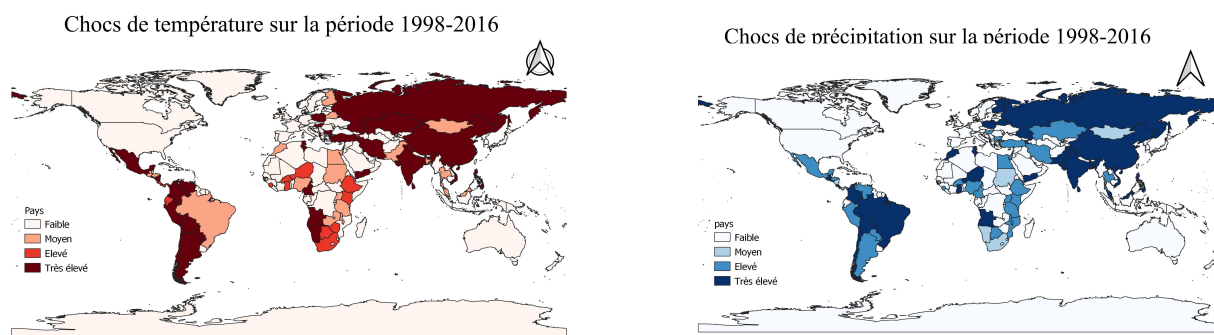
There are different ways of measuring poverty, depending on its definition. Among the different measures of poverty, there is the incidence and depth of poverty. The latter measures the difference between the average income level of the poor and the poverty line. [Decaluwé et al. \(1999\)](#) use the incidence of poverty as the primary measure of poverty to measure poverty and inequality. The same measure has been adopted by [Montaud \(2003\)](#) to identify and measure the determinants of household poverty in Burkina Faso. It first studies the explanatory factors of poverty and the mechanisms of diffusion of monetary poverty, thus the incidence of poverty within households in Burkina Faso.

For this study, we use the incidence of poverty at 1.90\$ as this is the poverty line recommended by the World Bank since 1985 and used in its estimates and forecasts. Poverty data is taken from the Our World in Data⁶. It is a measure of extreme poverty. The incidence of poverty measures the number of people below the poverty line as a proportion of the total population. It is the measure of the dependent variable in this study. It measures poverty at 1.90 \$ per day per person, measured in purchasing power parity (PPP) for international comparison. It is an international measure of extreme poverty. In this study, it should be considered that the depth and severity of poverty are alternative measures of poverty and could be used as dependent variables for robustness. This study's measurement of poverty incidence is an analysis that mobilizes a purely economic approach based on monetary income [Folefack \(2010\)](#). The incidence of poverty is appropriate for this study because it is the component of poverty that measures the socioeconomic conditions of the poorest.

We use as a dependent variable the poverty rate at the 1,90\$. Our variable of interest is climate shock. We then control for a series of variables : education and social spending, the contribution of agriculture to national output, the Gini index, the secondary school enrolment rate, natural resources, grain production, socio-economic conditions, population growth, foreign direct investment, and inflation. The period (1998-2016) is chosen based on the availability of data on climate shocks.

6. <https://ourworldindata.org/poverty>

1.4.1.2 Measuring the climate shock



Source : Author's calculation, CRU (Climate Research Unit).

Source : Author's calculation, CRU (Climate Research Unit).

The temperature data is from the University of Anglia East database ⁷ (Archive (Version 5.01) released in August 2018). These monthly station air temperature averages were interpolated onto a 0.5-degree by 0.5-degree latitude/longitude grid, where the grid nodes were centered on 0.25 degrees. The gridded fields were estimated from the monthly station means using a combination of spatial interpolation methods. This interpolation is assisted by : the Digital Elevation Method (DEM) Willmott and Matsuura (1995); the traditional interpolation method (Willmott et al., 1985a; Willmott et al., 1985b) and the Climatology Assisted Interpolation (CAI) method Willmott and Robeson (1995). The rainfall data is also taken from the University of Anglia East database ⁸, the consortium Climate Research Unit(CRU). These monthly averages of station precipitation have been interpolated to a 0.5-degree by 0.5-degree latitude/longitude grid.

Bello (2016) defines shock as a random and unpredictable event likely to affect the population's well-being. The studies of Marchetta et al. (2021) study the impact of climatic events on the migration of a cohort of young adults living in rural Madagascar. This measure of drought shock allows comparison between different localities in the same country (or in different countries). The method used calculates, for each grid or satellite unit (SBU), the amount of rainfall during the agricultural season between November and April of each year and thus calculates the mean and standard deviation. To do this, they use geo-located individual data to match each individual with the locality where they live. In order to calculate the shock, other studies define extreme weather events at the level of each cell and then aggregate to the country level, calculating the percentage of cell-month or cell-year peers that experienced an extreme weather event for a given country and year. To do this, it is necessary to choose whether or not to consider the spatial distribution of the population within a country. Then, one chooses to focus or not on the most critical months for agri-

7. <https://www.uea.ac.uk/groups-and-centres/climatic-research-unit>

8. <https://www.uea.ac.uk/groups-and-centres/climatic-research-unit>

cultural production. A country is linked to the underlying cells for aggregation at the country level.

In this study, the calculation of the climate shock is based on the method used by (Feindouno et al., 2020; Feindouno et al., 2016). We calculate an index of countries' vulnerability to temperature and precipitation shocks. These are the two components of the index. In concrete terms, the shock is calculated as follows : The value of the precipitation shock is the ratio between the deviation from the mean and the standard deviation. The same operation is performed for the temperature shock. Then we calculate the mean root square of the two components. This mean root square represents our country's vulnerability index to the temperature and rainfall shock. This index of vulnerability to the temperature and precipitation shock is the variable of interest in this study.

For the country-level aggregation of temperature and precipitation values, we link a country with the underlying cells for each component. The average precipitation and temperature over the study period (historical average) are also calculated for each country. In the numerator, we have the absolute value of the precipitation or temperature deficit, which is the difference between the precipitation or temperature of a year and the historical average precipitation or temperature. The formula for climate shock is :

$$CMShock = |x - X| / standarddeviation(x) \quad (1)$$

Where x is the value of precipitation or temperature for any year, and X is the average precipitation or temperature for each country over the study period. The value of the rainfall shock is the ratio of the deviation from the mean by the standard deviation. Several works use this same calculation method to measure the climate shock Feindouno et al. (2020); Closset et al. (2017). Guillaumont and Simonet (2011) also uses the same method to calculate the vulnerability index to climate shocks. The variable of interest measuring the climate shock vulnerability index is continuous, so the higher its value, the more vulnerable or exposed the country is to temperature or rainfall shocks.

The remaining variables are basic model controls :

Inflation is the measure of the general price level. It directly impacts the purchasing power of poor households. The higher it is, the more poverty increases because poor households will find it increasingly difficult to meet their needs Cardoso (1992). Other works (Easterly and Fischer, 2001; Blank and Blinder, 1985; Ivanic and Martin, 2008) also show that a rise in the general level of prices increases poverty. Climate change also increases inflation (Parker, 2018). This effect could be through lower agricultural production. This decline in agricultural production increases the price, and therefore inflation.

The Gini index shows the income gap between people. It is a measure of income inequality. Indeed, the higher the Gini index, the higher the poverty because income inequality increases poverty. The sign in front of the Gini index is expected to be positive. Several studies ([Alvaredo and Gasparini, 2015](#); [Kakwani, 1980](#)) show that income inequality increases poverty. In our analysis, income inequality is expected to also increase poverty.

Expenditure on education measures current public expenditure on education in capital and transfers, which is expressed as a percentage of total public expenditure in all sectors. The idea is to know the weight of education expenditure in public expenditure. It also plays an essential role in improving the living conditions of poor households insofar as it enables them to acquire better training to obtain a job and thus escape poverty. Spending on education does not have a direct effect on poverty reduction because they do not directly affect the socioeconomic conditions of households. Spending on education affects those who are enrolled in school. Several studies ([Bursztyn, 2016](#); [Celikay and Gumus, 2017](#); [Edeh et al., 2018](#)) analyze the link between education expenditure and poverty and find that these expenditures contribute to reducing poverty. In our analysis, expenditure on education is expected to also decrease poverty.

Social expenditure is the total amount spent by the state on social matters. The higher this expenditure, the more it contributes to relieving the poor [Caminada and Goudswaard \(2009\)](#). We expect social spending to reduce poverty. These are expenditures that directly affect the socioeconomic conditions of populations. Economic studies ([Caminada and Goudswaard, 2009](#); [Caminada and Goudswaard, 2010](#); [Cantillon et al., 2003](#); [Cammeraat, 2020](#)) highlight the link between social expenditures and poverty reduction and show the importance of social spending in reducing poverty. Social spending can also contribute to mitigating the effects of climate change by improving the resilience of the population affected by climate change. In this study, social spending is expected to have a negative effect on poverty.

Natural resources provide information on the income derived from exploiting natural resources. The higher they are, the more resources the country has to implement public policies likely to improve living conditions and thus fight against poverty and mitigate the effects of climate change. These resources are expected to affect poverty negatively. The works of [Pegg \(2006\)](#) show that the poorest countries are often holders of several natural resources but fail to transform these resources for the benefit of poverty reduction because of the curse of natural resources. They show that the reality of mineral-driven development has not delivered on its promise.

Agriculture : Agricultural production improves the living conditions of the poor. Indeed, a country with a high level of cereal production can use this quantity to fight poverty. [Kang et al. \(2009\)](#); [Lobell and Burke \(2010\)](#) and [Challinor et al. \(2014\)](#) analyze the effect of climate change on agricultural production and show that there is a negative link between climate change and agricultural production. [Atkinson et al. \(2001\)](#) show that there is a link between agricultural production and poverty. Therefore, we expect the contribution of agriculture to affect poverty

negatively.

GDP Per capita : captures the wealth a country creates concerning its population. Per capita income plays a vital role in poverty reduction. The studies of (Roemer and Gugerty, 1997 ; Chen and Wang, 2001) highlight the link between economic growth and poverty reduction. They show that economic performance is used in the process of poverty reduction. Economic performance makes it possible to finance development projects useful for improving the socio-economic conditions of the population, and therefore reducing poverty.

Population growth : Annual population growth rate for year t is the exponential rate of growth of midyear population from year $t-1$ to t , expressed as a percentage⁹. The link between population growth and poverty reduction is ambiguous in the economic literature. The works of Klasen and Lawson (2007) show that population growth in Uganda contributes significantly to poor poverty reduction outcomes. On the other side, the studies of Ahlburg (1996) find that there is little direct evidence of the impact of population growth on the process of poverty reduction. The author shows that rapid population growth increases landlessness and therefore the incidence of poverty. Other works Birdsall (1980) show, however, that population growth increases poverty. The authors show that rapid population growth is draining national and family budgets with increasing numbers of children to feed and educate and workers to find jobs. It also explains the fact that population growth could lead to slower growth in per capita income, a lack of progress in reducing income inequality, and in turn, an increase in poverty. In our study, population growth is expected to negatively affect poverty.

Institution : Institutional factors play a significant role in the fight against poverty and climate change. In this study, these factors are captured by indices that capture socioeconomic conditions and the quality of the judicial system : Socioeconomic condition is an index that captures the socioeconomic pressures at work in a society that could constrain government action or fuel social dissatisfaction. The higher this index is, the less poor the population is. Law and order is an index that captures making justice accessible to all through measures such as legal aid, provision of legal advice, and support for victims of crime.

1.5 Identification strategy

1.5.1 The empirical model

The empirical model used in this study is based on the Jalilian and Kirkpatrick (2005), which uses the Gini index, inflation, government expenditure, and a growth variable to analyze the effect of financial development in reducing poverty in developing countries. Other economic works, such as that of Jalilian and Kirkpatrick (2002), use the same variables in their analysis. For reasons of

9. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship

model extension, we add other control variables to those listed above in [Jalilian and Kirkpatrick \(2005\)](#). We use the fixed effects model to analyze the causal effect.

Assumption 1

$$\text{Poverty}_{it} = \alpha + \beta_1 \text{climate shock}_{it} + \sum_{k=1}^k \Delta X_{i,t} + \eta_i + \gamma t + \epsilon_{it} \quad (2)$$

η_i is the fixed country effect. γt is the fixed effect that capture temporal characteristics and ϵ_{it} is the error term.

(With $i = 1, \dots, N$; $t = 1, \dots, T$).

In equation (2), Poverty is the dependent variable of the model. The indices i and t refer respectively to the model's individual (country) and temporal (period) dimensions. They are used to take into account individual and annual heterogeneity between countries. Climate shock (see equation (2)) is the variable of interest in the model. The vulnerability index in equation (2) captures temperature and precipitation shocks. The vector X represents the set of control variables. It comprises the following variables : education expenditure, GDP per capita, natural resources, cereal production, population growth, social protection expenditure and institutions which are captured by two indices (judicial power and the socioeconomic pressures at work in society that could constrain government action or fuel social dissatisfaction). They are all control variables. The error term is identically and independently distributed.

Assumption 2

$$\text{Poverty}_{it} = \alpha + \beta_1 \text{climate shock}_{it} * \text{Public Expenditure}_{it} + \sum_{k=1}^k \Delta X_{i,t} + \eta_i + \gamma t + \epsilon_{it} \quad (3)$$

η_i is the fixed country effect. γt is the fixed effect that capture temporal characteristics and ϵ_{it} is the error term.

(With $i = 1, \dots, N$; $t = 1, \dots, T$).

In equation (3), poverty is the dependent variable in the model. The indices i and t refer respectively to the individual (country) and temporal (period) dimensions of the model. They are

used to take into account individual and annual heterogeneity between countries. The intersection between the climate shock variable and public expenditure (see equation (2)) is the model's variable of interest. This cross-tabulation variable makes it possible to capture the capacity of public expenditure to attenuate the effect of climatic shocks on poverty. The vector X represents the set of control variables. It includes the following variables : education expenditure, GDP per capita, natural resources, cereal production, population growth, social protection expenditure, and institutions which are captured by two indices (judicial power and the socioeconomic pressures at work in society that could constrain government action or fuel social dissatisfaction). These are all control variables. The error term is identically and independently distributed.

1.6 Interpretation of results

1.6.1 Impact of climate shock on poverty

The results (see table 2) show a positive and significant relationship between temperature, rainfall shock, and poverty. The coefficient is positive and significant at the 5% . A one-unit increase in the temperature and precipitation shock increases the poverty rate by 0.82 percentage points (2). Indeed, this could be explained by the fact that an increase in a temperature or rainfall shock increases household vulnerability through reduced agricultural yields, exposure to health risks, and a decline in activities that provide resources for the population. Temperature and rainfall shocks, therefore, increase poverty. These results are similar to those obtained in the work of (Azzarri and Signorelli, 2020 ; Diwakar and Lacroix, 2021 and Hallegatte et al., 2014), which also show that climate instability increases poverty (2). The more vulnerable a country is to precipitation and temperature shocks, the more poverty increases in that country as the climate shock affects the socio-economic conditions of the population and increases their vulnerabilities. Hallegatte et al. (2018) find a double causal link between climate change and poverty, as poverty is one of the main factors explaining the vulnerability of populations to climate hazards, and this vulnerability prevents the poor from escaping poverty. Leichenko and Silva (2014) show that poverty is a factor that increases the propensity of people to be exposed to climate hazards. The World Bank's 2016 report on the effects of climate change on poverty¹⁰ of Hallegatte (2016) reveals that climate shocks worsen the socio-economic conditions of the poor and warns that if no concrete action is taken to combat the effects of climate change, by 2030, 100 million people will be pushed into extreme poverty. Climate shocks increase household poverty through higher agricultural prices (Hertel et al., 2010 ; Nelson et al., 2014), food insecurity (Hallegatte, 2016 ; Hertel and Rosch, 2010 ; Lamb, 2002) and the deterioration of the health conditions of the populations (Watts et al., 2017 ; Lohmann

10. Shock waves : managing the impacts of climate change on poverty

and Lechtenfeld, 2015; Meierrieks, 2021; Andalon et al., 2016).

1.6.2 The use of fiscal policy instruments and external financing

In this section, we examine how fiscal policy instruments can mitigate the effects of climate shock. This is done by creating an interaction variable between social expenditure, health expenditure, and the vulnerability index to climate shocks (temperature and rainfall). Fiscal policy instruments play an essential role in reducing the effects of climate change on poverty. These different instruments can be mobilized when a country faces extreme climate variability. As poverty is a rigid phenomenon, its eradication is a long-term process. Similarly, climate change has long-term effects. Adaptation and mitigation are long-term processes.

1.6.3 The use of social expenditure

Column 3 of the table 2 presents the effects of health spending in mitigating the effects of climate shocks. The use of social spending is even more relevant to mitigating climate change and poverty 2. The negative and significant effect of the variable of interest justifies this. Social spending directly impacts the well-being of poor households and significantly increases their resilience. This expenditure also allows for the implementation of projects that improve living conditions. It contributes effectively to poverty reduction. It can therefore be deduced that social expenditures contribute significantly to the effort to reduce the socio-economic vulnerability of poor households and mitigate the effects of climate hazards. The use of and increase in social expenditure is also a boon to the poor as it mitigates the effects of climate change through resilience policies. In sum, these results demonstrate the importance of social expenditures in reducing poverty and mitigating the effects of climate change.

When comparing the coefficient on the climate shock with that on the interaction variable with social expenditures, we find that social expenditures (see $(1.734 - 0.010) = 1.724$) partially mitigate the effects of the climate shock on poverty.

1.6.4 The use of health expenditure

Column 2 of the table 2 presents the effects of using health spending to mitigate the effects of climate shocks. The results show that using health expenditure during the shock significantly mitigates the effects of climate shocks. Indeed, climate shocks degrade the health conditions of populations (Watts et al., 2017; Watts et al., 2015; Lohmann and Lechtenfeld, 2015; Meierrieks, 2021; Andalon et al., 2016) exposing them to diseases that result from the effects of climate change

(malaria, diarrhea, etc.). Under these conditions, using health expenditure during the climate shock would help mitigate the effects of the shock and contribute to increasing the resilience of those impacted by climate instability.

When we compare the coefficient in front of the climate shock with that in front of the interaction variable with health expenditure, we notice that health expenditure (see $(1.886-0.046)=1.84$) partially attenuates the effects of the climate shock on poverty.

1.6.5 The use of Official Development Assistance (ODA)

Column 4 of the table 2 presents the effects of Official Development Assistance (ODA) in mitigating the effects of climate shocks. The results show that the interaction variable (between ODA and vulnerability to shocks) mitigates the effects of climate shocks and significantly reduces poverty 2. This confirms the idea that using ODA during the shock helps mitigate climate change's effects on poverty. Developing countries sometimes use ODA to finance social projects and meet immediate needs during a natural disaster. This funding fills an essential gap in climate change adaptation and mitigation financing. This external source of funding also helps finance the reconstruction of destroyed homes, job creation, etc. (Michaelowa and Namhata, 2022; Ranger et al., 2014). Eyckmans et al. (2016) and Arndt and Tarp (2017) study the impact of ODA and also show the importance of these types of funding in improving overall welfare and in the process of poverty reduction. In order to make better use of these resources to improve the welfare of poor people, it is necessary to ensure that these resources are used effectively and efficiently for the benefit of people affected by climate-related hazards. Economic work (Michaelowa and Michaelowa, 2012; McGillivray et al., 2006 and Betzold, 2016) analyses the link between Official Development Assistance (ODA) and climate change and reveals the vital contribution of ODA in the adaptation and mitigation process.

When we compare the coefficient in front of the climate shock with that in front of the interaction variable with Official Development Assistance, we find that Official Development Assistance (see $(0.935-0.026)=0.909$) partially mitigates the effects of the climate shock on poverty.

1.6.6 The use of migrant remittances

Column 5 of the table 2 presents the contribution of remittances in mitigating the effects of climate shocks. The results show that the interaction variable between the shock and remittances does not affect poverty. This suggests that remittances do not mitigate the effects of climate shock. Several economic studies (Paul, 2008; Diagne and Diane, 2008) show that migrant remittances could increase poverty through inflation. Indeed, Paul (2008) highlights the link between migrant remittances and poverty in Haiti and shows that migrant remittances contribute to creating inflation,

and this general rise in the price level increases poverty.

1.6.7 Fiscal space

In this section, we analyze how fiscal space (fiscal space for maneuver) contributes to mitigating the effects of climate shock. The primary balance captures the fiscal space. We create a dummy variable that takes the value 1 if the budget balance is above average and 0 otherwise. We lag this variable by 1 to see the fiscal space before the climate shock. Then we cross-reference this lagged variable with social spending and the climate shock. Column 6 of the table 2 analyses the effect of this interaction variable on poverty. The results show that fiscal space mitigates the effect of climate shock. Countries with more fiscal space have a higher capacity to cope with climate shocks than countries with less fiscal space. Thus, the more fiscal space a country has, the more resources it can mobilize to combat the effects of climate change.

When comparing the coefficient for the climate shock with the coefficient for the interaction variable with the budget balance, it can be seen that a high fiscal space (see $1,378 - 0.009 = 1,369$) partially mitigates the effects of the climate shock on poverty.

1.7 Sensitivity analysis of results

1.7.1 Robustness

In this section, we choose to test the robustness of our previously analyzed results. Thus, a model is robust if it is valid under different circumstances. The robustness of the basic model is tested in two phases :

First, we use a fixed effect model, and second, we use the generalized methods of moments (GMM) to test the robustness of our basic model. More precisely, the methods of [Arellano and Bond \(1991\)](#) and [Blundell and Bond \(1998\)](#), [Blundell and Smith \(1990\)](#) allow us to test the robustness of the results. We can use GMM because the number of individuals (countries) is greater than the study period, our coefficients are stable, and the variables are stationary. Also, the number of groups is greater than the number of instruments. Finally, there is the presence of a first-order auto-correlation, but there is no second-order auto-correlation. Several economic studies use the HP filter in robustness to calculate the proxy for climate shock. Indeed, the Hodrick-Prescott (HP) filter is a commonly used method to relax time series, identifying the trend component from the cyclical component separately. It is used to decompose a time series into cyclical fluctuations and its more stable trends. Economic work ([Ortiz-Bobea et al., 2018](#) ; [Heutel, 2012](#)) use HP filters to calculate climate shock. [Chauvet and Guillaumont \(2009\)](#) also uses the Hodrick-Prescott (HP) filter in robustness in its work to measure the volatility of aid and income. In the first phase of the robustness analysis, we use the fixed-effects model to test the robustness of our results ; we change

the variable of interest by two proxies : the temperature and precipitation shocks calculated using the deviation from the mean [Stoeffler and Premand \(2021\)](#). To do this, we define extreme weather events (shocks) and then aggregate them to the country level. For the aggregation at the country level, a country is linked to the underlying cells. For each country, the average precipitation and temperature over the study period (historical average and the precipitation and temperature deficit : the difference between the precipitation or temperature of a year and the historical average) are also calculated. The climate shock formula is :

$$CMShock = abs|x - X| \quad (4)$$

Where x is the precipitation value in any year and X is the average temperature or rainfall over the study period. The "abs" means the absolute value of the deviation from the mean. [Pailler and Tsaneva \(2018\)](#) also uses the same method to calculate the impact of climate change on psychological well-being in India.

Results (table 4) show that temperature and precipitation shocks are positive and significant. These results (table 4) confirm those obtained previously with the basic model.

In the second step, we use generalized methods of moments (GMM) to test the robustness of our basic model. First, we use the method of [Arellano and Bond \(1991\)](#) to estimate dynamic models of panel data. A proxy changes the variable of interest for the climate shock (using the [Arellano and Bond \(1991\)](#)) calculated by FERDI¹¹ which measures the vulnerability of developing countries to exogenous shocks (climate shock, etc.). The results are robust and show that the coefficient in front of the variable of interest is positive and significant 5. Its effect is significant at the 1% level. Subsequently, we add additional control variables (access to electricity, military involvement in politics, Official Development Assistance received, government stability, unemployment, religious tensions, internal conflicts, and the index that captures the attractiveness of investments and the dedicated framework for non-recourse litigation financing) to the basic model, we find that the coefficient of the interest variable is always positive (see table 5). The significance of this variable remains unchanged (1%). Secondly, we change the estimation method to check whether the results are valid under different circumstances. We use the estimation method of [Blundell and Bond \(1998\)](#). For this model, we use the lagged value of the variable that measures the rainfall level in mm/year as the proxy for the climate shock. The results converge with those obtained with the two previous methods. The coefficient of the variable of interest remains positive (see table 6). When other control variables are added to the model, the effect of the variable of interest is still significant at the 1%. The results converge with those obtained with the basic model. In sum, the coefficients of the variable of interest are all positive in the estimates. The effects of these variables are significant (1% et 5%). The robustness results obtained are stable and confirm the different results and arguments obtained and developed previously.

11. <https://ferdi.fr/>

1.7.2 Heterogeneity

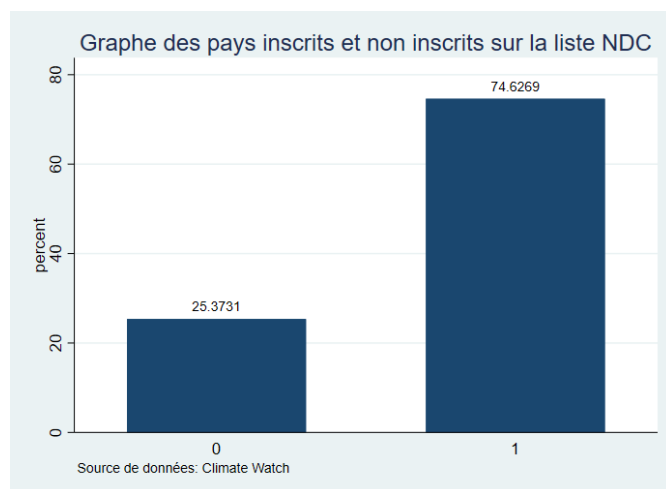
Heterogeneity analysis is a focus of the model sensitivity analysis. For this study, several heterogeneity analyses are performed :

First, we distinguish in the first two columns of the table 7 countries with above-average GDP over the study period and those with below-average GDP. The explanation for this distinction lies in the fact that climate shock affects the economic performance of countries and can therefore be a factor in explaining the poverty gap between developing countries. The results (see Table 7) show that Official Development Assistance (ODA) mitigates the effects of climate shock most in countries with a low level of GDP compared to countries with a high level of GDP. The effect of ODA use during the climate shock is only significant for countries with a low level of GDP. This is because countries with low GDP are the most exposed to climate hazards (Guivarch and Taconet, 2020; Tubiana et al., 2010) and therefore devote the most ODA (compared to the level of ODA received) to mitigate the effects of climate shocks. Also, countries with a high GDP are the least impacted by climate hazards and therefore devote the least ODA to mitigating the effects of climate shocks. This justifies that ODA mitigates the effects of climate shocks the most in countries with a low GDP compared to countries with a high GDP.

In the second step, the distinction is always relative to the level of GDP (see third and fourth columns of the table 7). Indeed, health expenditure is one of the first fiscal policy instruments that a country mobilizes in the face of climate shocks because it directly assists those affected by the effects of climate instability. The third and fourth columns of the table 7 distinguish between countries with a high level of GDP and those with a low level of GDP. The results 7 show that health spending on climate change mitigation has a significant effect in countries with low GDP (more impacted by climate change) than in countries with high GDP (less impacted by climate change and with more resources). This is because countries with low GDP levels are more impacted by climatic contingencies Guivarch and Taconet (2020) and spend more on health (relative to their income level) to mitigate the effects of climate shock than countries with a high GDP level.

In columns 5 and 6, the distinction is also made according to the level of GDP. The fifth and sixth columns of the table 7 distinguish between countries with a high level of GDP and those with a low level of GDP. We find that using social expenditures during the shock mitigates the effects of climate shock only in countries with a low GDP level. The economic literature shows that the poorest countries (with a low level of GDP) are the most vulnerable to the effects of climate change Mertz et al. (2009) and are, therefore, those that spend the most on social expenditure (compared to their income level) to mitigate the effects of climate change. This justifies that social spending mitigates the effects of climate shock most in countries with a low GDP.

1.7.3 Heterogeneity : Effects of climate shock on Paris Agreement signatories and NDC list



This section makes the distinction according to whether or not developing countries have signed the Paris Climate Agreement (PCA). The idea is to find out whether the fact that a country is more affected by climate shocks encourages it to make a greater commitment through the Paris Climate Agreement. Indeed, the Paris climate agreement ¹² is an essential tool for finding out how committed countries are to tackle climate change. Columns 1 and 2 of the table 8 distinguish between countries that have signed the Paris Agreement(1) and those that have not(0). The results show that countries that have signed the Paris Climate Agreement are more impacted by the precipitation and temperature shock than countries that have not signed the Paris Climate Agreement (PCA). This result could be explained by the fact that countries more impacted by climate shock have a greater incentive to commit to the fight against climate change(CPA). Similarly, in columns 3 and 4 of table 8, The results show that countries that have registered on the NDC list are more affected by the climate shock than countries that are not registered on the list. These results could also be justified by the fact that countries that are more affected by the climate shock have a greater incentive to join the Nationally Determined Contributions (NDC) list ¹³, therefore, communicate regularly on their CO2 emissions and their efforts to combat climate change (NDC List).

In sum, being more impacted by the effects of climate shock could encourage a country to

12. The objective of the Paris climate agreement is to strengthen the global response to the threat of climate change by keeping the global temperature increase this century well below 2 degrees Celsius above pre-industrial levels and to continue efforts to further limit the temperature increase to 1.5 degrees Celsius. In addition, the agreement aims to increase the capacity of countries to cope with the impacts of climate change and to make financial flows consistent with a low-GHG emissions and climate change resilient pathway. The agreement also provides for an enhanced transparency framework for action and support

13. "The Paris Agreement requires all Parties to do their best through "nationally determined contributions" (NDCs) and to strengthen these efforts in the coming years. This includes the obligation for all Parties to regularly report on their emissions and efforts to implement the agreement."

become more actively involved in the fight against climate change.

1.7.4 Heterogeneity : Paris Agreement commitment and mitigation

In this section, we try to find out whether the countries that signed the Paris climate agreement¹⁴ This is why we distinguish between (1) countries that are signatories to the Paris Agreement and (0) countries that are not signatories. For this purpose, we distinguish between (1) countries that sign the Paris Agreement and (0) non-signatories. The results (columns 1 and 2) ⁹ show that health spending mitigates the effects of the climate shock more in countries that are not signatories to the Paris agreement than in signatory countries. However, the Paris climate agreement calls for signatory countries to be more involved in mitigating the effects of climate change on the population. This result could be justified by the fact that countries that are signatories to the Paris Agreement are not meeting their commitments contained in the Paris Climate Agreement (PCA)¹⁵, This is why in these countries (signatories), health spending is the least effective in mitigating the effects of climate change compared to other countries. This explains why in these (signatory) countries, health expenditure mitigates the effects of climate shock the least compared to other countries. In the Paris Agreement countries, the use of social expenditure (columns 3 and 4) ⁹ The last two columns show the impact of climate shock in both signatory and non-signatory countries. In the last two columns of the table ⁹, the distinction is made based on whether or not a developing country is on the NDC list¹⁶. The results show that social spending mitigates the effects of climate shock in both NDC and non-NDC countries.

14. (a) Limiting the increase in global average temperature to well below 2°C above pre-industrial levels and continuing efforts to limit the increase in temperature to 1.5°C above pre-industrial levels, while recognizing that this would significantly reduce the risks and impacts of climate change ;

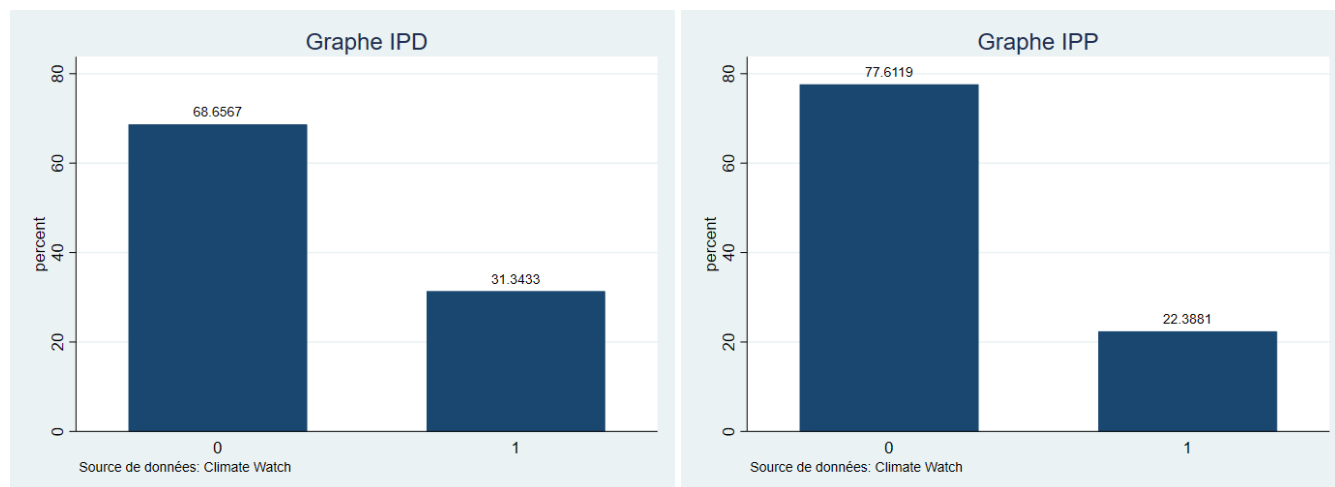
(b) Building capacity to adapt to the adverse effects of climate change and promoting resilience to climate change and low greenhouse gas emission development in a manner that does not threaten food production ;

(c) Making financial flows consistent with a pathway to low greenhouse gas emission and climate change resilient development.

15. According to the UNEP report, only Gambia complies with the Paris Climate Agreement (PCA)

16. Indeed, the NDCs embody each country's (listed) efforts to meet the commitments contained in the Paris climate agreement, including reducing its national emissions and adapting to the effects of climate change

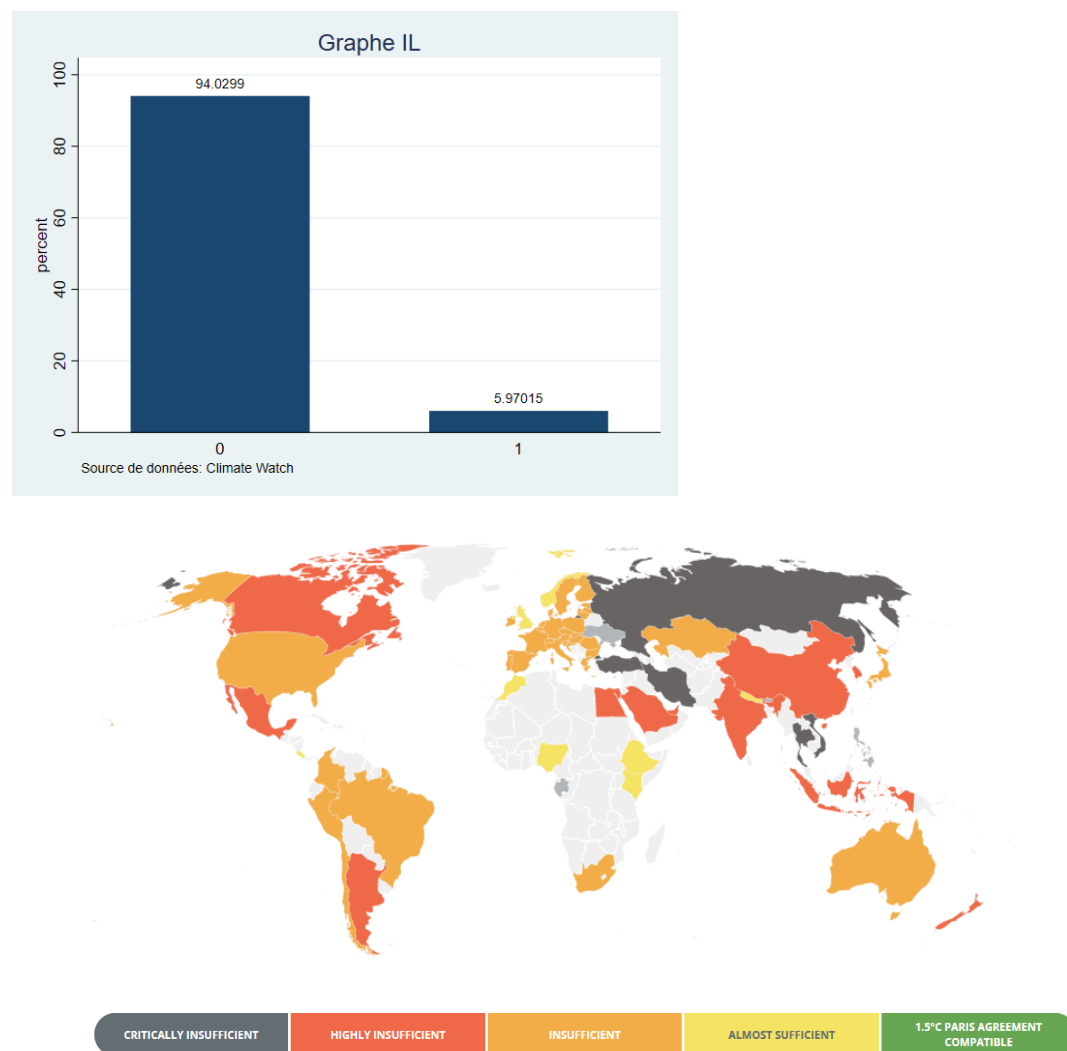
1.7.5 Heterogeneity : Relevance of commitments Paris Climate Agreement : IPD, IPP, IL



As a result of the Paris Agreement, the signatory countries have committed themselves to achieve the agreement's objective and informing the parties' subsequent individual actions. To this end, three mechanisms are available to the signatory countries : a commitment to the achievement of the objective of the Paris Agreement through an environmental policy document (IPD), a commitment through a political declaration in favor of the achievement of the objective of the Agreement (IPP) and a commitment through the creation of a law that aims better to combat the effects of climate change (IL). Among the three types of commitments, we wish to determine which is the most respectful and allows developing countries to mitigate the effects of climate shocks better. The results of the table 10 and 11 show that health and social spending mitigate the climate shock the most in countries that have not committed to all three types of commitments (IPD, IPP, and IL). These results could be justified because countries that have made these commitments are not meeting them. The United Nations Environment Programme's (UNEP) annual baseline report shows that among the signatories to the Paris Climate Agreement (PCA), only Gambia is a good performer in compliance. It must also be said that the Paris Agreement is flawed in that it does not establish obligations to achieve results; each country is not legally bound to achieve its national objectives and commitments (in terms of GHG emission reductions, financing, adaptation, etc.) set out in its NDC by a given deadline, nor to reinforce them at each review.¹⁷ Of the three types of commitments (IPD, IPP, and IL), none is sufficiently respected because only the countries that have made these commitments are mitigating the effects of climate shock the most. It is, therefore, clear that developing countries need to meet their climate change commitments (CCAs). This could also be explained by difficulties related to international law, procedural constraints, international entry into force requirements, domestic legal requirements of each country, lack of commitment,

17. https://www.citepa.org/wp-content/uploads/veille/CITEPA_I NT_C LIMAT_C NUCC_Paris_131215.pdf

and the non-binding nature of the PCA [Clarenc \(2016\)](#).



1.7.6 Heterogeneity : Public expenditure thresholds

In this part of the heterogeneity analysis, we use public expenditure thresholds. For this purpose, we distinguish two types of thresholds [12](#) (25%). The results show that [12](#) that health and social spending mitigate the effects of the climate shock the most when a country has a threshold of over 25% of public expenditures compared to a threshold of less than 25% of public expenditures.

1.8 Transmission channel validation

The transmission channels through which climate change impacts poverty have been the subject of much economic work. [Slingo et al. \(2005\)](#); [Hoddinott and Kinsey \(2001\)](#) et [Burke et al. \(2015\)](#) identify agriculture and conflict as the main channels through which climate change affects poverty. In this section, we present the economic mechanisms through which the precipitation and temperature shocks affect poverty in developing countries. Two methods are used to determine the transmission channels : First, we perform a Pearson correlation analysis. Second, we perform a fixed-effect linear regression analysis to confirm the causal effect of the channels. The results of the Pearson correlation analysis (see Table 14) show that channels such as income inequality, agricultural production, Official Development Assistance (ODA), and social spending are correlated with the climate shock (at the threshold of 10%).

The linear regression results with fixed effect show that Official Development Assistance, social expenditure, income inequality, and agricultural production are all significant (at the threshold of 1 and 10% level). Inequality increases poverty, and agricultural production decreases poverty. According to the linear regression results with fixed effect, income inequality, and agricultural production are channeled through which the climate shock affects poverty (see table 13). [Hallegatte et al. \(2014\)](#) show that productivity and opportunity are the factors through which climate change affects people's poverty. Thus, income inequality and agricultural production are channels through which rainfall and temperature shock affects poverty in developing countries. These channels are valid and credible economic mechanisms and likely transmission channels. It is through these factors that climate shock affects poverty in developing countries.

Conclusion

The study analyses the effects of climate change on poverty in developing countries. It tests two significant hypotheses : the first hypothesis shows that climate shock increases poverty, and the second hypothesis shows that fiscal policy instruments and external financing can mitigate the effects of climate change. The results confirm both hypotheses. Official Development Assistance, social spending, (income) inequality, and agricultural production are the channels through which the effects of climate change on poverty are transmitted. The studies of ([Hussein et al., 2013](#); [Hallegatte et al., 2014](#)) show that income is a factor through which climate change affects poverty. [Letta et al. \(2018\)](#) also identifies agricultural production as the main factor of climate change affecting poverty. [Islam and Winkel \(2017\)](#) and [Rozenberg and Hallegatte \(2015\)](#) also show that health is a channel through which climate change affects poverty. [Hallegatte et al. \(2014\)](#) identify price as a potential factor through which climate change affects poverty. The work of [López-Feldman and Mora Rivera \(2018\)](#) identifies farm income as a factor through which climate change affects poverty.

We use the fixed effects model to analyze the causal effect. The results show that climate shock increases poverty. The effect of the shock on poverty is significant. These results are similar to those obtained in the work of (Azzarri and Signorelli, 2020 ; Diwakar and Lacroix, 2021). Hallegatte et al. (2014) also shows that climate change will likely be a significant obstacle to sustainable poverty eradication. The inflexible nature of poverty and the fact that climate change is a phenomenon whose effects are felt over time lead to an assessment of the extent to which the effects of climate shock can be mitigated. This analysis of the effects of the shock in the presence of fiscal policy instruments and external financing led to a cross-tabulation of the interest variable with the different fiscal policy instruments and external financing in the estimations. The results reveal that using Official Development Assistance (ODA), social spending, and health spending help mitigate the effects of climate shock. The effects are significant at the 5 et 10% . The results thus confirm the second hypothesis put forward earlier. Regarding fiscal policy instruments, it is particularly social and health spending that mitigates the effects of climate shock the most.

The heterogeneity analysis shows that Official Development Assistance mitigates the effects of climate shock more in countries with a low level of GDP than in countries with a high level of GDP. Health spending on climate change mitigation significantly affects low-GDP countries (more impacted by climate change) than in high-GDP countries (less impacted by climate change). The precipitation and temperature shock more impact countries that have signed the Paris Climate Agreement (PCA) than countries that have not. The effects of climate shock more impact countries that are on the NDC list than those that are not. Health expenditure mitigates the effects of climate shock more in countries that are not signatories to the Paris Agreement than in countries that are signatories. Social spending mitigates the effects of the shock in both signatory and non-signatory countries(CPA). For all three types of commitments (IPD, IPP, and IL), health and social spending mitigate the climate shock the most in countries that are not signatories to these types of commitments compared to countries that are signatories to these commitments.

Analysis of the effects of climate change on poverty in developing countries shows that climate instability increases the vulnerability of poor people. However, this analysis does not directly capture the effects on households, which could have been more interesting. This is one of the main limitations of this study. This study only considers the effect of climate change on income poverty at the thresholds of 1,90\$ (measuring the incidence of poverty). However, it does not take into account the multidimensional aspect of poverty. This is the second limitation of the study. Also, the level of data aggregation is a significant challenge in the study of the effects of climate change on the socio-economic conditions of the population, as the weight of the effect will depend on this aggregation. Regarding the construction of the climate shock variable, data aggregation is done at the country-time level. This could underestimate, to some extent, the effects of climate shocks

at the local level (in regions or municipalities). Capturing the effects of the shock directly at the local level makes it possible to know the specificities (in terms of shock) at the level of the regions of a country because the effects of the shock in a given region are not necessarily the same in the rest of the country. Consequently, an aggregation of the data at the country-time level can be a source of underestimation of the effects at the local level. Moving from a disaggregated level of data to a country-time level may lead to a loss of information. This can affect the quality of the macroeconomic study since aggregation at the country level only allows for practical analysis of regional or municipal effects. It also needs to capture potential effects between countries. This is the third limitation of the study.

As a fourth limitation, the study analyses the effects of climate instability on poverty but does not capture soil fertility conditions, which are of great importance in analyzing the effects of climate change because soil degradation or impoverishment not only decreases agricultural production but also increases the vulnerability of the (agricultural) population, as this will lead to a drop in income (linked to the drop in agricultural yields), and therefore to more poverty. Taking into account soil fertility conditions in climate shocks could help better understand the real effects of climate change on the socio-economic conditions of the population.

In terms of economic policy implications, it is desirable that countries consider the challenges of climate change in developing economic policies. Implementing social programs is paramount as these programs provide immediate responses and help build resilience to the effects of climate change rapidly. It is also essential for developing countries to put in place a green initiative (green investment fund). This initiative is a debt contracted by each economic zone (CEMAC, UEMOA, ECOWAS, BRICS, etc.) to finance the climate change adaptation and mitigation strategy. The repayment of this debt could be based on the economic weight of each country within the economic zone. This enshrines the principle of solidarity between the member countries of an economic area and allows the development of a common strategy to combat the effects of climate change. It is also recommended that countries that have not yet adopted budgetary rules put in place on inflation and the budget deficit to reassure investors about the management of fiscal policy and thus quickly mobilize resources to combat the effects of climate change. In order to prevent the effects of climate shock, infrastructure construction must be adapted to the climatic realities of the areas at risk. In the event of an extreme shock, it is helpful to put in place a "green" response plan. This plan contains immediate and medium- and long-term solutions to counter the effects of climate hazards. This plan will be partly funded by public expenditure, input from international financial institutions, and donations. The private sector and civil society should be involved in the quest to develop response plans and find financing for climate change. When a climate shock lasts for a long time and causes significant devastation, it is desirable not to count the financial resources mobilized to combat the effects of climate change in the debt-to-GDP ratio for the duration of

the shock, as this will allow the victim countries to have sufficient (fiscal) leeway for the conduct of fiscal policy. However, the implementation of such mechanisms must be highly restrictive and must be supervised in order to avoid free-riding situations. Building countries' capacity requires significant investment. The implementation of policies and strategies involving the climate issue at all levels, the development of technological capacities to adapt to climate change, and innovation are solutions that will make it possible to build a sustainable and resilient future for all.

To better reflect on climate change's impact on poverty, it is desirable to explore the possibilities of a microeconomic study of the effects of climate change on household poverty using field surveys. Also, it is desirable to extend the reflection on the effects of climate change on multidimensional poverty and, more globally, on inequalities.

Appendix

TABLE 2 – Fixed effect model

Dependent variable : Poverty	1	2	3	4	5	6
Health.expenditure*Shock		-0.046** (0.018)				
Shock	0.826** (0.371)	1.886*** (0.633)	1.734*** (0.522)	0.935** (0.363)	0.816** (0.371)	1.378*** (0.497)
Health.expenditure		0.0002 (0.0004)				
Natural ressources	-0.001 (0.002)	-0.002 (0.002)	-0.002 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.002 (0.002)
GDP per capita	0.016 (0.024)	0.014 (0.023)	0.015 (0.024)	0.017 (0.024)	0.016 (0.024)	0.017 (0.024)
Population.Growth	-0.015 (0.029)	-0.038 (0.028)	-0.032 (0.029)	-0.018 (0.029)	-0.017 (0.030)	-0.027 (0.027)
Education.expenditure	-0.027* (0.014)	-0.037 (0.027)	-0.026* (0.014)	-0.028* (0.014)	-0.027* (0.014)	-0.027* (0.014)
Agriculture	-0.004 (0.021)	-0.008 (0.020)	-0.009 (0.020)	-0.005 (0.021)	-0.005 (0.021)	-0.007 (0.020)
Social Protection	-0.053** (0.022)	-0.043** (0.018)	-0.048** (0.022)	-0.052** (0.022)	-0.054** (0.023)	-0.050** (0.022)
Law and Order	-0.008 (0.005)	-0.009* (0.005)	-0.008 (0.005)	-0.008 (0.005)	-0.008 (0.005)	-0.007 (0.005)
Schoolenrollmentsecondary	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)
BSocioeconomicConditions	0.003 (0.006)	0.004 (0.006)	0.003 (0.006)	0.003 (0.006)	0.003 (0.006)	0.003 (0.006)
Gini	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)
Inflation	-0.004 (0.007)	-0.006 (0.008)	-0.004 (0.007)	-0.004 (0.007)	-0.004 (0.007)	-0.004 (0.007)
Social.Protection*Shock			-0.010** (0.004)			
ODA-Shock				-0.026** (0.010)		
ODA				0.008** (0.003)		
T.remittances*Shock					0.001 (0.001)	
T.remittances					-0.0001** (0.0001)	
Fiscal.space*Shock						-0.009* (0.005)
Fiscal space						0.001 (0.015)
Constant	4.048*** (0.409)	4.151*** (0.396)	4.119*** (0.389)	4.051*** (0.408)	4.058*** (0.411)	4.091*** (0.383)
Observations	1,154	1,087	1,147	1,154	1,154	1,147
R-squared	0.134	0.137	0.139	0.136	0.135	0.139
Number of id	67	67	67	67	67	67
Country FE,Year	Yes	Yes	Yes	Yes	Yes	Yes

Notes : We use the Fixed effect model in this table. The dependent variable is the poverty ratio. The variable of interest is the index of vulnerability to temperature and precipitation shocks. In column (2), we measure the effect of the contribution of health expenditures. In column (3), we measure the effect of social spending. In column (4), we measure the effect of public development aid. In column (5), we measure the effect of migrant remittances. In column (6), we measure the effect of fiscal space. ***p<0.001, **p<0.01, *p<0.05. Standard errors are in parentheses.

TABLE 3 – Fixed effect model with additive robustness

Dependent variable : Poverty	1	2	3	4	5	6	7	8	9
shock	0.826** (0.371)	0.748** (0.369)	0.827** (0.371)	0.882** (0.361)	0.852** (0.381)	0.835** (0.374)	0.813** (0.371)	0.828** (0.371)	0.826** (0.374)
Natural ressources	-0.001 (0.002)	-0.002 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)
GDP per capita	0.016 (0.024)	0.016 (0.024)	0.016 (0.024)	0.017 (0.024)	0.017 (0.024)	0.014 (0.024)	0.016 (0.024)	0.016 (0.024)	0.016 (0.023)
Pop.Growth	-0.015 (0.029)	-0.034 (0.030)	-0.015 (0.029)	-0.018 (0.030)	-0.017 (0.030)	-0.015 (0.030)	-0.015 (0.030)	-0.015 (0.029)	-0.015 (0.029)
Education.expenditure	-0.027* (0.014)	-0.025* (0.014)	-0.027* (0.014)	-0.027* (0.014)	-0.027* (0.014)	-0.026* (0.014)	-0.026* (0.015)	-0.027* (0.014)	-0.027* (0.014)
Agriculture	-0.004 (0.021)	-0.006 (0.021)	-0.004 (0.021)	-0.005 (0.021)	-0.004 (0.021)	-0.006 (0.021)	-0.005 (0.021)	-0.004 (0.021)	-0.004 (0.021)
Social Protection	-0.053** (0.022)	-0.051** (0.022)	-0.054** (0.022)	-0.055** (0.022)	-0.053** (0.022)	-0.053** (0.022)	-0.052** (0.024)	-0.053** (0.022)	-0.053** (0.022)
Law and Order	-0.008 (0.005)	-0.007 (0.006)	-0.008 (0.005)	-0.008 (0.005)	-0.008 (0.006)	-0.008 (0.005)	-0.007 (0.005)	-0.008 (0.006)	-0.008 (0.005)
Schoolenrollmentsecondary	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)
BSocioeconomicConditions	0.003 (0.006)	0.003 (0.006)	0.003 (0.006)	0.002 (0.006)	0.003 (0.006)	0.002 (0.006)	0.003 (0.006)	0.002 (0.006)	0.003 (0.006)
Gini	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)
Inflation	-0.004 (0.007)	-0.004 (0.007)	-0.004 (0.007)	-0.004 (0.007)	-0.004 (0.007)	-0.004 (0.007)	-0.004 (0.007)	-0.004 (0.007)	-0.004 (0.007)
Health.expenditure		-0.0004 (0.0002)							
ODA			-0.0001 (0.003)						
Unemploymenttotaloftotal				0.001 (0.001)					
AGovernmentStability					0.001 (0.002)				
Foreigndirectinvestmentneti						0.001 (0.001)			
Salaried workers							0.0002 (0.0004)		
DInternalConflict								0.0001 (0.003)	
Quality of public policies									0.0002 (0.022)
Constant	4.048*** (0.409)	4.096*** (0.402)	4.047*** (0.409)	4.052*** (0.410)	4.031*** (0.405)	4.079*** (0.403)	4.036*** (0.416)	4.044*** (0.404)	4.048*** (0.407)
Observations	1,154	1,147	1,154	1,154	1,154	1,154	1,154	1,154	1,154
R-squared	0.134	0.137	0.134	0.135	0.135	0.136	0.135	0.134	0.134
Number of id-count	67	67	67	67	67	67	67	67	67
Country FE,Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

TABLE 4 – Robustness

Dependent variable : Poverty	1	2	3	4	5	6	7	8
Precipitation Shock	0.0001** (0.0001)	0.0001** (0.0001)	0.0001** (0.0001)	0.0001** (0.0001)	0.0001** (0.0001)	0.0001** (0.0001)	0.0001** (0.0001)	0.0001** (0.0001)
Temperature Shock	0.019*** (0.005)	0.019*** (0.005)	0.019*** (0.005)	0.019*** (0.005)	0.019*** (0.005)	0.018*** (0.005)	0.019*** (0.005)	0.019*** (0.005)
Natural Ressources	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)
GDP per capita	0.018 (0.023)	0.018 (0.024)	0.017 (0.024)	0.018 (0.024)	0.020 (0.024)	0.017 (0.023)	0.019 (0.024)	0.018 (0.024)
Population.Growth	-0.017 (0.029)	-0.017 (0.029)	-0.017 (0.028)	-0.017 (0.029)	-0.015 (0.028)	-0.018 (0.027)	-0.019 (0.030)	-0.017 (0.029)
Education.expenditure	-0.024* (0.014)	-0.024* (0.014)	-0.024* (0.014)	-0.024* (0.014)	-0.020 (0.013)	-0.024* (0.014)	-0.024* (0.014)	-0.024* (0.014)
Agriculture	-0.004 (0.021)	-0.004 (0.021)	-0.004 (0.021)	-0.004 (0.021)	-0.001 (0.020)	-0.004 (0.022)	-0.004 (0.021)	-0.004 (0.021)
Social Protection	-0.061*** (0.023)	-0.061*** (0.023)	-0.061*** (0.023)	-0.061*** (0.023)	-0.062** (0.023)	-0.061** (0.023)	-0.062** (0.023)	-0.061*** (0.023)
Law and Order	-0.008 (0.005)	-0.008 (0.005)	-0.008 (0.005)	-0.008 (0.006)	-0.009 (0.006)	-0.008 (0.005)	-0.008 (0.006)	-0.008 (0.005)
Schoolenrollmentsecondary	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)
BSocioeconomicConditions	0.002 (0.006)	0.002 (0.006)	0.002 (0.007)	0.002 (0.006)	0.002 (0.006)	0.002 (0.006)	0.003 (0.006)	0.002 (0.006)
Gini	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)
Inflation	-0.005 (0.007)	-0.005 (0.007)	-0.005 (0.007)	-0.005 (0.007)	-0.005 (0.008)	-0.005 (0.007)	-0.005 (0.007)	-0.005 (0.007)
financial opening		-0.002 (0.003)						
CInvestmentProfile			-0.0001 (0.003)					
DInternalConflict				0.0001 (0.003)				
HReligiousTensions					0.011 (0.012)			
Level of study (SC)						-0.0004 (0.001)		
AGovernmentStability							0.002 (0.002)	
ODA								-0.0001 (0.003)
Constant	4.049*** (0.409)	4.058*** (0.409)	4.050*** (0.410)	4.044*** (0.403)	3.920*** (0.353)	4.073*** (0.378)	4.031*** (0.405)	4.049*** (0.409)
Observations	1,154	1,154	1,154	1,154	1,154	1,154	1,154	1,154
R-squared	0.137	0.137	0.137	0.137	0.141	0.137	0.137	0.137
Number of id-count	67	67	67	67	67	67	67	67
Country FE,Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

TABLE 5 – Robustness : Arellano Bond (1991)

Dependent variable : Poverty	1	2	3	4	5	6	7	8	9
L.Poverty 1	-0.350*** (0.033)	-0.351*** (0.033)	-0.351*** (0.033)	-0.351*** (0.033)	-0.348*** (0.033)	-0.351*** (0.033)	-0.352*** (0.033)	-0.350*** (0.033)	-0.350*** (0.033)
Shock 1	3.009*** (0.961)	2.999*** (0.962)	3.018*** (0.962)	2.998*** (0.961)	2.990*** (0.961)	3.009*** (0.961)	2.998*** (0.961)	2.995*** (0.962)	3.020*** (0.961)
Natural Ressources	0.005** (0.002)	0.005** (0.002)	0.005** (0.002)	0.004** (0.002)	0.004** (0.002)	0.005** (0.002)	0.004** (0.002)	0.005** (0.002)	0.005** (0.002)
GDP per capita	-0.093*** (0.010)	-0.093*** (0.010)	-0.092*** (0.010)	-0.092*** (0.010)	-0.093*** (0.010)	-0.093*** (0.010)	-0.093*** (0.010)	-0.093*** (0.010)	-0.093*** (0.010)
Population.Growth	0.004 (0.037)	0.010 (0.038)	0.005 (0.037)	0.004 (0.037)	0.003 (0.037)	0.008 (0.038)	0.005 (0.037)	0.004 (0.037)	0.005 (0.037)
Education.expenditure	-0.019 (0.028)	-0.018 (0.028)	-0.017 (0.028)	-0.020 (0.028)	-0.019 (0.028)	-0.019 (0.028)	-0.014 (0.028)	-0.019 (0.028)	-0.019 (0.028)
Agriculture	-0.009 (0.017)	-0.008 (0.017)	-0.009 (0.017)	-0.009 (0.017)	-0.007 (0.017)	-0.009 (0.017)	-0.008 (0.017)	-0.009 (0.017)	-0.009 (0.017)
Social Protection	-0.002 (0.023)	-0.002 (0.023)	-0.002 (0.023)	-0.001 (0.023)	-0.002 (0.023)	-0.002 (0.023)	-0.000 (0.023)	-0.002 (0.023)	-0.002 (0.023)
Law and Order	-0.013* (0.008)	-0.013 (0.008)	-0.015* (0.008)	-0.014* (0.008)	-0.015* (0.008)	-0.013* (0.008)	-0.015* (0.008)	-0.015* (0.009)	-0.013 (0.008)
Schoolenrollmentsecondary	0.0001 (0.0004)	0.0001 (0.0004)	0.0001 (0.0004)	0.0001 (0.0004)	0.0001 (0.0004)	0.0001 (0.0004)	0.0001 (0.0004)	0.0001 (0.0004)	0.0001 (0.0004)
BSocioeconomicConditions	0.004 (0.004)	0.004 (0.004)	0.004 (0.004)	0.004 (0.004)	0.004 (0.004)	0.004 (0.004)	0.004 (0.004)	0.004 (0.004)	0.005 (0.005)
Gini	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003* (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)
Inflation	-0.014*** (0.005)	-0.014*** (0.005)	-0.014*** (0.005)	-0.015*** (0.005)	-0.014*** (0.005)	-0.014*** (0.005)	-0.014*** (0.005)	-0.014*** (0.005)	-0.014*** (0.005)
Energy Access		0.001 (0.000)							
GMilitaryinPolitics			0.005 (0.007)						
ODA-inf				-0.0001 (0.0002)					
AGovernmentStability					0.004 (0.003)				
Unemploymenttotaloftotal						-0.001 (0.002)			
HReligiousTensions							0.013 (0.009)		
DInternalConflict								0.002 (0.004)	
CInvestmentProfile									-0.002 (0.004)
Constant	5.920*** (0.310)	5.879*** (0.311)	5.892*** (0.312)	5.923*** (0.309)	5.867*** (0.312)	5.920*** (0.310)	5.830*** (0.316)	5.910*** (0.311)	5.930*** (0.310)
Observations	946	946	946	946	946	946	946	946	946
Number of id-count	67	67	67	67	67	67	67	67	67
Arellano Bond	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 6 – Robustness : Blundell Bond (1998)

Dependent variable : Poverty	1	2	3	4	5	6	7	8
L.Poverty 2	-0.077*** (0.022)	-0.059*** (0.022)	-0.078*** (0.022)	-0.078*** (0.022)	-0.082*** (0.023)	-0.081*** (0.022)	-0.080*** (0.022)	-0.077*** (0.022)
Shock 2	0.0001*** (0.0003)	0.0001*** (0.0003)	0.0001*** (0.0003)	0.0001*** (0.0003)	0.0001*** (0.0003)	0.0001*** (0.0003)	0.0001*** (0.0003)	0.0001*** (0.0003)
Natural Ressources	0.006*** (0.002)	0.007*** (0.002)	0.006*** (0.002)	0.006*** (0.002)	0.006*** (0.002)	0.006*** (0.002)	0.006*** (0.002)	0.006*** (0.002)
GDP per capita	-0.069*** (0.008)	-0.061*** (0.008)	-0.069*** (0.008)	-0.068*** (0.008)	-0.069*** (0.008)	-0.070*** (0.008)	-0.068*** (0.008)	-0.069*** (0.008)
Population.Growth	0.039 (0.032)	-0.001 (0.032)	0.038 (0.032)	0.040 (0.032)	0.036 (0.032)	0.045 (0.032)	0.040 (0.032)	0.039 (0.032)
Education.expenditure	-0.018 (0.018)	-0.019 (0.018)	-0.018 (0.018)	-0.018 (0.018)	-0.018 (0.018)	-0.017 (0.018)	-0.015 (0.018)	-0.017 (0.018)
Agriculture	-0.046*** (0.009)	-0.051*** (0.009)	-0.046*** (0.009)	-0.046*** (0.009)	-0.046*** (0.009)	-0.043*** (0.009)	-0.043*** (0.009)	-0.046*** (0.009)
Social Protection	0.002 (0.021)	-0.004 (0.021)	0.002 (0.021)	0.002 (0.021)	0.003 (0.021)	0.004 (0.021)	0.004 (0.021)	0.002 (0.021)
Law and Order	-0.011 (0.008)	-0.013* (0.007)	-0.010 (0.008)	-0.011 (0.008)	-0.012 (0.008)	-0.012 (0.008)	-0.013* (0.008)	-0.012 (0.008)
Schoolenrollmentsecondary	0.0001 (0.0004)	-0.0001 (0.0004)	0.0001 (0.0004)	0.0001 (0.0004)	0.0001 (0.0004)	0.0001 (0.0004)	0.0001 (0.0004)	0.0001 (0.0004)
BSocioeconomicConditions	0.006 (0.004)	0.004 (0.004)	0.006 (0.004)	0.006 (0.004)	0.006 (0.004)	0.006 (0.004)	0.006 (0.004)	0.006 (0.004)
Gini	0.001*** (0.0002)	0.001*** (0.0002)	0.001*** (0.0002)	0.001*** (0.0002)	0.001*** (0.0002)	0.001*** (0.0002)	0.001*** (0.0002)	0.001*** (0.0002)
Inflation	-0.015*** (0.005)	-0.014*** (0.005)	-0.015*** (0.005)	-0.015*** (0.005)	-0.015*** (0.005)	-0.015*** (0.005)	-0.015*** (0.005)	-0.015*** (0.005)
Salaried workers		-0.004*** (0.000)						
GMilitaryinPolitics			-0.003 (0.007)					
ODA-				0.016 (0.013)				
Acces-elec					-0.0004 (0.0003)			
Corruption						0.065** (0.029)		
HReligiousTensions							0.013 (0.008)	
DInternalConflict								0.001 (0.004)
Constant	5.008*** (0.218)	5.105*** (0.215)	5.025*** (0.222)	5.005*** (0.218)	5.050*** (0.221)	5.009*** (0.218)	4.917*** (0.224)	5.003*** (0.220)
Observations	1,154	1,154	1,154	1,154	1,154	1,154	1,154	1,154
Number of id	67	67	67	67	67	67	67	67
Blundell Bond	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

TABLE 7 – Heterogeneity

	1	2	3	4	5	6
	Pib-e	Pib-f	Pib-1e	Pib-1f	Pib-2e	Pib-2f
Dependent variable : Poverty						
ODA*Shock	2.932-0.028***					
	(2.086)	(0.010)				
Shock	0.349	0.847*	0.566	1.973***	0.612	1.777**
	(1.030)	(0.429)	(0.995)	(0.625)	(1.166)	(0.716)
ODA	1.575	0.009**				
	(4.118)	(0.004)				
Natural Ressources	0.005	-0.0004	0.005	-0.001	0.006*	-0.001
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
GDP per capita	0.004	0.031	-0.0006	0.021	0.005	0.028
	(0.045)	(0.025)	(0.046)	(0.026)	(0.044)	(0.024)
Population.Growth	0.053	-0.020	0.038	-0.033	0.058*	-0.034
	(0.035)	(0.032)	(0.035)	(0.030)	(0.034)	(0.031)
Education.expenditure	-0.006-0.048***		0.017	-0.072**	-0.002-0.046***	
	(0.028)	(0.015)	(0.031)	(0.028)	(0.030)	(0.015)
Agriculture	0.011	-0.014	0.016	-0.016	0.010	-0.018
	(0.024)	(0.027)	(0.021)	(0.025)	(0.024)	(0.025)
Social Protection	-0.0007-0.061***		-0.011	-0.040**	0.001	-0.056**
	(0.025)	(0.023)	(0.021)	(0.018)	(0.024)	(0.023)
Law and Order	0.011-0.017***		0.012-0.018***		0.011-0.017***	
	(0.009)	(0.006)	(0.008)	(0.006)	(0.009)	(0.006)
Schoolenrollmentsecondary	0.0004	-0.001	0.0004	-0.001	0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
BSocioeconomicConditions	0.004	0.004	0.002	0.004	0.003	0.004
	(0.006)	(0.008)	(0.006)	(0.008)	(0.006)	(0.008)
Gini	-0.0005	0.001*	-0.0005	0.001*	-0.0005	0.001*
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Inflation	0.013*	-0.008	0.012*	-0.010	0.012*	-0.008
	(0.006)	(0.008)	(0.007)	(0.009)	(0.006)	(0.008)
Health.expenditure*Shock			0.006-0.055***			
			(0.019)	(0.017)		
Health.expenditure			-0.0001	0.0001		
			(0.0001)	(0.0001)		
Social.Protection*Shock					0.002	-0.011*
					(0.005)	(0.006)
Constant	3.429***	4.203***	3.374***	4.352***	3.422***	4.279***
	(0.255)	(0.509)	(0.289)	(0.484)	(0.268)	(0.471)
Observations	232	922	226	861	232	915
R-squared	0.367	0.138	0.352	0.139	0.361	0.141
Number of id	21	62	21	61	21	62
Country FE,Year	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

TABLE 8 – Heterogeneity : Effects of climate shock on Paris Agreement signatories and NDC list

	1	2	3	4
	AP=1	AP=0	NDC=1	NDC=0
Dependent variable : Poverty				
shock	1.760*	0.320	1.123*	0.266
	(0.883)	(0.437)	(0.582)	(0.566)
Natural Ressources	0.002	-0.002	-0.003	-0.001
	(0.005)	(0.002)	(0.004)	(0.002)
GDP per capita	-0.040	0.042	-0.001	0.071**
	(0.027)	(0.031)	(0.027)	(0.030)
Pop.Growth	-0.054	0.063*	-0.056*	0.136**
	(0.043)	(0.034)	(0.028)	(0.047)
Education.expenditure	-0.040**	-0.015	-0.033**	0.002
	(0.016)	(0.019)	(0.014)	(0.028)
Agriculture	0.029	0.017	-0.015	-0.016
	(0.020)	(0.024)	(0.026)	(0.035)
Social Protection	-0.056**	-0.040*	-0.048*	-0.028
	(0.026)	(0.022)	(0.028)	(0.026)
Law and Order	-0.015**	0.003	-0.009	0.006
	(0.006)	(0.007)	(0.006)	(0.008)
Schoolenrollmentsecondary	-0.0002	0.0002	-0.001*	0.001*
	(0.0003)	(0.0003)	(0.001)	(0.001)
BSocioeconomicConditions	-0.006	-0.003	0.004	-0.003
	(0.008)	(0.005)	(0.008)	(0.007)
Gini	0.0001*	0.0001	0.0001	0.001*
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Inflation	-0.011	0.009*	-0.008	0.008
	(0.007)	(0.005)	(0.011)	(0.006)
Constant	4.121***	3.347***	4.429***	3.328***
	(0.371)	(0.411)	(0.492)	(0.577)
Observations	344	637	857	297
R-squared	0.367	0.335	0.137	0.343
Number of id-count	20	37	50	17
Country FE,Year	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

TABLE 9 – Heterogeneity : Paris Agreement commitment and mitigation

	1	2	3	4	5	6	7	8
	AP=1	AP=0	AP=1	AP=0	NDC=1	NDC=0	NDC=1	NDC=0
Dependent variable : Poverty								
Health.expenditure*Shock	-0.019	-0.056**			-0.024	-0.064*		
	(0.011)	(0.022)			(0.023)	(0.031)		
Shock	1.498	1.804**	2.131**	1.682**	1.434**	2.085**	1.603***	1.880**
	(0.988)	(0.733)	(0.855)	(0.767)	(0.690)	(0.919)	(0.565)	(0.706)
Health.expenditure	-0.0001	0.0004			-0.0003	0.0003		
	(0.0004)	(0.001)			(0.0008)	(0.001)		
Natural Ressources	0.004	-0.004	0.003	-0.004	-0.002	-0.002	-0.003	-0.003
	(0.005)	(0.003)	(0.005)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)
GDP per capita	-0.031	0.027	-0.035	0.035	0.002	0.039	0.001	0.063**
	(0.028)	(0.031)	(0.026)	(0.032)	(0.025)	(0.032)	(0.026)	(0.027)
Population.Growth	-0.085**	0.034	-0.068	0.037	-0.076***	0.123**	-0.065**	0.106**
	(0.034)	(0.031)	(0.046)	(0.030)	(0.027)	(0.045)	(0.030)	(0.044)
Education.expenditure	-0.063**	-0.011	-0.041**	-0.013	-0.047*	0.012	-0.033**	-0.001
	(0.027)	(0.030)	(0.015)	(0.019)	(0.027)	(0.039)	(0.014)	(0.029)
Agriculture	0.024	0.012	0.026	0.010	-0.014	-0.020	-0.016	-0.026
	(0.019)	(0.020)	(0.020)	(0.021)	(0.026)	(0.032)	(0.027)	(0.034)
Social Protection	-0.038	-0.031	-0.053**	-0.032	-0.038*	-0.020	-0.046	-0.020
	(0.024)	(0.019)	(0.025)	(0.023)	(0.022)	(0.018)	(0.028)	(0.024)
Law and Order	-0.015**	0.002	-0.015**	0.004	-0.009	0.005	-0.009	0.007
	(0.006)	(0.007)	(0.006)	(0.007)	(0.006)	(0.008)	(0.006)	(0.008)
Schoolenrollmentsecondary	-0.001*	0.0009	-0.0009	0.0004	-0.001**	0.001**	-0.001*	0.001*
	(0.000)	(0.0005)	(0.0005)	(0.0001)	(0.0004)	(0.001)	(0.001)	(0.001)
BSocioeconomicConditions	-0.004	-0.004	-0.005	-0.003	0.005	-0.006	0.004	-0.005
	(0.008)	(0.005)	(0.008)	(0.005)	(0.008)	(0.006)	(0.008)	(0.006)
Gini	0.0006	0.0001	0.0002*	0.0002	0.0003	0.001**	0.0002	0.001**
	(0.0002)	(0.0004)	(0.0003)	(0.0003)	(0.0004)	(0.0001)	(0.0003)	(0.0002)
Inflation	-0.011	0.007	-0.011	0.009*	-0.012	0.008	-0.008	0.008
	(0.007)	(0.004)	(0.006)	(0.005)	(0.012)	(0.006)	(0.011)	(0.006)
Social.Protection*Shock			-0.006**	-0.014**			-0.006*	-0.014**
			(0.003)	(0.006)			(0.004)	(0.006)
Constant	4.179***	3.533***	4.133***	3.494***	4.442***	3.556***	4.437***	3.541***
	(0.372)	(0.332)	(0.366)	(0.349)	(0.508)	(0.492)	(0.496)	(0.528)
Observations	326	597	344	630	814	273	857	290
R-squared	0.409	0.355	0.374	0.350	0.135	0.412	0.138	0.377
Number of id-count	20	37	20	37	50	17	50	17
Country FE,Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

TABLE 10 – Heterogeneity : Relevance of Paris Agreement commitments : IPD and IPP

	1	2	3	4	5	6	7	8
	IPD=1	IPD=0	IPD=1	IPD=0	IPP=1	IPP=0	IPP=1	IPP=0
Dependent variable : Poverty								
Health.expenditure*Shock	-0.028	-0.046**			-0.060	-0.053**		
	(0.047)	(0.021)			(0.040)	(0.022)		
Shock	1.134	1.451**	0.845	0.970*	3.552	2.059***	2.481	2.242***
	(1.808)	(0.711)	(2.230)	(0.544)	(3.239)	(0.670)	(2.499)	(0.722)
Health.expenditure	0.0001	0.0002			-0.0004	-0.0003		
	(0.001)	(0.0006)			(0.001)	(0.0001)		
Natural Ressources	-0.009	-0.002	-0.009	-0.001	0.004	-0.004**	0.007	-0.004*
	(0.007)	(0.003)	(0.007)	(0.003)	(0.008)	(0.002)	(0.005)	(0.002)
GDP per capita	0.038	0.007	0.038	0.011	0.005	0.020	-0.003	0.025
	(0.052)	(0.027)	(0.048)	(0.028)	(0.052)	(0.029)	(0.050)	(0.030)
Population.Growth	-0.121**	0.017	-0.116**	0.022	-0.197	-0.007	-0.158	-0.006
	(0.054)	(0.029)	(0.055)	(0.029)	(0.124)	(0.027)	(0.101)	(0.027)
Education.expenditure	-0.098	-0.014	-0.044*	-0.015	-0.022	-0.031	-0.005	-0.025
	(0.064)	(0.030)	(0.025)	(0.017)	(0.068)	(0.026)	(0.021)	(0.015)
Agriculture	-0.111	0.014	-0.112	0.012	-0.059	0.004	-0.067	0.002
	(0.086)	(0.018)	(0.085)	(0.020)	(0.043)	(0.017)	(0.051)	(0.019)
Social Protection	-0.024	-0.036**	-0.057	-0.034	-0.083	-0.034**	-0.071	-0.040**
	(0.038)	(0.016)	(0.036)	(0.020)	(0.099)	(0.015)	(0.096)	(0.017)
Law and Order	-0.000	-0.010	-0.003	-0.007	-0.022	-0.002	-0.016	-0.001
	(0.006)	(0.007)	(0.006)	(0.007)	(0.018)	(0.006)	(0.018)	(0.006)
Schoolenrollmentsecondary	-0.002	-0.0004	-0.002	-0.0005	-0.003	-0.0004	-0.003	0.0006
	(0.001)	(0.0006)	(0.001)	(0.0002)	(0.002)	(0.0003)	(0.002)	(0.0007)
BSocioeconomicConditions	0.007	0.001	0.008	-0.000	0.019	-0.004	0.014	-0.004
	(0.016)	(0.004)	(0.016)	(0.005)	(0.017)	(0.004)	(0.016)	(0.005)
Gini	0.0002	0.0003	0.0002	0.0004	0.001	0.0005	0.001	0.0004
	(0.001)	(0.0002)	(0.001)	(0.0002)	(0.001)	(0.0007)	(0.001)	(0.0004)
Inflation	-0.030	0.003	-0.024	0.005	-0.035	0.0004	-0.030	0.002
	(0.020)	(0.004)	(0.017)	(0.005)	(0.037)	(0.005)	(0.029)	(0.005)
Social.Protection*Shock			-0.001	-0.009*			-0.010	-0.014**
			(0.007)	(0.005)			(0.008)	(0.006)
Constant	5.823***	3.689***	5.753***	3.662***	5.455***	3.835***	5.489***	3.815***
	(1.585)	(0.327)	(1.500)	(0.339)	(1.313)	(0.329)	(1.257)	(0.339)
Observations	345	742	365	782	244	843	256	891
R-squared	0.157	0.299	0.157	0.288	0.187	0.306	0.176	0.303
Number of id-count	21	46	21	46	15	52	15	52
Country FE, Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

TABLE 11 – Heterogeneity : Relevance of commitments Paris Agreement : IL

	1	2	3	4
	IL=1	IL=0	IL=1	IL=0
Dependent variable : Poverty				
Health.expenditure*Shock	-0.165	-0.044**		
	(0.123)	(0.018)		
Shock	8.242	1.787***	4.570	1.809***
	(3.912)	(0.645)	(3.086)	(0.528)
Health.expenditure	0.002	0.0002		
	(0.002)	(0.0005)		
Natural Ressources	0.004	-0.003	0.006	-0.003
	(0.005)	(0.002)	(0.004)	(0.002)
GDP per capita	0.051	0.013	0.064	0.013
	(0.058)	(0.024)	(0.028)	(0.024)
Pop.Growth	-0.114	-0.038	-0.143*	-0.031
	(0.049)	(0.031)	(0.054)	(0.032)
Education.expenditure	0.027	-0.038	-0.022	-0.026*
	(0.024)	(0.028)	(0.021)	(0.015)
Agriculture	-0.003	-0.003	0.007	-0.004
	(0.047)	(0.020)	(0.037)	(0.021)
Social Protection	0.025	-0.044**	0.022	-0.050**
	(0.092)	(0.019)	(0.106)	(0.023)
Law and Order	-0.012	-0.008	-0.003	-0.007
	(0.008)	(0.006)	(0.008)	(0.006)
Schoolenrollmentsecondary	-0.001	-0.001	-0.001**	-0.001
	(0.001)	(0.0004)	(0.0005)	(0.0006)
BSocioeconomicConditions	-0.005	0.004	-0.006	0.003
	(0.016)	(0.007)	(0.013)	(0.007)
Gini	-0.001	0.0004	-0.001	0.0003
	(0.001)	(0.0003)	(0.001)	(0.0004)
Inflation	-0.021*	-0.006	-0.021*	-0.003
	(0.008)	(0.008)	(0.008)	(0.008)
Social.Protection*Shock			-0.014	-0.011**
			(0.033)	(0.004)
Constant	3.200*	4.100***	3.239**	4.072***
	(1.247)	(0.399)	(0.940)	(0.393)
Observations	65	1,022	69	1,078
R-squared	0.642	0.139	0.668	0.141
Number of id-count	4	63	4	63
Country FE, Year	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

TABLE 12 – Heterogeneity : Threshold effect with 25% of public expenditures

	1	2	3	4
	DEPPib-e	DEPPib-f	DEPPib-e	DEPPib-f
Dependent variable : Poverty				
Health.expenditure*Shock	-0.063*** (0.018)	-0.001 (0.047)		
Shock	2.446*** (0.685)	0.940 (1.261)	1.678*** (0.530)	1.268 (1.294)
Health.expenditure	0.0007 (0.0001)	-0.0003 (0.0001)		
Natural Ressources	-0.001 (0.002)	-0.006* (0.004)	-0.0002 (0.002)	-0.007* (0.004)
GDP per capita	-0.020 (0.023)	0.052 (0.049)	-0.014 (0.024)	0.055 (0.051)
Population.Growth	-0.029 (0.030)	-0.016 (0.037)	-0.031 (0.029)	-0.000 (0.046)
Education.expenditure	-0.048* (0.027)	0.019 (0.036)	-0.027* (0.014)	-0.014 (0.026)
Agriculture	-0.024 (0.023)	-0.008 (0.039)	-0.023 (0.023)	-0.008 (0.038)
Social Protection	-0.038 (0.023)	-0.030 (0.031)	-0.042 (0.027)	-0.023 (0.030)
Law and Order	-0.014** (0.006)	-0.002 (0.007)	-0.012* (0.006)	0.002 (0.008)
Schoolenrollmentsecondary	-0.001 (0.001)	-0.0003 (0.001)	-0.001 (0.001)	-0.0003 (0.001)
BSocioeconomicConditions	0.011 (0.007)	-0.016** (0.007)	0.010 (0.007)	-0.016** (0.007)
Gini	0.001** (0.000)	-0.0001 (0.0001)	0.001** (0.000)	-0.0001 (0.0001)
Inflation	-0.010 (0.009)	0.010 (0.008)	-0.008 (0.009)	0.010 (0.009)
Social.Protection*Shock			-0.010** (0.005)	-0.001 (0.013)
Constant	4.635*** (0.470)	3.668*** (0.671)	4.522*** (0.453)	3.676*** (0.633)
Observations	818	269	862	285
R-squared	0.156	0.338	0.156	0.337
Number of id	64	32	64	32
Country FE, Year	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

TABLE 13 – Channel validation : Fixed effect

	1	2	3	4
Dependent variable : Poverty				
ODA		-0.011***		
		(0.003)		
Natural Ressources	-0.001	-0.001	-0.003	-0.000
	(0.002)	(0.002)	(0.002)	(0.002)
GDP per capita	0.016	0.017	0.022	0.018
	(0.024)	(0.024)	(0.024)	(0.024)
Pop.Growth	-0.015	-0.017	-0.000	-0.019
	(0.029)	(0.029)	(0.028)	(0.028)
Education.expenditure	-0.029*	-0.028*	-0.027**	-0.032**
	(0.014)	(0.014)	(0.013)	(0.013)
Agriculture	-0.005	-0.004	-0.004	-0.012
	(0.021)	(0.021)	(0.021)	(0.020)
Social Protection	-0.049**	-0.050**	-0.058**	-0.044**
	(0.022)	(0.022)	(0.024)	(0.021)
Law and Order	-0.008	-0.008	-0.012*	-0.006
	(0.005)	(0.005)	(0.006)	(0.005)
Schoolenrollmentsecondary	-0.001	-0.001	-0.001	-0.001
	(0.0004)	(0.0004)	(0.0004)	(0.0004)
BSocioeconomicConditions	0.002	0.002	0.003	0.002
	(0.006)	(0.006)	(0.006)	(0.006)
Gini	0.0002	0.0002	0.0004	
	(0.0003)	(0.0004)	(0.0006)	
Inflation	-0.004	-0.004	-0.008	-0.004
	(0.007)	(0.007)	(0.008)	(0.007)
Agricultural production			-0.047*	
			(0.028)	
gini(dis)			0.096***	
			(0.030)	
Constant	4.058***	4.058***	4.979***	3.987***
	(0.410)	(0.410)	(0.776)	(0.420)
Observations	1,154	1,154	1,116	1,154
R-squared	0.134	0.135	0.172	0.145
Number of id	67	67	66	67
Country FE, Year	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

TABLE 14 – Table of correlation

Pairwise correlations

Variables	1	2	3	4	5	6
(1) poverty	1.000					
(2) Shock	0.1093*	1.000				
(3) gini(dis)	0.0069	0.0787*	1.000			
(4) agricultural production	0.2605*	0.0896*	0.0296	1.000		
(5) ODA	-0.1247*	-0.1118*	0.0110	-0.0068	1.000	
(6) Social Protection	-0.1132*	0.0563*	-0.3039*	0.0155	-0.0437	1.000

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

TABLE 15 – Description

Variables	Description	Source
Poverty	The poverty rate is the percentage of the population living on less than \$.90 per day at international prices.	WDI
Precipitation	Average precipitation is the long-term annual average of all forms of water falling from clouds, measured in millimeters per year.	Anglia East University
Temperature	Temperature measures how hot or cold a country feels over a period of time. It is measured in degrees Celsius	Anglia East University
FDI	Foreign direct investment is the net inflow of capital to acquire at least a 10% ownership in a foreign enterprise.	WDI
Debt/ GDP	Debt denotes the government's total fixed-term financial liabilities, domestic and external, outstanding at a given date.	WDI
GDP per capita	GDP per capita measures the wealth created by each person in the country over a given period of time period	WDI
ODA	Net official development assistance is the percentage of disbursements that meet DAC criteria for aid to eligible countries and territories.	WDI
Natural resources	Ratio of resource revenues to GDP	WDI
cereal production	Cereal production refers to the annual harvest of dry cereals, measured in metric tons.	WFO
Inflation	Inflation, captures the ratio of the general price level	WDI
GINI	Measures income inequality	WDI
Education expenditure	Education expenditure is the percentage of total public spending allocated to education, including current, capital, and transfer expenses.	WDI
Law and Order	The law variable assesses trust in societal rules, including contract enforcement, property rights, law enforcement, and crime risk.	ICRG
socioeconomic conditions	It is an index that captures socio-economic conditions	ICRG
Population growth	Population growth measures the demographic growth of a population over a defined period	WDI
Education	Secondary education rate, measures the ratio of people who have completed secondary education	WDI
Agriculture	Agriculture measures the ratio of wealth generated by the agricultural sector	WDI

Descriptive statistic¹⁸

TABLE 16 – Descriptive statistic

Table					
Variables	Observations	Moyenne	SD	Min	Max
Poverty	1273	42.22238	9.275034	1.4	86.3
Precipitation	1273	1158.055	845.0188	23.73374	3704.786
Temperature	1273	20.26029	7.451563	-5.168159	29.13025
Education expenditure	1273	3.687483	0.4787194	1.857785	4.388242
Natural resources	1273	3.278504	4.28063	0	31.290448
Social protection	1273	3.209637	.4187831	1.48067	4.429459
Inflation	1273	30.63044	685.0559	-12.845	24411.39
Agriculture	1273	14.99482	2.445752	4.941642	20.25037
Gini	1273	38.40876	34.39351	0	99.999
Law and Order	1273	3.052585	1.088463	1	6
secondary education rate	1273	58.27143	26.60667	5.22076	142.0175
socio-economic conditions	1273	5.097964	1.682177	1.333333	10.29167
Population growth	1273	4.059848	1.662605	1.58	7.426

18. The study covers a sample of 67 developing countries. The period covered by the study is 1998-2016. On average, 42,22% of people in the sample live below the poverty line(1,90\$. In this study, poverty is the incidence of poverty, i.e., the number of people below the poverty line relative to the total population. The average ratio of natural resource wealth to GDP in developing countries over the study period is 3,37% The average rainfall and temperature are 1158.055 millimeters and 20.26 degrees Celsius, respectively. The average ratio of education expenditure to GDP is 3,68% . On average, social protection expenditure represents up to 3,20% of public expenditure. On average, the ratio of Foreign Direct Investment (FDI) to GDP is 2,78% and inflation averages 30,63% The contribution of agriculture to GDP is 18% on average, and the Gini index is on average 38,40. Cereal production averages 15 metric tons, and secondary school enrolment averages 58% in developing countries. Population growth, on the other hand, averages 4% On average, the indices capturing law and socio-economic conditions are 3.05 and 5.09, respectively, in the sample countries.

The list of sample countries		
Number	Country	Type
1	Angola	Developing country
2	Albania	Developing country
3	Armenia	Developing country
4	Azerbaijan	Developing country
5	Burkina Faso	Developing country
6	Bangladesh	Developing country
7	Belarus	Developing country
8	Brazil	Developing country
9	Botswana	Developing country
10	China	Developing country
11	Cameroon	Developing country
12	Colombia	Developing country
13	Costa Rica	Developing country
14	Dominican Republic	Developing country
15	Algeria	Developing country
16	Ecuador	Developing country
17	Ethiopia	Developing country
18	Ghana	Developing country
19	Guatemala	Developing country
20	Honduras	Developing country
21	Indonesia	Developing country
22	India	Developing country
23	Jamaica	Developing country
24	Jordan	Developing country
25	Kazakhstan	Developing country
26	Kenya	Developing country
27	Kuwait	Developing country
28	Lebanon	Developing country
29	Sri Lanka	Developing country
30	Morocco	Developing country
31	Madagascar	Developing country
32	Mexico	Developing country
33	Mali	Developing country
34	Myanmar	Developing country
35	Mongolia	Developing country
36	Mozambique	Developing country
37	Malawi	Developing country
38	Malaysia	Developing country
39	Namibia	Developing country
40	Niger	Developing country
41	Nigeria	Developing country
42	Nicaragua	Developing country
43	Oman	Developing country
44	Pakistan	Developing country
45	Panama	Developing country
46	Peru	Developing country
47	Philippines	Developing country
48	Poland	Developing country
49	Paraguay	Developing country
50	Qatar	Developing country
51	Russian Federation	Developing country
52	Saudi Arabia	Developing country
53	Sudan	Developing country
54	Senegal	Developing country
55	Sierra Leone	Developing country
56	El Salvador	Developing country
57	Togo	Developing country

58	Thailand	Developing country
59	Trinidad and Tobago	Developing country
60	Tunisia	Developing country
61	Turkey	Developing country
62	Uganda	Developing country
63	Ukraine	Developing country
64	Uruguay	Developing country
65	South Africa	Developing country
66	Zambia	Developing country
67	Zimbabwe	Developing country

Chapter II

Fiscal Rules and Foreign Direct Investment in Developing Countries

HISGUIMA DASSIDI Crépin^{19 20 21}

Abstract

Using a sample of 78 developing countries, we use the entropy balancing method to analyze the causal effect of fiscal rule adoption on Foreign Direct Investment (FDI). Two hypotheses are tested in this study. The first states that adopting fiscal rules (FR) increases FDI, and the second is related to the ability of different types of rules to attract more investments. Our results confirm that adopting fiscal rules increases FDI. A country's ratio of public deficit to GDP, its long-term sovereign debt rating in foreign currency, and the ratio of short-term external outstanding debt are the transmission channels through which fiscal rules affect FDI. This effect is amplified in the presence of a high level of business climate, strong economic performance, and adequate structuring of a country's agricultural and industrial sectors. The effect is attenuated by mineral rents and an economy's high real interest rate.

Keywords : Fiscal rules, Foreign Direct Investment, fiscal policy

JEL Classification : C33, E62, F21

19. We want to take this opportunity to express our gratitude and appreciation to Xavier GALIEGUE, Senior Lecturer in Economics at the University of Orléans ; Djamel KIRAT, Senior Lecturer in Economics at the University of Orléans, and Bao-wé BAMBE, Ph.D in Economics for their advice and guidance in the framework of this study.

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21. This paper was presented at the 11th UECE Conference in Lisbon in 2023

Introduction

Budgetary drift and debt crises have revealed the importance of financial institutions in executing fiscal policy. In the 1990s, following the economic and financial crises, the issue of fiscal rules (FR) became one of the major concerns of international financial institutions such as the International Monetary Fund (IMF). Also, these fiscal rules are increasingly at the heart of the significant issues that preoccupy political decision-makers given their considerable contribution to macroeconomic stability (Fatás and Mihov, 2006; Badinger, 2009; Andrés and Doménech, 2006; Schaechter et al., 2012). The numerous debt crises and other abuses of budgetary management by decision-makers have shown the need for budgetary discipline (Drazen, 2004; Kopits, 2001; Schaechter et al., 2012). Without a binding measure on fiscal policy management, several economies risk macroeconomic instability, which can affect the process of poverty reduction and annihilate the efforts of progress and development obtained over many years (Barnes et al., 2012b). However, it is essential to clarify the debates on the nature of the budgetary discipline and the means to implement fiscal rules (Wyplosz, 2012). The desire to impose budgetary discipline has led to the establishment of fiscal rules, constituting numerical and procedural constraints in executing fiscal policy. A strict numerical limitation of budgetary aggregates manifests these rules. Fiscal rules have two fundamental characteristics that make them crucial tools for budget management. First, they are concrete indicators of budgetary management. Second, they are binding on policymakers and political decisions. Fiscal rules can also help constrain political budget cycles (Gootjes et al., 2021).

According to the World Bank, Foreign Direct Investment (FDI) flows direct equity investment into the host country's economy. It is the sum of equity, profit reinvestment, and other capital. FDI is a category of cross-border investment associated with a resident of one economy having control or significant influence over managing an enterprise resident in another. Ownership of at least 10% of an enterprise's voting (or standard) stock is the criterion for determining the existence of a direct investment relationship. These sources of external finance contribute significantly to filling the financing gap in many developing countries (Iamsiraroj, 2016; Alfaro et al., 2004; Azman-Saini et al., 2010; Ayanwale, 2007) and are thus important for their economic performance. From 1990 to 2020, total FDI increased from 203 billion to 1,000 billion in 2020, an increase of 80 per cent. This increase has played an important role in financing development.

The link between FDI and FR is through the stability channel. The impact of fiscal rules concerns the effects on the primary macroeconomic aggregates such as debt, inflation, budget deficit, and revenue. The impact of fiscal rules forces policymakers to consider two essential and complementary notions : the procedure for applying the rules and the numerical constraint they impose on macroeconomic aggregates. FR affects FDI through the credibility it gives to fiscal policy management. Macroeconomic stability plays an essential role in attracting FDI; it sends a signal to investors about the possibility of investing in a favourable environment. This effect on

FDI also depends on the capacity of fiscal rules to make a country's economic environment more competitive. Good management of the budgetary framework increases FDI (Simões et al., 2015; Ajayi, 2006). Fiscal rules also allow for a reasonable allocation of resources, which also renders the economic environment more attractive to investors. An attractive economic environment sends a positive signal to foreign investors. It influences investors' decision to invest (the macroeconomic stability channel). Although fiscal rules help to improve fiscal performance, it is important to note that rules vary from region to region, and their success depends on their ability to force governments to supervise the execution of fiscal decisions strictly.

This article is linked to two streams of literature : The first stream demonstrates the importance of fiscal rules (Debrun and Kumar, 2007; Debrun, 2007; Debrun et al., 2008; Debrun et al., 2009; Rose, 2006; Combes et al., 2021; Beetsma et al., 2018; Schuknecht, 2004) and Foreign Direct Investment (FDI) (Hrechyshkina and Samakhavets, 2018; Hrechyshkina and Samakhavets, 2018; Alfaro et al., 2004; Lee and Chang, 2009; Ajayi, 2006). The second stream questions the link between fiscal policy and FDI (Simões et al., 2014; Simões et al., 2015; Göndör and Nistor, 2012; Rădulescu and Druica, 2014; Schoeman, 2000). In the first stream, understanding the importance of fiscal rules is important for knowing the contribution of fiscal policy and, more particularly, that of macroeconomic stability and fiscal policy credibility. It also shows the importance of FDI in countries' economic performance. In the second stream, (Mitsi and Kottaridi, 2022; Simões et al., 2015; Ajayi, 2006; Rădulescu and Druica, 2014; Schoeman, 2000) highlight the link between budgetary institutions and foreign investment. Increasing macroeconomic stability and fiscal policy credibility help promote the entry of FDI and fill the financing gap in the economy. The literature shows that fiscal discipline and fiscal stimulus help to attract more FDI in the long run.

Even if several studies analyze the link between fiscal policy and FDI, very few works have focused on the effect of fiscal rules on FDI in developing countries; hence, we are interested in distinguishing ourselves from existing works by analyzing the effect of fiscal rules on FDI in developing countries. Therefore, this analysis answers the following question : How does adopting fiscal rules affect FDI in developing countries? In this study, we make four main contributions to the existing literature on fiscal institutions and FDI : First, we contribute to the existing literature by studying the effects of fiscal rules on FDI in developing countries. This study is oriented towards developing countries because of the high level of developing countries that receive FDI. Also, developing countries are particularly vulnerable because of their constant exposure to macroeconomic volatility. The governments of these countries adopt restrictive fiscal rules to mitigate the effects of exogenous macroeconomic shocks on the economy and attract more foreign investment. Secondly, on the empirical side, we enrich the existing literature using the entropy balancing method of Hainmueller (2012). Other methods, such as the Propensity Score Matching (PSM) of Rosenbaum and

[Rubin \(1983\)](#) are used in robustness. The entropy balancing method is an innovative method that combines a reweighting mechanism with a regression analysis. This method is performed in two steps : First, we calculate weights assigned to the control units (countries that have not adopted fiscal rules). In the second step, we use the weights obtained in the first step in a regression analysis with the treatment variable as an explanatory variable. Subsequently, we match the countries that have adopted the fiscal rule and those that have not adopted a fiscal rule based on observable characteristics. This is a more reliable method than the usual ones.

This study makes a new contribution to analyzing the capacity of different fiscal rules to attract FDI. It provides empirical evidence on the channels through which fiscal rules affect FDI. We find evidence that the ratio of government deficit to GDP, the rating of long-term foreign currency debt, and the ratio of outstanding short-term external debt are transmission channels through which fiscal rules affect FDI. Second, except for expenditure rules, we find that all income, deficit, and debt rules increase FDI. In a further contribution, we perform a heterogeneity analysis that allows for specificities between developing countries.

Finally, this study makes a new contribution in terms of economic policy implications. It allows us to propose concrete economic policy recommendations that will likely help developing countries attract FDI better.

The rest of the paper is structured as follows : Section 2.1 reviews the theoretical and empirical literature related to the theme of the study. Section 2.2 presents stylized facts on fiscal rules and FDI in developing countries. Section 2.3 focuses on the theoretical identification of transmission channels. In Section 2.4, we present the data. Sections 2.5, 2.6, and 2.7 present the identification strategy and the study's primary results. Sections 2.8 and 2.9 analyze the heterogeneity and validation of the transmission channels. The final section concludes the study.

2.1 Literature review

Fiscal policy is one of the last degrees of freedom for governments. However, this freedom is increasingly constrained by the adoption of fiscal rules, the primary role of which is to discipline policymakers in exercising fiscal policy. Fiscal rules are budgetary institutions that provide a better framework for the conduct of fiscal policy. They function as devices that constrain fiscal policy executors and reduce the information asymmetry between the electorate and decision-makers. These rules prevent the decision-makers from drifting in the execution of the budget and strengthen fiscal policy by reinforcing its credibility ([Combes et al., 2021](#)). They also play an essential role in

reducing financial risk. However, the implementation of fiscal rules must be done independently to achieve their objectives and rules specifically designed to prevent conflicts with the stabilization function of fiscal policy are indeed associated with less pro-cyclical policies. Sawadogo (2020) analyzes the link between fiscal rules and financial market access in developing countries and shows that adopting fiscal rules lends credibility to fiscal policy management and gives a positive signal to investors about the ability of borrowers to repay loans. Thus, adopting fiscal rules improves developing countries' access to the financial market by reducing borrowing costs. Debrun (2007) highlights the role of budgetary institutions in strengthening budgetary discipline. His study shows that fiscal rules are more effective when the cost of circumventing them is high because this discourages decision-makers from violating them. He also reveals that full budget transparency and strong democratic accountability are sufficient to establish the credibility of fiscal rules.

The work of Schuknecht (2004) shows the advantages (solving the problem of deficit bias and time inconsistency, reducing transaction costs on the financial market) and the limits of fiscal rules (their complexity, limiting the ambitions of public decision-makers). It proposes the reforms necessary to align these rules with economic realities. Several studies show the importance of fiscal policy in attracting FDI (Simões et al., 2014; Schoeman, 2000). Schoeman (2000) analyzes the link between fiscal policy and FDI and shows that this link involves an adjustment of fiscal policy, which allows the government to contribute to creating a favourable environment capable of attracting more FDI. Fiscal rules have a strong link with FDI because, by giving fiscal policy more credibility and stability, they make FDI more attractive to investors and lead to a better attractiveness of FDI. Indeed, the decision to invest in a country is not only conditioned by the size of the market and its political and legal stability but also by the stability of its macroeconomic framework and, more globally, by the credibility of its fiscal policy.

Poor management of a country's macroeconomic framework discourages foreign investors. It sends a negative signal on the capacity to make a return on its investments, as no investor wishes to invest sustainably in a country where the macroeconomic environment is characterized by strong instability (Simões et al., 2014). Macroeconomic stability is one of the factors that influence the decision of foreign investors to invest (Ranjan and Agrawal, 2011; Shah, 2014; Aizenman, 2003). According to UNCTAD²² global foreign direct investment (FDI) flows amounted to \$,580 billion, an increase of 64% compared to the exceptionally low level of 2020 (linked to the Covid crisis¹⁹) before rising again in 2021. This increase in FDI in 2021 is due to record profits of multinationals in 2021²³.

Recent work on fiscal rules and foreign direct investment shows that expenditure rules hurt foreign direct investment because they refer to budgetary indiscipline. In the framework of our study, we will carry out the exact estimations to see if this effect is confirmed.

22. <https://unctad.org/webflyer/world-investment-report-2022>, in 2021

23. World Investment Report 2022 International tax reforms and sustainable investment

According to Eurostat²⁴, FDI is the category of international investment that reflects the objective of obtaining a lasting interest by an investor from one economy in a resident enterprise in another economy. Sustained interest implies a long-term relationship between the investor and the enterprise and that the investor has a significant influence on how the enterprise is managed. Such an interest is formally deemed to exist where a direct investor holds 10% or more of the voting rights on the board of directors (for an incorporated company) or the equivalent (for an unincorporated company). These types of financing help fill the domestic financing gaps in many developing countries (Hrechyshkina and Samakhavets, 2018; Alfaro et al., 2004; Lee and Chang, 2009; Ajayi, 2006). Tang et al. (2014) identify GDP, real exchange rate, financial development, and macroeconomic uncertainty as the main determinants of FDI.

Sound fiscal policy management increases FDI (Simões et al., 2015; Ajayi, 2006). Several studies (Rădulescu and Druica, 2014; Schoeman, 2000; Simões et al., 2015) analyze the link between fiscal policy and foreign direct investment (FDI) and show the contribution of fiscal policy to the attractiveness of FDI. Indeed, a stable fiscal policy sends a positive signal to foreign investors and attracts more foreign investment. On the other hand, a poorly conducted fiscal policy reduces investment. Indeed, a significant increase in expenditure reduces investment because this increase reduces the budgetary margins of manoeuvre. The expansionary effects of budgetary adjustments explain this. Similarly, the work of Rădulescu and Druica (2014) demonstrates the link between fiscal policy and FDI and shows that economic stimulus programs can incentivize foreign investment. The study shows high interest rates and inflation attract less FDI to Romania. On the other hand, indirect taxes seem to play a lesser role as they are only relevant over the long term. The study suggests fiscal stimulus, infrastructure, and political and legal stability attract more FDI than direct taxes. Göndör and Nistor (2012) highlight the link between fiscal policy and FDI in emerging economies in Europe and show that tax competition between governments for FDI is not necessarily competition of corporate tax rates but of the business environment, which is mainly determined by fiscal policy. The study shows that fiscal policies are decisive in attracting FDI. Fiscal policy, therefore, plays an essential role in attracting FDI by managing the primary macroeconomic aggregates. The worse a country's macroeconomic framework, the less attractive it is to FDI, as investors are not encouraged to invest in countries with an unstable macroeconomic framework. Simões et al. (2014) highlight the relationship between FDI and fiscal policy and show that fiscal policy is an increasingly important tool in countries' competition to attract FDI. The authors identify the geographical and cultural proximity between FDI home and host countries and the market size of (FDI) host countries as the main factors that attract FDI. The link between fiscal policy and FDI is also explained by the fact that a well-managed fiscal policy framework in a country influences decision-making when countries or investors compete to invest (FDI) in a host

24. <https://ec.europa.eu/eurostat/web/economic-globalisation/globalisation-in-business-statistics/foreign-direct-investments>

country. The economic literature discusses the link between fiscal policy and FDI in developing countries. It analyses the impact of fiscal policy on FDI. It shows a formal link between FDI flows and fiscal policy variables such as the deficit/GDP ratio, representing fiscal discipline, and the tax burden on foreign investors. This linkage involves adjusting fiscal policy that allows the government to help create an investor-friendly environment. Other works ([Škare et al., 2020](#); [Mahmood and Khalid, 2013](#)) reveal the existence of a long-run relationship between FDI and fiscal policy through a vector error correction model (VECM) to test the existence of a causal relationship.

2.2 Stylized facts

Figure 1 : Average evolution of the FDI of FR and non-FR countries (% of the GDP)

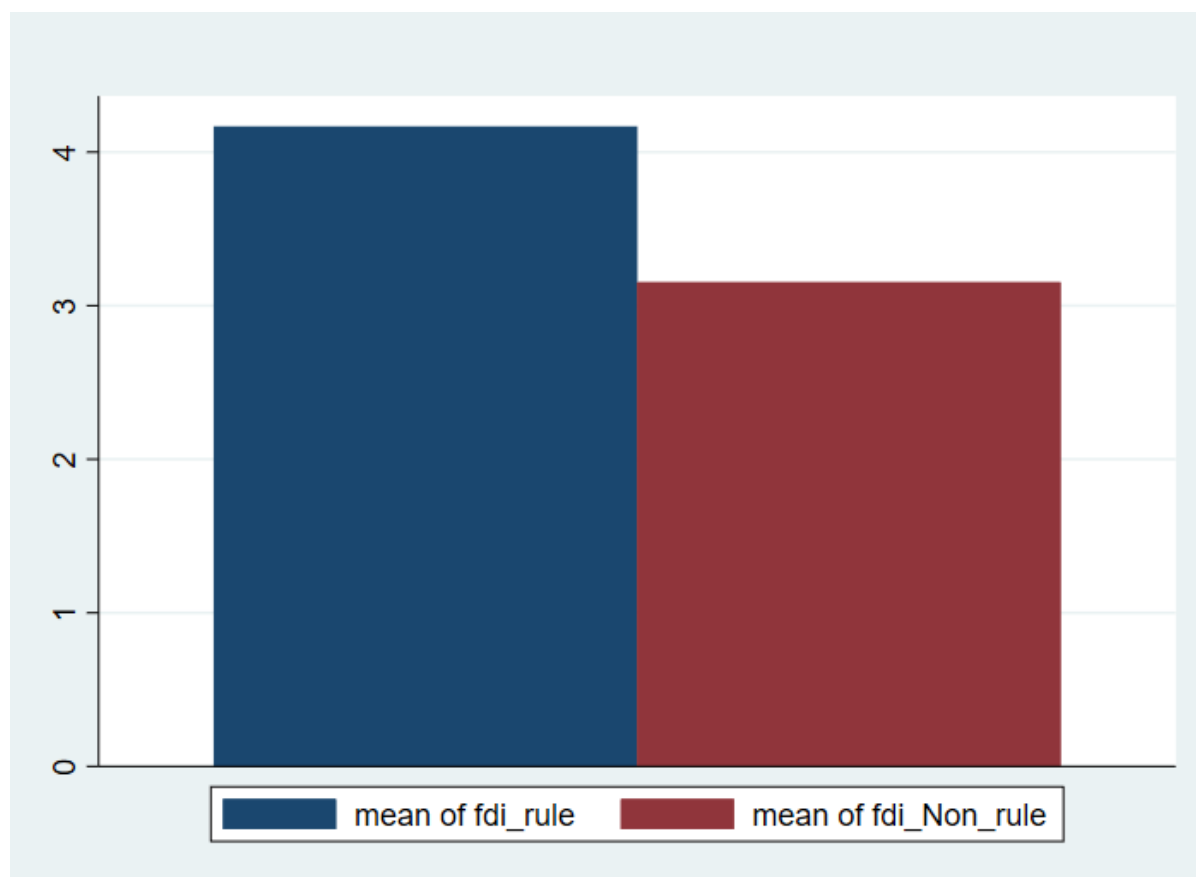


Figure 2 : Evolution of FDI between 1990-2020 (% of the GDP)

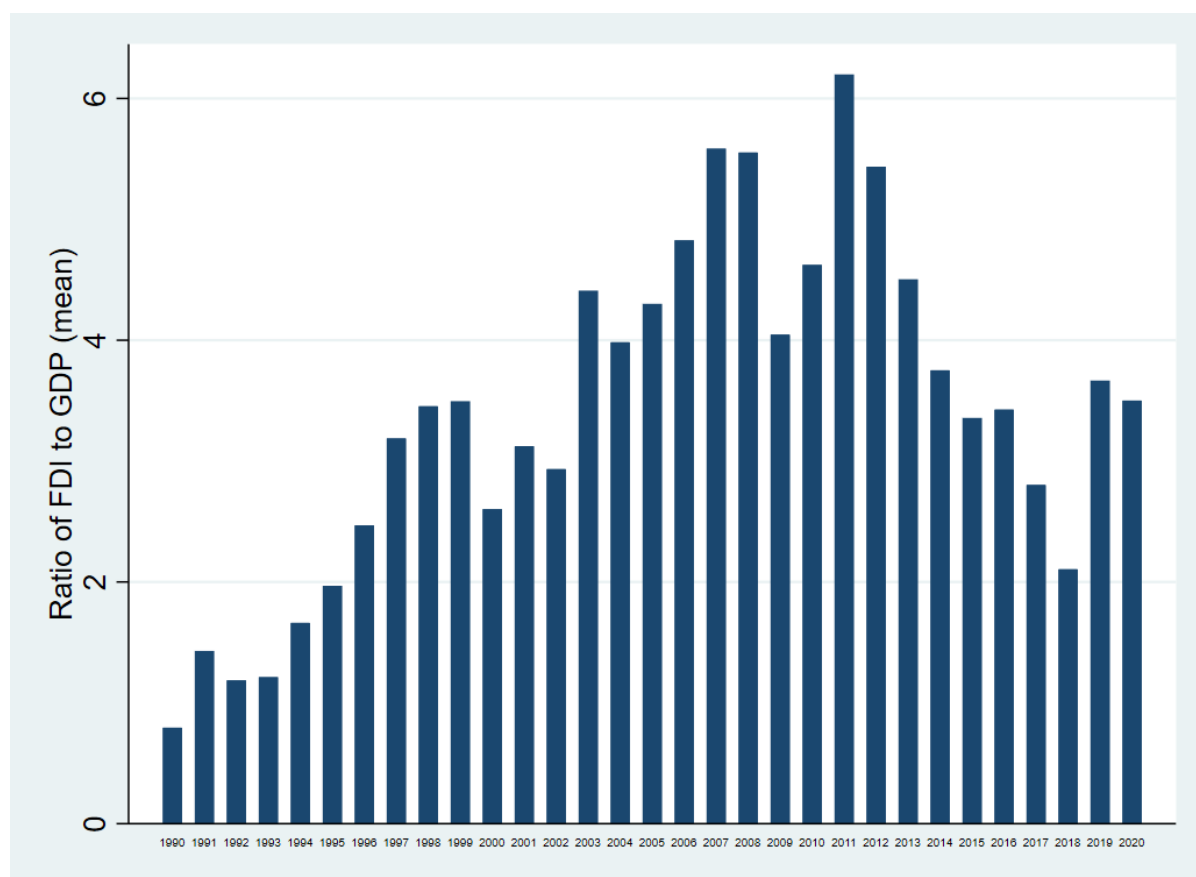
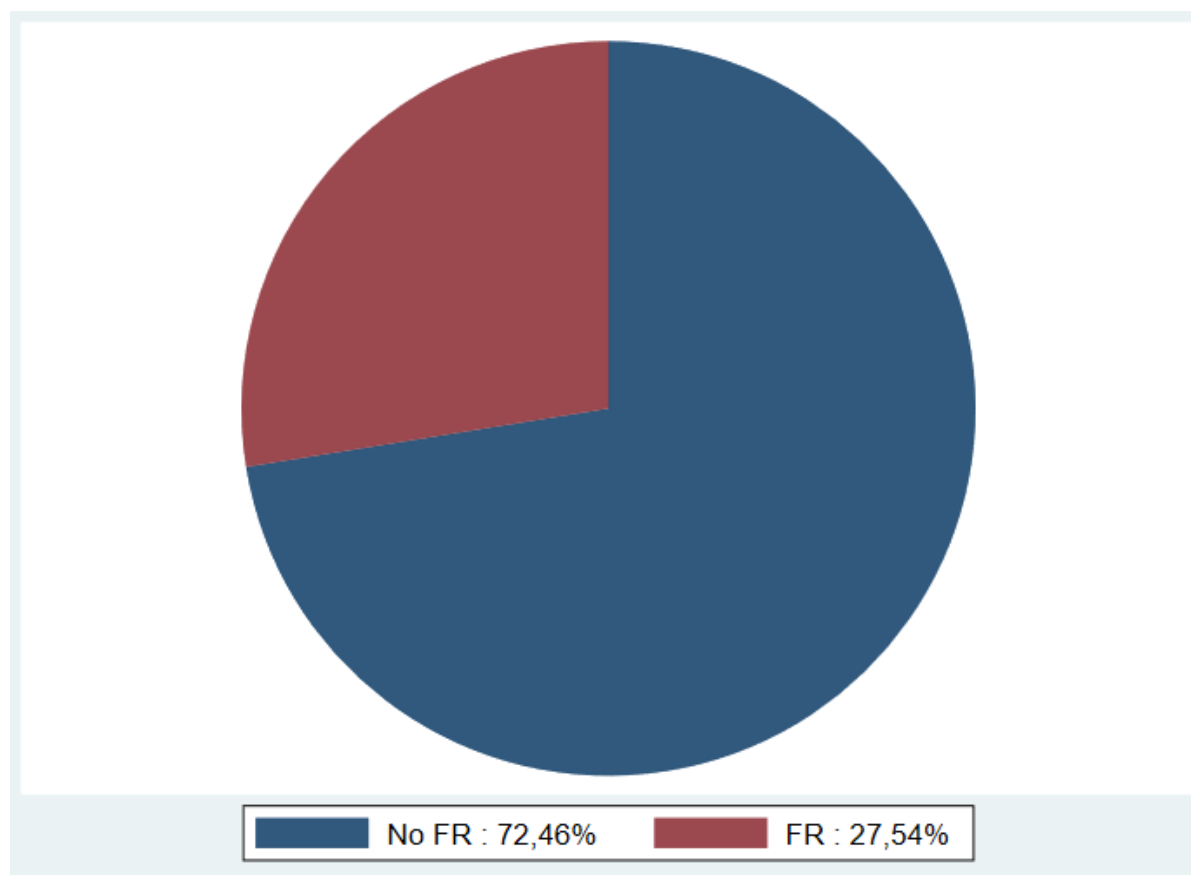


Figure 3 : Distribution diagram of FR and non-FR countries



This section presents the stylized facts about FDI and FR in developing countries. Several economic studies highlight the important contribution of fiscal rules to FDI dynamics. The work of (Simões et al., 2015 ; Ajayi, 2006 ; Rădulescu and Druica, 2014 ; Schoeman, 2000 ; Simões et al., 2015) reveal the existence of a positive and significant effect of budgetary institutions on FDI. Figure 1 shows us the FDI/GDP ratio level as a function of adoption or non-adoption of fiscal rules from 1990-2020. On average, the ratio of FDI to gross domestic product increased by 77% over the study period. However, this increase was more significant in countries that adopted at least one fiscal rule (around 4.2% of GDP) than in countries that did not (with 3.2% of GDP on average) (see Figure 1). A link can, therefore, be established between adopting fiscal rules (FR) and increasing Foreign Direct Investment (FDI). This link has been highlighted in Schoeman (2000), which shows that the existence of fiscal rules helps guarantee macroeconomic stability and creates a favourable environment for attracting more FDI. The stability of macroeconomic aggregates conferred by the rules also influences the decision-making of investors (FDI) when coming to a country.

We note a substantial increase (77%) in FDI in developing countries since 1990. However, this

progression of FDI has been slowed down by the recent crises (Coronavirus, etc.) that the world has experienced. As a result, the FDI ratio will decrease between 2019 and 2020 (see Figure 2). Following the numerous economic crises and other budgetary abuses, international financial institutions have massively advised adopting fiscal rules for developing countries to resist exogenous shocks and allow for a better allocation of resources and a stable macroeconomic framework. Thus, many countries have adopted one or more fiscal rules to guard against exogenous shocks and, more specifically, to discipline their fiscal policy. However, nowadays, fewer developing countries have adopted fiscal rules than have not. This is also the case for the countries in this study's sample (see Figure 3). In sum, it can be seen that both FDI and the adoption of fiscal rules have increased in developing countries over the period 1990-2020.

2.3 Theoretical identification of transmission channels

Based on the existing literature, we theoretically identify the channels through which fiscal rules could affect Foreign Direct Investment (FDI) in developing countries.

The adoption of fiscal rules aims at increasing the allocation of resources and contributes to stabilizing the macroeconomic framework. Adopting rules increases efficiency in financing growth policies, strengthens resilience to exogenous shocks, and reduces income disparities. This better allocation of resources through fiscal rules helps to use resources efficiently in sectors such as infrastructure, agriculture, and services. A better organization of the infrastructure, agriculture, and services sectors through a better allocation of expenditure is likely to attract massive Foreign Direct Investment (FDI) (Kumar, 2006 ; Awunyo-Vitor and Sackey, 2018) and a better allocation of expenditure is likely to attract massive Foreign Direct Investment (FDI). Fiscal institutions increase the stability of macroeconomic aggregates by reducing inflation, and this economic stability attracts FDI. Inflation is thus one of the theoretical determinants through which fiscal rules affect FDI. Secondly, adopting fiscal rules contributes to reducing the level of debt by making it more sustainable. This debt sustainability sends a positive signal to investors (FDI) about the country's macroeconomic stability and influences the decision to invest. In the same vein, adopting rules reduces the budget deficit by making the fiscal policy more credible, and this credibility conferred by the rules favours FDI. Finally, the rules increase the economic performance of the countries (Afonso and Jalles, 2013 ; Castro, 2011 ; Servén, 2007), and this performance positively affects the investors who wish to make their investments bear fruit and invest in places with high added value for the business.

It appears, therefore, that fiscal rules through the different transmission channels (pro-cyclicality, inflation, debt, budget deficit, and economic performance) affect Foreign Direct Investment (FDI).

2.4 Data

2.4.1 Source of data

Most of the data for this study comes from the World Development Indicators (WDI) database. Fiscal rules data are from the International Monetary Fund (IMF) Fiscal Rules dataset. The institutional data comes from the International Country Risk Guide (ICRG) database.

2.4.2 Description of the database

We use the ratio of foreign direct investment inflows (FDI) to GDP as a dependent variable. Our variable of interest is a binary variable that indicates if the country has adopted a fiscal rule and 0 otherwise. Then, we control for a series of variables : inflation, monetary union membership, fiscal balance, capital openness, inflation targeting, and institutional variables (Checks and corruption). The period (1990-2020) is chosen according to the availability of FDI data.

Inflation is the measure of the general price level. It directly impacts the purchasing power of poor households. It is a variable that captures economic stability. The higher it is, the more unstable the economic situation. Excessively high inflation is a brake on the attractiveness of FDI. The works of [Sayek \(2009\)](#) suggest that FDI is used as a hedging tool, mitigating the effects of inflation taxes even if there are no formal hedging mechanisms.

Membership of a monetary union is a binary variable that indicates if the country belongs to a monetary union and 0 otherwise. The work of [Kilic et al. \(2014\)](#) shows that membership of a monetary union increases FDI by reducing exchange rate volatility, inflation volatility, and distance and by supporting economic growth.

Checks and balances are an institutional variable. It is a determinant of fiscal rules. The work of [Perotti and Kontopoulos \(2002\)](#) shows that political checks and balances (other than budgetary constraints) can be considered an implicit contract between governments and voters, reducing the need for fiscal rules. This variable is expected to affect FDI positively.

Capital opening : This variable captures the country's financial openness. An opening of the capital allows the mobilization of more resources. The work of [Bergman and Hutchison \(2015\)](#) highlights that financial openness is associated with less cyclicity in fiscal policy.

Inflation targeting : It allows for more excellent economic stability through inflation discipline. Several studies ([Mason and Vacheva, 2017](#) ; [Tapsoba, 2012](#)) demonstrate that targeting allows for the attraction of more FDI. In this study, we expect inflation targeting to affect FDI positively.

Institution : This index captures the fight against corruption in the political system. Corruption hurts the attractiveness of foreign investment. In this study, we expect the fight against corruption to affect FDI positively.

Fiscal balance : This variable captures the government's money from tax revenue and the proceeds of assets sold minus any government spending. When the balance is negative, the government

has a fiscal deficit. When the balance is positive, the government has a fiscal surplus ²⁵.

2.4.3 The measurement of fiscal rules

Fiscal rules are tools for managing fiscal policy. They aim to combat deficit bias, fight against fiscal policy's procyclicality, generate credibility to borrow more cheaply on international markets and combat the fiscal externalities resulting from excessive deficits. The economic literature distinguishes several types of fiscal rules, namely procedural rules and numerical rules.

Procedural rules

Procedural rules are the rules of the budgetary procedure. Whatever the institutional structure of the country, two main procedures can be distinguished in the sense of decision-making :

- Collegial procedure : a procedure that authorizes the representation of several groups in decision-making, with several structures participating in budgetary decision-making. This allows a better representation of social groups but could lead to the tragedy of the commons.
- Hierarchical procedure : predominant role of one agent in elaborating the budget. In the budget vote, limited room for manoeuvring the parliament and the right to amend the budget is limited. In executing the budget, parliament votes on the government's procedure to reduce expenditures. The most effective way to reduce the tragedy of the commons is to adopt hierarchical top-down budgeting procedures.

Numerical rules

These are numerical goals. They manifest themselves through ceilings, floors, etc., which consist of constraining budget aggregates. They are permanent constraints on fiscal policy and are expressed as a synthetic indicator of budgetary performance.

However, fiscal rules are not without their critics. Firstly, they encourage the procyclicality of fiscal policy ; in periods of expansion, it is easier to respect the rule than in periods of economic slowdown. The target is the structural balance, which does not depend on the economic situation. Budgetary rules sometimes penalize public investment : when you impose budgetary constraints on the government, they will sacrifice investment because it is easier to sacrifice investment than to reduce current expenditure. Fiscal rules could have positive endogenous effects because the countries that adopt them are generally virtuous regarding fiscal policy management. The second criticism is that these rules sometimes weaken investment spending. For example, debt or deficit

25. EUROSTAT

will be limited or even prohibited when the debt is generated by investment spending. In addition to fiscal rules, independent budgetary committees should be set up to monitor the execution of the budget and make an independent forecast. Several economic studies suggest that the control of the significant budgetary aggregates should be entrusted to these independent budgetary committees (Debrun et al., 2009; Beetsma et al., 2017; Beetsma et al., 2018). In this study, fiscal rules are measured by a binary variable that takes the value one if the country has adopted a fiscal rule and 0 otherwise.

2.4.4 Measuring Foreign Direct Investment

Foreign Direct Investment (FDI) is the net inflow of investment to acquire a lasting management stake (10 per cent or more of the voting shares) in an enterprise operating in an economy other than the investors. According to the OECD, FDI is a type of transnational investment made by a resident of one economy ("the direct investor") to establish a lasting interest in an enterprise ("the direct investment enterprise") that is resident in an economy other than that of the direct investor. The investor is motivated to establish a lasting strategic relationship with the enterprise to influence its management significantly. A "lasting interest" is established when the direct investor holds at least 10% of the voting rights of the direct investment company. Schoeman (2000) highlights the link between FDI and fiscal rules and shows that FRs contribute to attracting FDI. The Foreign Direct Investment (FDI) data are taken from the World Development Indicators database²⁶. The FDI data in this study represent the ratio of inward FDI to GDP. Several economic works (Blanco et al., 2013; Jenkins, 2006; Ang, 2009; Decreuse and Maarek, 2015) use the ratio of FDI to GDP.

Several institutions (UNCTAD, IMF, etc.) publish FDI data online. The UNCTAD and IMF data show a similar trend for all countries. However, there are differences in magnitude, particularly concerning FDI stocks in developing countries. A few observations are worth noting : First, regarding FDI flows, the differences between the two data sources are more relevant in the case of developing countries. For example 2000, UNCTAD data peaked at USD 264 billion, while IMF data started a downward trend. Second, regarding FDI stocks, the differences between the two databases are more significant, especially for developing countries. This is explained by the fact that for developing countries, there is the problem of a lack of data related to the quality of data in these countries. The main reason is the IMF data's lack of information on many developing countries. Overall, the UNCTAD data is more informative than the IMF data. However, in this study, we favour using the ratio of FDI to GDP because the ratio better captures the effect of fiscal rules on FDI. After all, ratios tell us the exact order and value between units, which allows for a wide range of descriptive and inferential statistics. They also offer a multitude of possibilities for statistical analysis. For all these reasons, we prefer the ratio of inward FDI to GDP.

26. <https://datatopics.worldbank.org/world-development-indicators/>

2.5 Identification strategy

In this study, the causal effect is analyzed through the entropy balancing method (Hainmueller, 2012; Hainmueller and Xu, 2013). The model developed in this study is based on the work of Badinger and Reuter (2017), which identifies inflation targeting and the checks variable as determinants of fiscal rules. We use these variables as controls in the study. A large amount of literature shows that inflation targeting increases discipline in fiscal policy management; it increases inflation and positively impacts foreign direct investment. For this reason, we also add the variable capturing inflation targeting among the control variables. Second, we rely on the work on fiscal rules by (Sawadogo, 2020; Kirsanova et al., 2007), which uses inflation, the balanced budget variable, and capital openness as controls. We also use these three variables as controls in our model. Several economic works (Bova et al., 2014; Gali and Monacelli, 2008; Dixit and Lambertini, 2003; Ferrero, 2009; Kirsanova et al., 2007; Erceg and Lindé, 2013) provide information on the importance of monetary unions in the adoption of fiscal rules. Thus, we introduce the variable that captures the membership of a monetary union among the controls. Finally, we add the institutional variable that captures corruption among the controls. We use the propensity score matching (PSM) method of Rosenbaum and Rubin (1983), the IPW method, the GMM estimator, and the Mahalanobis distance balancing method to test the robustness of our results.

2.5.1 Entropy balancing

Referring to the recent literature on impact assessment, we use the entropy balancing method of Hainmueller (2012), which was later implemented in the work of Neuenkirch and Neumeier (2016). It is a method carried out in two steps: In the first step, we calculate weights assigned to the control units (countries that have not adopted budget rules). In the second step, we use the weights obtained in the first step in a regression analysis with the treatment variable (countries having adopted the fiscal rule) as the explanatory variable. Subsequently, we match countries that have adopted the fiscal rule with countries that have not adopted a fiscal rule based on observable characteristics. This study aims to analyze the link between adopting fiscal rules and FDI. In other words, to see whether adopting fiscal rules improves Foreign Direct Investment (FDI) in developing countries. The FDI used in this analysis is the ratio of FDI to GDP. The treatment variable indicates one if at least one fiscal rule is adopted and 0 otherwise. More precisely, countries that have adopted fiscal rules constitute the treatment group. Our empirical study's main challenge is determining a causal relationship between fiscal rules and FDI. However, it must be said that the reasons countries adopt fiscal rules (economic stability, limiting fiscal drift, fiscal profligacy, political risk, lack of liquidity, desire to attract more investment, etc.) could be associated with macroeconomic factors and the political situation of a country. This could, of course, trigger an endogeneity problem. To remedy this situation, we use the matching method. This matching method is more

reliable and sufficiently robust than simple linear regression methods. The relationship gives the average treatment effect on the treated (ATT) :

$$ATT = E[(Y_{i1} - Y_{i0})|FR = 1] = E[(Y_{i1}|FR = 1)] - E[(Y_{i0}|FR = 1)] \quad (5)$$

In equation (1), FR is a binary variable that represents the adoption of fiscal rules (FR) in country i . Y_{i1} is a variable that captures foreign direct investment (FDI) when country i has not adopted FR (non-FR). $Y_{i0}|FR=1$ denotes the value of FDI that would have been observed if a country that has not adopted FR (non-FR) had adopted FR. $Y_{i1}|FR=1$ denotes the FDI observed for the same non-FR country. Eq. (1) above tells us that comparing the observed FDI in non-FR countries with the observed FDI in the same countries if they had adopted the fiscal rules (FR) would give us an unbiased estimate of ATT. However, the main difficulty with this equation is that the second term on the right-hand side is unobservable. To circumvent this difficulty, we randomly select countries that have not adopted FR (Non-FR). Using this random selection, we can compare the sample average of the non-FR countries with that of the FR countries.

$$ATT = E[Y_{i1}|FR = 1, X_i] - E[Y_{i0}|FR = 0, X_i] \quad (6)$$

Where

$$E[Y_{i0}|FR = 1, X_i] \quad (7)$$

is replaced by

$$E[Y_{i0}|FR = 0, X_i] \quad (8)$$

,and we obtain this equation :

$$ATT = E[(Y_{i1} - Y_{i0})|FR = 1] = E[Y_{i1}|FR = 1, X_i] - E[Y_{i0}|FR = 0, X_i] \quad (9)$$

The entropy balancing method has several advantages : Its efficiency and reliability are compared to classical matching methods (e.g. PSM) through its non-parametric character. With this method, there is very little chance of a problem with the misspecification of the model's functional form, which could bias our results. Secondly, as the treatment variable is orthogonal to the covariates due to the reweighting mechanism, it avoids the multicollinearity problems that could eventually arise.

Finally, the entropy balancing method combines a reweighting mechanism with a regression analysis (Neuenkirch and Neumeier, 2016). This method allows controlling for country and time-fixed effects in the regression analysis. Including country-fixed effects allows for potential unobserved heterogeneity between countries with and without fiscal rules. To account for country-specific temporal and structural specificities, we use fixed effects to capture the invariant factors that explain differences in the attractiveness of FDI.

2.6 Results interpretation

In this section, we present the main results of our analysis.

2.6.1 Entropy balancing : Results

TABLE 17 – Descriptive statistics

Variables	(1)	(2)	3=(2-1)			
Variables	FR	Non-FR	Difference	T- value	P-value	
lag Currency	0.248	0.044	-0.203	-11.6248	0.0000	
lag Inflation	4.833	48.638	43.804	5.3755	0.0000	
lag Fiscal balance	-2.374	-2.205	0.169	0.6860	0.4928	
lag Checks and balances	3.112	2.537	-0.575	-8.0823	0.0000	
lag Financial openness	0.311	-0.165	-0.476	-7.1641	0.0000	
lag Hardit	0.299	0.071	-0.2280	-12.0851	0.0000	
lag Institution	2.362	2.433	0.0714	1.7444	0.0813	
Number of observations	562	1154				

TABLE 18 – Covariate balancing

	(1)	(2)	3=(2-1)			
Variables	FR	Non-FR	Difference	T- value	P-value	
lag Currency	0.2473	0.2503	0.000	-0.142	0.887	
lag Inflation	5.123	5.469	0.000	-1.330	0.184	
lag Fiscal balance	-2.401	-2.392	0,000	-0.031	0.975	
lag Checks and balances	3.148	3.142	3,4	0.058	0.954	
lag Financial openness	0.3314	0.3216	22,502	0.142	0.887	
lag Hardit	0.2865	0.2839	0,096	0.116	0.908	
lag Institution	2.373	2.373	-0,002	0.133	0.998	
Number of observations	562	1154				

The results of the table (17) show us that there is a difference in average between the group of countries that have adopted the fiscal rule and those that have not adopted the fiscal rule. Column (1) represents the average of the countries that have adopted the fiscal rule and column

TABLE 19 – Entropy balancing : Baseline model

Dependent variable : FDI

Variables	Estimation 1	Estimation 2	Estimation 3	Estimation 4	Estimation 5	Estimation 6	Estimation 7
Fiscal rules	1.376*** (0.404)	0.692* (0.373)	1.307*** (0.472)	1.491** (0.663)	1.369*** (0.388)	0.717* (0.370)	1.598** (0.689)
Lag Currency					-1.006** (0.401)	-0.407 (0.413)	0.354 (1.902)
Lag inflation					0.007 (0.022)	0.012 (0.024)	-0.027 (0.020)
Lag Fiscal balance					0.038** (0.018)	0.005 (0.025)	0.003 (0.020)
Lag Checks and balances					0.113 (0.092)	0.077 (0.092)	0.164** (0.081)
Lag financial openness					0.791*** (0.223)	0.756*** (0.216)	-0.033 (0.236)
Lag hardit					-0.763 (0.471)	-1.025** (0.502)	0.767** (0.311)
Lag Institution					0.249* (0.146)	0.636*** (0.146)	0.478*** (0.175)
Constant	2.712*** (0.156)	1.128 (0.725)	0.069 (1.526)	-0.136 (1.820)	2.035*** (0.663)	-0.585 (1.012)	-0.888 (1.999)
Observations	1,714	1,714	1,714	1,714	1,714	1,714	1,714
R-squared	0.010	0.049	0.337	0.363	0.056	0.088	0.367
Country FE	No	No	Yes	Yes	No	No	Yes
Years	No	Yes	No	Yes	No	Yes	Yes

Notes : ***p<0.001, **p<0.01, *p<0.05. Standard errors in parentheses.

(2) for those that have not adopted a fiscal rule. Column (3) shows the difference between columns 2 and 1. The fourth and fifth columns show the t-test statistic and p-value results. Overall, we find that countries belonging to a monetary union are more likely to adopt a fiscal rule, and their

number is higher compared to countries without having adopted fiscal rules. Similarly, financial openness, inflation targeting, and the Checks and balance index²⁷ are higher in countries that have adopted a fiscal rule compared to those observed in countries that have not adopted a fiscal rule. However, we notice through the table (17) that the level of inflation and corruption is lower in countries that have adopted a budget rule than in those that have not adopted fiscal rules. With these descriptive statistics, choosing a reliable control group before estimating the treatment's effect (matching approach) is still useful. If this is not the case, it could be that the effect of the treatment estimated through the fiscal rules on Foreign Direct Investments (FDI) is biased. This is how, in the table (18), we construct a control group and perform a comparison between the means of all the corresponding covariates in the treatment group and the control group created earlier. The results of the table (18) show us that the differences in means between these two groups are statistically insignificant.

Based on the control group in table (4), we estimate the effect of fiscal rules on FDI. For this, we use weighted least squares regressions. The results are presented in the table (19). In column (1), we run a simple regression without adding country and time-fixed effects. We add the time and country effects in columns (2) and (3). In column (4), we add the time and country effects to our basic equation (1). In column (5), we only add the control variables. Finally, in column (6), in addition to the explanatory variables, we add time-fixed effects, and in column (7), we simultaneously add country and time-fixed effects. Results (1)-(7) show that the adoption of fiscal rules increases Foreign Direct Investments (FDI). Indeed, the adoption of the rules gives more credibility to the fiscal policy, and this credibility in the management of the budgetary framework encourages more investors to invest in the country (Andrés and Doménech, 2006; Sacchi and Salotti, 2015; Fatás and Mihov, 2006). These results could also be justified by the fact that adopting fiscal rules sends a positive signal to investors on the country's economic stability because the rules, through their binding nature, confer macroeconomic stability and make the economic environment more attractive to investors. It is also necessary to add the fact that the adoption of the rules allows a better allocation of resources in the economic sectors, and this contributes to making the various sectors (infrastructures, health, etc.) more attractive and favourable to investments (FDI) (Schick, 2003; Primus, 2016; Sutherland et al., 2005). Finally, adopting the rules makes it possible to reduce the cost of borrowing for states and private investors because the markets, being reassured of the credibility of the budgetary framework, reduce the cost of borrowing (Thornton and Vasilakis, 2018). This allows states to quickly mobilize resources to make the economic environment more attractive to foreign investment. One of the significant problems developing countries encounter is the lack of image (credibility and economic stability) in the eyes of investors, which often leads to an increase in the cost of borrowing on the financial markets and with other financial partners.

27. It measures whether the powers are endowed with the constitutional titles allowing them to invade the domain of a competing body and are also allowed to defend themselves against the encroachments of their rivals

With the adoption of fiscal rules, the resulting economic stability makes it possible to reduce the cost of borrowing and thus enable developing countries to attract enough investors (Sawadogo, 2020; Thornton and Vasilakis, 2018) and mobilize resources to make the economic environment more attractive to foreign investors.

2.6.2 Entropy balancing : The effect of different types of fiscal rules

In table (20), we present the effects of different fiscal rules on FDI. The objective is to identify the fiscal rules that can attract more Foreign Direct Investments (FDI). The results (20) show through column (2) that fiscal rules on the budget deficit increase FDI. We also find (column (3)) that debt ratio rules increase FDI. Their effects are positive and significant. In column (4), expenditure rules do not affect FDI. The procyclicality of fiscal rules could explain this. The works of (Combes et al., 2017; Bova et al., 2014) show the procyclicality of rules in developing countries. They find that fiscal rules mitigate the procyclicality of fiscal policy. Recent work by Mitsi and Kottaridi (2022) also shows that spending rules negatively affect FDI. Column (5) of the table (20) shows that income rules also increase FDI. Among the four types of rules, apart from the rules on expenditure, the other types of rules positively and significantly affect FDI.

2.7 Robustness

2.7.1 Robustness : Additional control variables (Entropy balancing)

To test the robustness of our results, we proceed with additive robustness. It is a question of whether the addition of the new control variables will be able to influence the basic results of the study. For this, we add new control variables, namely the binary variable capturing the holding of presidential elections, political stability, the index of internal and external conflicts, the index of socio-economic well-being, and the quality of the public administration and democracy. By gradually adding the different variables, the results of the table (21) show that overall, adopting fiscal rules positively affects FDI, and the effect is significant. With the addition of the new control variables, the results remain convergent. These results (21) corroborate those obtained previously with the study's basic model and demonstrate our results' robustness.

2.7.2 Change in the estimation method : The propensity score matching (PSM) method

The study analyses whether adopting at least one fiscal rule contributes to increasing Foreign Direct Investments (FDI) in developing countries. To obtain a causal impact of fiscal rules, we compare the foreign direct investments of countries that have adopted at least one fiscal rule with

TABLE 20 – Robutness checks : Entropy balancing : Types of fiscal rules

	1	2	3	4	5
	FR	BBR	DR	ER	RR
Variables	FDI	FDI	FDI	FDI	FDI
Fiscal rules	1.598** (0.689)				
Lag Currency	0.354 (1.902)	0.858 (1.946)	-0.190 (2.208)	2.964 (2.561)	-0.319 (2.201)
Lag inflation	-0.027 (0.020)	-0.028 (0.025)	-0.052 (0.035)	0.021 (0.124)	-0.053 (0.035)
Lag Fiscal balance	0.003 (0.020)	-0.008 (0.026)	-0.004 (0.026)	-0.058 (0.056)	0.002 (0.019)
Lag Checks and balances	0.164** (0.081)	0.137* (0.071)	0.202 (0.130)	0.195 (0.215)	-0.075 (0.130)
Lag financial openness	-0.033 (0.236)	-0.173 (0.237)	-0.117 (0.341)	-0.702 (0.532)	0.274 (0.431)
Lag hardit	0.767** (0.311)	0.643** (0.327)	0.860** (0.433)	1.385** (0.647)	-0.292 (0.407)
Lag Institution	0.478*** (0.175)	0.523*** (0.183)	0.723*** (0.221)	0.584 (0.374)	0.570*** (0.216)
Deficit rules		0.823* (0.427)			
Debt rules			1.412** (0.677)		
Expenditure rules				-3.808 (2.457)	
Revenue rules					1.755*** (0.492)
Constant	-0.888 (1.999)	-1.142 (2.096)	-1.018 (2.372)	-2.481 (3.253)	0.109 (2.360)
Observations	1,714	1,714	1,714	1,714	1,713
R-squared	0.367	0.365	0.376	0.256	0.497
Country FE	Yes	Yes	Yes	Yes	Yes
Years	Yes	Yes	Yes	Yes	Yes

*** p<0.01, ** p<0.05, * p<0.1

TABLE 21 – Robutness checks : Entropy balancing : Additional controls

Dependent variable	1	2	3	4	5	6	7	8
	FDI	FDI	FDI	FDI	FDI	FDI	FDI	FDI
Fiscal rules	1.596** (0.688)	1.478* (0.756)	1.387** (0.677)	1.483** (0.683)	1.490** (0.679)	1.641** (0.701)	1.594** (0.715)	1.588** (0.687)
Lag Currency	0.368 (1.898)	0.560 (1.946)	1.067 (1.943)	0.864 (1.931)	-0.042 (1.935)	0.322 (1.894)	0.367 (1.942)	0.292 (1.899)
Lag inflation	-0.028 (0.020)	-0.025 (0.020)	-0.020 (0.020)	-0.026 (0.020)	-0.028 (0.020)	-0.026 (0.020)	-0.028 (0.020)	-0.026 (0.020)
Lag Fiscal balance	0.003 (0.020)	0.001 (0.020)	-0.002 (0.019)	0.002 (0.020)	0.005 (0.020)	-0.001 (0.022)	0.004 (0.021)	0.002 (0.020)
Lag Checks and balances	0.164** (0.081)	0.151* (0.085)	0.178** (0.084)	0.156** (0.078)	0.164** (0.081)	0.168** (0.082)	0.164** (0.083)	0.146* (0.075)
Lag financial openness	-0.034 (0.235)	-0.033 (0.236)	-0.082 (0.229)	-0.021 (0.235)	-0.058 (0.230)	-0.030 (0.234)	-0.031 (0.231)	-0.047 (0.236)
Lag hardit	0.768** (0.312)	0.781** (0.311)	0.997*** (0.319)	0.884*** (0.319)	0.735** (0.309)	0.740** (0.310)	0.773** (0.317)	0.742** (0.310)
Lag Institution	0.481*** (0.176)	0.478*** (0.174)	0.433** (0.175)	0.463*** (0.178)	0.521*** (0.171)	0.492*** (0.175)	0.479*** (0.176)	0.432*** (0.167)
Lag exelec	-0.086 (0.480)							
Lag Internal conflicts		0.093 (0.101)						
Lag Government stability			0.419** (0.172)					
Lag External conflicts				0.210 (0.191)				
Lag Bureaucracy					-0.556 (0.433)			
Lag Investment-quality						0.178 (0.150)		
Lag socioeconomic conditions							-0.012 (0.162)	
Lag Democracy								0.249 (0.158)
Constant	-0.901 (1.995)	-1.554 (2.240)	-3.489 (2.200)	-2.979 (2.682)	-0.222 (2.120)	-1.807 (2.135)	-0.830 (2.026)	-0.970 (1.976)
Observations	1,714	1,714	1,714	1,714	1,714	1,714	1,714	1,714
R-squared	0.367	0.367	0.370	0.367	0.367	0.367	0.367	0.367
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Years	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

*** p<0.01, ** p<0.05, * p<0.1

those that have not adopted a fiscal rule. However, it should be noted that a potential selection bias could affect this comparison. Indeed, the treated and untreated groups are not identical, and their differences, in addition to being discussed, can act as confounding factors if they affect the dynamics of Foreign Direct Investments (FDI). A simple comparison of our control variables according to the treatment status of the individuals (Table 1) shows that this is the case in our sample. Developing countries adopt fiscal rules due to the lack of macroeconomic stability, the issues of the credibility of fiscal policy, the mobilization of resources on the financial market, the attractiveness of investments, etc. These factors could be associated with macroeconomic factors and political stability. Thus, the outcome of the treatment individuals and those of the control group may even differ in the absence of treatment. However, a problem of endogeneity could arise. To solve this problem, we use a matching approach.

2.7.2.1 Propensity Score Matching

We use a relevant method of analysis and evaluation of the effects of development policies, which is the Propensity Score Matching (PSM) of (Rosenbaum and Rubin, 1983; Abadie and Imbens, 2016; Chapel, 2022; Rubin and Thomas, 1996). This method minimizes the selection bias by comparing each country that has adopted a fiscal rule with a counterfactual that has not adopted a fiscal rule deemed sufficiently similar in specific observable characteristics. Indeed, the PSM is a two-step method : first, using a probit model, we generate for each country a propensity score $p(x)$, which estimates the probability that this country, with its characteristic vector, adopts a fiscal rule.

$$p(X) = Pr(T = 1|X) = E(T|X) \quad (10)$$

Where, $T = 0;1$ is the binary variable that indicates whether the country has adopted a fiscal rule, and X is the vector of observed characteristics before treatment. We first define the variables used for the estimation with the descriptive statistics of these variables. Second, we assess the impact of adopting the fiscal rule by estimating a country's average treatment effect (ATT), which is expressed as :

$$ATT = E[(Y_{i1} - Y_{i0})|T_i = 1] = E[(Y_{i1}|T_i = 1)] - E[(Y_{i0}|T_i = 1)] \quad (11)$$

T_i (treatment) is a binary variable that takes the value one if country i has adopted at least one fiscal rule and 0 otherwise. Y_{i1} captures foreign direct investment when the country adopts a fiscal rule, and Y_{i0} is the foreign direct investment observed if the country had not adopted a fiscal rule. The problem is that we cannot observe Y_{i1} and Y_{i0} simultaneously. We are, therefore, faced with a counterfactual problem. Several solutions can be envisaged. We favour the solution which compares the average levels of increase in Foreign Direct Investments between the countries that have adopted a fiscal rule and those that have not adopted a fiscal rule to circumvent this difficulty. However, this approach assumes that treatment assignment is random. This hypothesis

would be ad hoc because the choice to adopt a fiscal rule may be dictated by certain omitted variables (instability of the macroeconomic framework, budgetary drifts, vulnerability to external shocks, etc.), which could affect the dynamics of Foreign Direct Investments(FDI), which would lead to a potential auto-selection problem. Moreover, according to the conditional independence assumption (Smith and Todd, 2005 ; Rosenbaum, 1984 ; Rosenbaum and Rubin, 1983 ; Agterberg and Cheng, 2002), we can replace in equation 7 the term

$$E[(Y_{i0}|T_{i1})] \quad (12)$$

by the expression

$$E[(Y_{i0}|T_{i0}, X_i)]. \quad (13)$$

This allows us to obtain equation 10.

$$ATT = E[(Y_{i1}|T_i = 1, X_i)] - E[(Y_{i0}|T_i = 1, X_i)] \quad (14)$$

The second hypothesis concerns the existence of a common support ($0 < p(X) < 1$). Indeed, this hypothesis assumes that for each treated country, there is at least one non-treated country that is similar to it and whose propensity score is close. Equation 10 can be rewritten as follows :

$$ATT = E[(Y_{i1}|T_i = 1, p(X_i))] - E[(Y_{i0}|T_i = 1, p(X_i))] \quad (15)$$

Where $p(X_i) = \Pr(RBLi = 1|X_i)$ predicts the probability of adopting at least one fiscal rule, subject to set X .

2.7.2.2 Choice of matching algorithms

In this part, we compare the treated countries to the untreated countries according to their propensity score through various matching methods. The ATT is the difference in access to FDI between the treated and untreated countries, matched based on a similar propensity score. Inspired by the economic work of (Heckman et al., 1998 ; Rubin and Thomas, 1996 ; Caliendo and Kopeinig, 2008), we test the robustness of our results using matching estimators commonly used in recent studies (Coulibaly et al., 2022 ; Sawadogo, 2020 ; Vikram and Chindarkar, 2020 ; Bagnoli, 2019 ; Sawadogo and Wandaogo, 2021). To get more precise standard errors for the ATT, we proceed as Lechner (2002). First, we use nearest-neighbour matching and its extension. Indeed, it associates each treated country with a control country with the closest propensity score. By extending this method, it is also possible to match each treated country with more than one control country. As a result, we match each treated country with the two and three nearest neighbours in terms of the propensity score. However, it should be noted that with this method, a treated country may be matched with one or more control countries having a very different propensity score, leading to a mismatch and potentially biased results. In order to solve this potential problem,

we proceed as [Dehejia and Wahba \(2002\)](#), using the radius gauge matching method to solve this bias. With this technique, each treated country is matched with all the control countries within a well-defined perimeter at the neighbourhood threshold, called a calibre. In our case, we use three different calibres : low ($r=0.005$), medium ($r=0.01$), and high ($r=0.05$) calibre. Finally, we add two other algorithms : kernel-matching and local linear regression. Kernel-matching associates with each treated unit a counterfactual equal to the average of all the untreated units weighted by a weight inversely proportional to their distance from the considered unit treated unit. Local linear regression, on the other hand, is a generalized version of the Kernel estimator. However, the difference is that it includes a linear term in the propensity score of a treated unit.

2.7.2.3 Interpretation and evaluation of matching quality

The goal of the matching technique is to achieve a balance between the treatment group and the comparison group on observable traits. In this part, we analyze the quality of the matching before proceeding to its interpretation. This step helps avoid potential bias problems that could call the results into question. According to the economic literature, there is no consensus on the best test to use to judge the effectiveness of this test. Other works ([Rosenbaum and Rubin, 1983](#); [Simone and Bazilian, 2019](#)) offer other methods to assess the quality of matching. Thus, the work of [Rosenbaum and Rubin \(1983\)](#) focuses instead on the standardized bias, which calculates the percentage of bias on each covariate. For a matching to be of good quality, the authors show that the bias must be significantly reduced compared to before the matching for each covariate. The closer it is to 0, the more efficient our matching is. Also, the p-value associated with the standardized bias must be greater than the critical value of 10 %. We also note this is the case in our study because all the values exceed this threshold. The work of [Simone and Bazilian \(2019\)](#) re-estimates the propensity score only for matched individuals and compares the Pseudo R2 obtained with that obtained before the matching process. Following the [Gangl \(2004\)](#) method, we perform a final test, the Rosenbaum lower bound sensitivity test ([Rosenbaum, 2010](#)), to assess the quality of the matching. This test analyzes whether unobservables will likely affect the probability of adopting a fiscal rule on Foreign Direct Investments (FDI). Our results are superior to those obtained by ([Vikram and Chindarkar, 2020](#); [Sawadogo and Wandaogo, 2021](#)).

In this part, we present the results (22) of the ATT estimations. First, we use the N-nearest-neighbours method, which matches each FR to non-FR N-nearest-neighbours with the most comparable propensity scores possible. In this study, we retain N-nearest-Neighbors ranging from 1 to 3 nearest neighbors. Secondly, we use the radius method ([Dehejia and Wahba, 2002](#)), which associates the countries that have adopted the rules with those that have not, located at a certain distance according to the propensity scores. To do this, we retain the small ($R=0.005$), the medium ($R=0.01$), and the large ($R=0.05$) radius. Third, we use the Kernel method ([Heckman et al., 1998](#)), which associates each country that has adopted the rule with a weighted average of all

TABLE 22 – Robutness checks : Propensity Score Matching(PSM)

ATT : FR FDI	1	2	3	4	5	6	7	8
	1-Nearest Neighbour Matching	2-Nearest Neighbour Matching	3-Nearest Neighbour Matching	r=0.005	r=0.01	r=0.05	Kernel Matching	Local Linear Matching
ATT	1.3485*** (0.4538)	1.3659*** (0.4350)	1.2868*** (0.4408)	1.1784*** (0.4252)	1.2943*** (0.4383)	1.2490*** (0.3652)	1.2443*** (0.4600)	1.2638*** (0.3904)
Observations	1714	1714	1714	1714	1714	1714	1714	1714
Treated	640	640	640	640	640	640	640	640
Untreated	1074	1074	1074	1074	1074	1074	1074	1074
Rosenbaum bound	1.55	1.4	1.3	1.1	1.1	1.15	1.1	1.1
Standardized bias (pvalue)	0.188	0.551	0.509	0.813	0.514	0.393	0.372	0.188
Pseudo R2	0.006	0.004	0.004	0.003	0.004	0.005	0.005	0.006

Notes : Bootstrapped standard errors based on 500 replications in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

the countries that have not adopted it, the weights being inversely proportional to the difference between the propensity scores of the countries who have adopted the rule and those who have not adopted the rule. Finally, we use the local linear regression method (Heckman et al., 1998), which associates the countries that have adopted the rule with the countries that have not adopted the rule, like Kernel Matching, but uses a linear factor in the weighting function. The results show a positive and significant link between adopting fiscal rules and Foreign Direct Investments (FDI). The estimated coefficients are positive and significant with an amplitude varying between 1.34 (N-nearest-Neighbors) and 1.24 (Local linear) percentage points (see table 22). These results suggest that adopting fiscal rules increases Foreign Direct Investments (FDI). Developing countries have a growing need in terms of infrastructure, and since a good part of FDI flows in the world is oriented towards infrastructure, good management of the fiscal policy (economic stability) conferred by the adoption of rules could send a positive signal to investors and lead to a strong attraction of FDI which generates new tax revenue intended for the reimbursement of the previous public debt. Indeed, the investments made in infrastructure positively affect well-being and increase economic growth.

2.7.3 Sensitivity analysis through robustness (Entropy balancing)

In this section, we test the robustness of our results. Thus, a model is robust if it is valid under different circumstances. In column (1) of the table (23), only countries with an inflation rate below 40% are considered. The results reveal that the effect of the rules is always positive and significant. In the second column, the financial crisis years of 2008 and 2009 are excluded from the sample. The results remain unchanged. In column (3) of the table (23), only the years after 1993 are considered. Indeed, the rules appeared around the 1990s, and their effects are visible in the medium and long term. Considering only the years after 1993, we want to know the effect of the rules after their adoption. The results show that rules always positively and significantly affect FDI. In column (4), only the least developed countries in the sample are considered. The results show a positive and significant effect between adopting rules and FDI. In column (5), we exclude 2019 and 2020; in

TABLE 23 – Robustness : Entropy balancing (Alternative)

	1	2	3	4	5	6	7
Dependent variable	FDI	FDI	FDI	FDI	FDI	FDI	FDI
Fiscal rules	1.631** (0.696)	1.618** (0.702)	1.481** (0.731)	1.598** (0.689)	1.598** (0.689)	1.598** (0.689)	15.821** (7.700)
Lag Currency	0.258 (1.911)	0.621 (2.190)	0.776 (1.949)	0.354 (1.902)	0.354 (1.902)	0.354 (1.902)	-21.324* (11.052)
Lag Inflation	-0.040* (0.024)	-0.035* (0.019)	-0.035 (0.023)	-0.027 (0.020)	-0.027 (0.020)	-0.027 (0.020)	0.000 (0.084)
Lag Fiscal balance	0.002 (0.020)	-0.001 (0.021)	0.001 (0.057)	0.003 (0.020)	0.003 (0.020)	0.003 (0.020)	0.040 (0.451)
Lag Checks and balances	0.161** (0.081)	0.181** (0.087)	0.154* (0.085)	0.164** (0.081)	0.164** (0.081)	0.164** (0.081)	1.371 (1.462)
Lag financial openness	-0.038 (0.242)	-0.061 (0.259)	-0.211 (0.271)	-0.033 (0.236)	-0.033 (0.236)	-0.033 (0.236)	12.442** (5.442)
Lag Hardit	0.727** (0.314)	0.840*** (0.325)	0.759** (0.322)	0.767** (0.311)	0.767** (0.311)	0.767** (0.311)	
Lag Institution	0.491*** (0.174)	0.484*** (0.182)	0.528*** (0.195)	0.478*** (0.175)	0.478*** (0.175)	0.478*** (0.175)	-1.512 (3.496)
Constant	-0.805 (2.013)	-1.222 (2.279)	-1.315 (2.038)	-0.888 (1.999)	-0.888 (1.999)	-0.888 (1.999)	38.656** (17.705)
Observations	1,64	1,573	1,597	1,714	1,714	1,714	216
R-squared	0.367	0.389	0.362	0.367	0.367	0.367	0.609
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Years	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

column (6), we consider only the years below 2020 to consider the COVID-19 effect. The results show that in these two columns, the effect of the rules is always positive and significant. Finally, in column (7), only fragile countries are considered. The results show that the rules positively and significantly affect FDI.

2.7.4 Robustness : The GMM Estimator

In this part of the study, we use the Generalized Method of Moments (GMM).

For the Generalized Method of Moments (GMM), the equation is as follows :

$$FDI_{it} = \alpha_i + \beta FDI_{i,t-1} + \gamma FR_{i,t} + \sum_{k=0}^n \Delta X_{i,t} + \epsilon_{it} \quad (16)$$

With FDI representing the dependent variable of the model. It represents the ratio of FDI. X is a vector representing the set of explanatory variables in the level used in the model. Epsilon is the error term.

We present in this part the results of the estimations with the GMM (24). The results in the first column represent the base model. It can be seen that there is a positive link between fiscal rules and FDI. This effect is significant at 1% (24). These results suggest that adopting fiscal rules increases FDI by 2.18 percentage points. The adoption of fiscal rules helps to attract more Foreign Direct Investments (FDI) (Andrés and Doménech, 2006; Sacchi and Salotti, 2015; Fatás and Mihov, 2006). The adoption of the rules avoids drifts in the management of macroeconomic aggregates (allows a better allocation of resources) and contributes to a discipline of the fiscal policy, thus giving a signal of stability to the investors (Schick, 2003; Primus, 2016; Sutherland et al., 2005). In the rest of the columns of the table (24), we add, in turn, a few control variables to the basic model, and we find that the link between the rules and the IDEs is always positive and significant (1%).

2.7.5 Robustness : Changing the variable of interest

Still, intending to test the robustness of our results, we change the variable of interest to a binary proxy variable, which indicates one if the country has adopted a flexible rule and 0 otherwise. Indeed, there are different types of flexible budget rules and binding rules. The results are significant and show that the adoption of these types of fiscal rules always increases FDI. The effect is positive and significant at 5% (25). Then, we use another proxy variable that indicates if the rules are enacted and written in an international treaty. The results show a significant positive link between adopting rules and FDI (27). Finally, we use a last proxy variable, indicating if the adopted rule is only governed by an international convention and 0 otherwise. The results highlight a positive and significant link between rules and FDI (26).

TABLE 24 – Robutness : GMM

	1	2	3	4	5	6	7	8	9	10
Dependent variable : FDI										
L.FDI	0.471*** (0.019)	0.467*** (0.020)	0.459*** (0.019)	0.470*** (0.020)	0.441*** (0.022)	0.466*** (0.022)	0.456*** (0.021)	0.469*** (0.019)	0.470*** (0.019)	0.463*** (0.020)
Fiscal rules	2.180*** (0.778)	2.167*** (0.784)	3.117*** (0.802)	2.210*** (0.782)	2.781*** (0.867)	2.792*** (0.970)	3.347*** (0.908)	2.450*** (0.792)	2.129*** (0.782)	2.210*** (0.776)
Currency	-21.084*** (5.072)	-21.335*** (5.093)	-20.873*** (5.046)	-20.937*** (5.173)	-3.305 (4.833)	-25.874*** (6.811)	-29.285*** (5.373)	-20.796*** (5.075)	-21.071*** (5.075)	-19.586*** (5.105)
Inflation	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	0.000 (0.005)	-0.001 (0.002)	-0.001 (0.001)	-0.000 (0.001)	-0.001 (0.001)	-0.001 (0.001)
Fiscal balance	0.054* (0.032)	0.069* (0.041)	0.061* (0.031)	0.054* (0.032)	0.066* (0.036)	0.058 (0.049)	0.027 (0.037)	0.045 (0.032)	0.050 (0.032)	0.025 (0.035)
Checks and balances	0.504*** (0.175)	0.489*** (0.176)	0.465*** (0.175)	0.502*** (0.175)	0.591*** (0.188)	0.467** (0.208)	0.907*** (0.247)	0.483*** (0.176)	0.498*** (0.176)	0.509*** (0.175)
Financial openness	0.137 (0.313)	0.166 (0.315)	0.397 (0.316)	0.129 (0.316)	0.582 (0.355)	-0.197 (0.380)	-0.269 (0.344)	0.121 (0.313)	0.127 (0.315)	0.190 (0.313)
Hardit	-3.756*** (1.046)	-3.717*** (1.053)	-2.342** (1.088)	-3.734*** (1.056)	-1.837 (1.179)	-3.614*** (1.275)	-4.075*** (1.182)	-3.549*** (1.052)	-3.869*** (1.055)	-3.491*** (1.050)
Institution	-0.059 (0.371)	0.026 (0.376)	-0.290 (0.370)	-0.059 (0.371)	0.141 (0.409)	-0.125 (0.475)	-0.127 (0.423)	-0.093 (0.371)	-0.010 (0.379)	0.000 (0.371)
Growth		0.034 (0.036)								
Age dependency ratio			0.141*** (0.032)							
Population				-0.000 (0.000)						
Domestic credit to private sector					-0.007 (0.021)					
Real interest rate						-0.024 (0.017)				
Vote Share of 3rd Largest Government Party							0.290*** (0.061)			
Gouvernement stability								0.212* (0.118)		
Invest-qual									0.082 (0.141)	
Total natural resources rents										0.082** (0.037)
Constant	2.928** (1.227)	2.696** (1.253)	-6.121** (2.378)	2.989** (1.300)	0.103 (1.477)	3.043** (1.486)	3.043** (1.377)	1.211 (1.557)	2.213 (1.720)	1.813 (1.327)
Observations	1,688	1,676	1,688	1,688	1,396	1,285	1,42	1,688	1,688	1,688
Number of idcoun	74	74	74	74	74	63	73	74	74	74

Notes : ***p<0.001, **p<0.01, *p<0.05. Standard errors in parentheses.

2.7.6 Change of estimation method : IPW and Mahalanobis distance matching method

Notes : ***p<0.001, **p<0.01, *p<0.05. Standard errors in parentheses.

In this part, we test the robustness of our results by changing the estimation method. This is an alternative matching method, "the Mahalanobis distance matching." It is a method that

TABLE 25 – Robustness : Entropy balancing (Flexibility rule)

Dependent variable : FDI	1	2	3	4	5	6	7
Variables Estimation 1 Estimation 2 Estimation 3 Estimation 4 Estimation 5 Estimation 6 Estimation 7							
Flexibility (rule)	1.907*** (0.558)	1.488*** (0.545)	1.220*** (0.470)	1.565** (0.652)	2.199*** (0.570)	1.871*** (0.590)	1.781*** (0.679)
Lag Currency					-1.371*** (0.356)	-0.934*** (0.359)	0.273 (1.894)
Lag Inflation					0.036 (0.026)	0.034 (0.028)	-0.025 (0.020)
Lag Fiscal balance					0.039** (0.018)	0.007 (0.024)	0.004 (0.020)
Lag Checks and balances					0.066 (0.081)	0.028 (0.080)	0.150* (0.077)
Lag Financial openness					0.746*** (0.211)	0.720*** (0.205)	-0.075 (0.232)
Lag Hardit					-0.678 (0.465)	-0.820* (0.493)	0.988*** (0.349)
Lag Institution					0.291** (0.142)	0.583*** (0.140)	0.542*** (0.176)
Constant	2.757*** (0.126)	1.122 (0.700)	0.069 (1.526)	-0.117 (1.814)	1.953*** (0.654)	-0.074 (0.899)	-1.015 (1.975)
Observations	1,714	1,714	1,714	1,714	1,714	1,714	1,714
R-squared	0.017	0.056	0.337	0.364	0.068	0.098	0.368
Country FE	No	No	Yes	Yes	No	No	Yes
Years	No	Yes	No	Yes	No	Yes	Yes

Notes : ***p<0.001, **p<0.01, *p<0.05. Standard errors in parentheses.

compares each processed unit to the closest control unit regarding distance (matching). Indeed, some economic works such as those of [King and Nielsen \(2019\)](#) show the limits of using propensity scores for matching. This work reveals that PSMs produce unreliable estimates varying greatly depending on the outcome model. For example, if one gradually removes units far from each other, the balance will eventually deteriorate with the propensity score, even if there are still units close. The study instead suggests using a potentially more robust method, the "Mahalanobis Distance Matching" method. However, recent works such as those of ([Liu et al., 2020](#) ; [Ripollone et al., 2018](#) ; [Tremblay et al., 2020](#) ; [Freedberg et al., 2020](#) ; [Kane et al., 2020](#)) instead show that propensity score matching does not appear to induce increased covariate imbalance when extreme thickness values were not used, well beyond what would be recommended. Following this proposal, we use the "Mahalanobis Distance Matching" method to test the robustness of our results. We add the control

TABLE 26 – Robustness : Entropy balancing (Legal basis rule)

Dependent variable : FDI	1	2	3	4	5	6	7
Variables Estimation 1	Estimation 2	Estimation 3	Estimation 4	Estimation 5	Estimation 6	Estimation 7	
Legal-basis (rule)	1.635*** (0.446)	1.016** (0.425)	1.236*** (0.433)	1.398** (0.600)	1.678*** (0.436)	1.131*** (0.431)	1.485** (0.621)
Lag Currency					-1.037*** (0.396)	-0.522 (0.403)	0.422 (1.892)
Lag Inflation					0.020 (0.023)	0.019 (0.025)	-0.027 (0.020)
Lag Fiscal balance					0.040** (0.019)	0.007 (0.025)	0.003 (0.020)
Lag Checks and balances					0.091 (0.086)	0.060 (0.087)	0.162** (0.081)
Lag Financial openness					0.790*** (0.222)	0.758*** (0.216)	-0.034 (0.236)
Lag Hardit					-0.771 (0.470)	-0.971* (0.497)	0.731** (0.309)
Lag Institution					0.252* (0.143)	0.595*** (0.142)	0.480*** (0.175)
Constant	2.686*** (0.142)	1.149 (0.721)	0.069 (1.526)	-0.175 (1.817)	1.992*** (0.653)	-0.349 (0.965)	-0.953 (1.990)
Observations	1,714	1,714	1,714	1,714	1,714	1,714	1,714
R-squared	0.014	0.051	0.337	0.363	0.060	0.090	0.366
Country FE	No	No	Yes	Yes	No	No	Yes
Years	No	Yes	No	Yes	No	Yes	Yes

Notes : ***p<0.001, **p<0.01, *p<0.05. Standard errors in parentheses.

variables, the index of democracy and socio-economic well-being, the quality of institutions, and the business climate regarding investment profile to the basic model to see if it is still performing under different circumstances. The results of the table (29) show us that the adoption of the rules always increases Foreign Direct Investments (FDI). This effect is also significant at the 1% level.

We test our results' robustness by changing the estimation method. This time, we use the inverse probability weight (IPW) estimator. The ATT estimator corrects for potential self-selection bias in policy adoption; however, this estimator may have limitations, including a significant lack of data. The IPW estimator, on the other hand, uses propensity scores by giving more weight to observations that are similar to each other in their observable characteristics, thus allowing a good

TABLE 27 – Robustness : Entropy balancing (Treaty rule)

Dependent variable : FDI	1	2	3	4	5	6	7
Variables Estimation 1 Estimation 2 Estimation 3 Estimation 4 Estimation 5 Estimation 6 Estimation 7							
Treaty (rule)	0.001 (0.635)	-0.558 (0.638)	1.298** (0.509)	1.259** (0.620)	1.604** (0.806)	0.653 (0.982)	1.312** (0.632)
Lag Currency					-1.676*** (0.406)	-0.597 (0.612)	0.794 (1.846)
Lag Inflation					0.019 (0.022)	0.020 (0.024)	-0.028 (0.021)
Lag Fiscal balance					0.039** (0.018)	0.004 (0.024)	0.002 (0.020)
Lag Checks and balances					0.096 (0.098)	0.072 (0.097)	0.097 (0.076)
Lag Financial openness					0.763*** (0.220)	0.743*** (0.214)	-0.063 (0.235)
Lag Hardit					-0.854* (0.448)	-1.108** (0.528)	0.819** (0.340)
Lag Institution					0.341** (0.166)	0.712*** (0.160)	0.530*** (0.174)
Constant	3.400*** (0.220)	1.207 (0.768)	0.069 (1.526)	-0.439 (1.797)	2.431*** (0.645)	-0.623 (1.073)	-1.363 (1.975)
Observations	1,714	1,714	1,714	1,714	1,714	1,714	1,714
R-squared	0.000	0.048	0.336	0.362	0.052	0.086	0.365
Country FE	No	No	Yes	Yes	No	No	Yes
Years	No	Yes	No	Yes	No	Yes	Yes

Notes : ***p<0.001, **p<0.01, *p<0.05. Standard errors in parentheses.

match, even in the presence of missing data. The results of the table (28) show us that the adoption of the rules increases Foreign Direct Investments (FDI). These results confirm those obtained in the basic model.

Finally, we replace the treatment variable with rule strength. It is an index constructed using several components, such as the procedure for adopting the rules, the character of the rules, the flexibility, the enforcement, and the nature of the rules. The results of column (1) of the table (30) show that the strength of fiscal rules increases Foreign Direct Investments. In columns (2,3,4,5,6, and 7), we add, in turn, the institutional variables (stability and election), macroeconomic (economic growth, normalized capital openness, and the primary balance), and a binary variable that indicates one if the country is emerging and 0 otherwise. The results of the table (30) show that

TABLE 28 – Robustness : change in estimation method : IPW
ATT : FR and FDI

	1	2	3	4	5
	IPW	IPW	IPW	IPW	IPW
ATET					
Fiscal rules	1.378*** (0.412)	1.159*** (0.423)	1.403*** (0.433)	1.646*** (0.433)	1.495*** (0.393)
Fiscal rules	2.709*** (0.163)	3.115*** (0.158)	2.683*** (0.188)	2.710*** (0.153)	2.778*** (0.164)
Lag Currency	2.095*** (0.125)	2.168*** (0.125)	2.108*** (0.135)	2.212*** (0.140)	2.098*** (0.129)
Lag Inflation	-0.029*** (0.005)	-0.027*** (0.006)	-0.029*** (0.005)	-0.024*** (0.005)	-0.027*** (0.006)
Lag Fiscal balance	-0.008 (0.006)	-0.005 (0.005)	-0.009 (0.007)	-0.007 (0.007)	-0.009 (0.007)
Lag Checks and balances	0.172*** (0.030)	0.123*** (0.028)	0.174*** (0.031)	0.168*** (0.029)	0.173*** (0.030)
Lag Financial openness	0.242*** (0.024)	0.233*** (0.026)	0.240*** (0.026)	0.285*** (0.030)	0.233*** (0.029)
Lag Hardit	0.944*** (0.098)	0.829*** (0.098)	0.937*** (0.092)	1.064*** (0.100)	0.909*** (0.097)
Lag Institution	-0.027 (0.044)	-0.083* (0.047)	-0.036 (0.045)	-0.035 (0.066)	-0.036 (0.044)
Democracy		0.185*** (0.035)			
Socioeconomic conditions			0.014 (0.022)		
ICRG Indicator of Quality of Government				-0.372 (0.450)	
Invest-qual					0.034 (0.024)
Constant	-1.125*** (0.152)	-1.583*** (0.170)	-1.185*** (0.185)	-1.093*** (0.211)	-1.418*** (0.244)
N	1714	1642	1714	1535	1642

there is always a positive and significant link between the strength of fiscal rules and FDI.

TABLE 29 – Robustness : change in estimation method (Mahalanobis distance matching)
ATT : FR and FDI

	1	2	3	4	5
ATT	0.711**	1.323***	0.944**	1.171***	1.176***
	(0.309)	(0.481)	(0.450)	(0.415)	(0.374)
N	1589	1642	1702	1714	1713

TABLE 30 – Robustness : change in estimation method (Mahalanobis distance matching) with use of the strength of fiscal rules

ATT : FR and FDI

	1	2	3	4	5	6	7
ATT(rule2)	1.098*	1.579***	1.180**	1.268**	1.580***	1.170**	1.348**
	(0.630)	(0.531)	(0.519)	(0.511)	(0.502)	(0.574)	(0.528)
N	1714	1451	1702	1713	1713	1714	1714

2.8 Heterogeneity

We analyze heterogeneity by considering several factors : investment profile, which captures factors affecting investment risk that are not covered by other components of political, economic, and financial risk; economic performance, rents from the exploitation of oil and gas, the added value of the agricultural and industrial sector in the wealth produced. The results (31) show that fiscal rules increase FDI. The effect of these fiscal rules is amplified in the presence of a high level of the business climate in the investment profiles of the countries, economic performance, and better structuring of the agricultural and industrial sectors. Next, we cross-reference the treatment variable with the rents from the exploitation of gas and oil and the real interest rate of the economy. The results show that the effect of fiscal rules is attenuated in the presence of a high level of rents from the exploitation of gas and oil, thus concurring with the work of (Kolstad and Søreide, 2009; Robbins, 2000; citeterum2019corruption) that highlight the negative effect of corruption and mismanagement in the exploitation of natural resources. The effect of the fiscal rules is also attenuated in the presence of a high level of the economy's real interest rate. This result is in line with the work of (Feldstein, 1986; Jacobs et al., 2020; Engen and Hubbard, 2004), which shows that fiscal rules affect the real interest rate of the economy.

TABLE 31 – Exploring the heterogeneity

Variables	1	2	3	4	5	6	7
	FDI	FDI	FDI	FDI	FDI	FDI	FDI
Fiscal rules	1.242*	1.479**	2.935***	1.865***	1.575**	1.482**	1.482**
	(0.665)	(0.664)	(0.885)	(0.701)	(0.666)	(0.664)	(0.664)
FR-invest-qual	3.221**						
	(1.557)						
FR-growth		3.529***					
		(0.646)					
FR-interest			-3.586***				
			(1.127)				
FR-oil				-0.310***			
				(0.075)			
FR-gas					-1.226***		
					(0.321)		
FR-agriculture-gdp						2.458***	
						(0.911)	
FR-ind							2.458***
							(0.911)
Constant	-0.190	-0.149	0.559	0.049	-0.285	-0.140	-0.140
	(1.804)	(1.820)	(1.834)	(1.848)	(1.809)	(1.818)	(1.818)
Observations	1,714	1,714	1,714	1,714	1,714	1,714	1,714
R-squared	0.369	0.364	0.377	0.366	0.365	0.364	0.364
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Years	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes : ***p<0.001, **p<0.01, *p<0.05. Standard errors in parentheses.

2.9 Validation of transmission channels

This part tests three transmission channels : the ratio of public deficit to GDP, the rating of long-term sovereign debt in foreign currency, and the ratio of outstanding short-term external debt.

The results (32) show that adopting fiscal rules reduces the public deficit. These results corroborate with the work of (Luechinger and Schaltegger, 2013 ; Milesi-Ferretti, 1997 ; Kennedy et al., 2001). The increase in the deficit also reduces foreign direct investment (Gale and Orszag, 2003). The results also reveal that fiscal rules increase sovereign debt ratings. These results are also confirmed by the work of (Sawadogo, 2020). An increase in sovereign debt rating signals macroeconomic stability to investors and increases foreign investment (Shah, 2017). Finally, for the third channel, the results show that fiscal rules decrease the debt ratio. This result is confirmed by the work of (Wyplosz, 2012). An increase in the debt ratio also decreases foreign direct investment because it sends a negative signal to foreign investors about the country's economic stability. All of these results show that the ratio of public deficit to GDP, the rating of long-term sovereign debt in foreign currency, and the ratio of outstanding short-term external debt are factors by which fiscal

TABLE 32 – Validation of transmission channels

Variables	Current account balance	2Sovereign debt FDI	rating	4External debt FDI	stocks	FDI
Fiscal rules	-1.388** (0.647)		0.286* (0.157)		-2.363*** (0.789)	
Current account balance		-0.179** (0.075)				
Sovereign debt ratings				0.139* (0.082)		
Short-term external debt stocks						-0.044* (0.025)
Constant	-0.939 (2.528)	2.661 (1.667)	6.681*** (0.836)	-4.271** (1.832)	13.260*** (1.648)	3.361* (1.954)
Observations	2,221	2,218	1,507	1,503	2,064	2,034
R-squared	0.334	0.358	0.845	0.299	0.523	0.290
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

rules affect Foreign Direct Investments (FDI).

Conclusion

This study highlights the link between fiscal rules and Foreign Direct Investments (FDI) in developing countries from 1990-2020. We make three contributions : First, we identify how fiscal institutions affect FDI in developing countries. Secondly, this study shows through the entropy method, accompanied by PSM, that there is a causal effect between fiscal rules and FDI. Finally, we deepen the reflection by analyzing the effects according to the differences between the countries through heterogeneity analysis. Two hypotheses are at the heart of this study : The first hypothesis states that adopting fiscal rules increases FDI, and the second relates to the decomposition of fiscal rules. We used the entropy balancing method of [Hainmueller \(2012\)](#) the causal effect between fiscal rules and Foreign Direct Investments (FDI). The [\(Rosenbaum and Rubin, 1983\)](#) propensity score matching (PSM) method, along with other usual robustness models, are used to analyze the causal effect between fiscal rules and Foreign Direct Investments (FDI). The results show that the adoption of fiscal rules increases FDI. Three arguments could justify these results. First, adopting the rules leads to discipline in managing macroeconomic aggregates ([Sacchi and Salotti, 2015](#); [Andrés and Doménech, 2006](#)), and this discipline is conferred by the rules attract more FDI in the country because investors invest in places where they can make their investments profitable. Then the second reason lies in the fact that the adoption of the fiscal rules refers to

sound management of the fiscal policy (Fatás and Mihov, 2006; Kopits, 2001; Sacchi and Salotti, 2015; Andrés and Doménech, 2006; Badinger, 2009) since the fiscal rules are binding. This good management of fiscal policy sends a positive signal to investors about economic stability, and this stability influences the decision to invest more in a country. Finally, the adoption of fiscal rules leads to a better allocation of resources (Schick, 2003; Sutherland et al., 2005; Primus, 2016) and this better allocation of resources implicitly leads to an improvement in the economic environment by making it more attractive to investment (FDI). Adopting the rules also leads to the countries' economic stability, allowing them to borrow at reduced costs (Sawadogo et al., 2020; Sawadogo, 2020). The other rules (income, deficit, and debt) positively influence FDI, except for expenditure rules. The analysis of transmission channels shows us that the ratio of public deficit to GDP, the rating of long-term sovereign debt in foreign currency, and the ratio of outstanding short-term external debt are channels through which FR affect FDI in developing countries. An in-depth analysis led us to perform a heterogeneity analysis. The results show that the effect of the fiscal rules is amplified in the presence of a high level of the business climate in the investment profiles of the countries, of the economic performance, and of a better structuring of the agricultural and industrial sectors. On the other hand, this effect is attenuated in the presence of mining rents (oil and gas) and a high level of the real interest rate of the economy.

By referring to the results of this study, we can propose some recommendations for economic policy. First, it helps developing countries struggling to mobilize external resources for development because of the image deficit, the lack of credibility of fiscal policy, etc., to adopt binding fiscal rules likely to restore their image and increase the credibility of budget management. For this, we must create institutional conditions capable of sufficiently increasing the cost of leaders circumventing fiscal rules. The sound management of macroeconomic aggregates must be based on an obligation to produce results. Reforms must be undertaken toward a better allocation of public resources to make the agricultural sector, infrastructure, industry, and mining sector more attractive to investors because a good part of the FDI in Africa is in these sectors.

Then, developing countries should improve the quality of institutions and maintain the country on a trajectory of political stability to avoid any situation that discourages investors who wish to invest. These countries must capitalize on the natural resource deposits they possess in order to attract sufficient FDI in the mining sector and thus create more jobs. For this, an attractive business climate is needed, as well as a mining code reform to reassure investors and security and guarantee the credibility of the judicial system (in the event of a dispute).

Regarding economic policy implications, it is necessary to limit the interference of politics or political actors in implementing fiscal rules as this distorts and prevents reform construction. To do this, fiscal rules should be implemented by sufficiently independent entities far from political interference. The decision to invest is also guided by the possibility of investors repatriating the capital invested. This is why countries should implement an innovative framework capable of

reassuring investors about the freedom of movement of capital. The business ecosystem must be sufficiently efficient through attractive reforms that attract investments.

Finally, in addition to adopting fiscal rules, a country must have excellent economic performance and improved structuring of its infrastructure, agriculture, and industry sectors in order to attract sufficient FDI. Such structuring involves implementing reforms that increase a country's competitiveness in terms of business climate and economic stability and improve property rights. All such reforms must be crowned by a quality judicial sector that can reassure foreign investors and thus influence them to invest.

To better deepen the research on the effects of fiscal rules on FDI, it would be helpful to explore the possibilities of a study on the severity of fiscal rules in developing countries. In addition, it would be desirable to extend research on the neighbourhood effects of fiscal rules.

TABLE 33 – Descriptive statistics

Apart from the FDI and FR the rest of the variables are laggy in the basic model					
Variables	Observations	Moyenne	SD	Min	Max
FDI	2366	3.4379	6.5531	-40.0866	109.0253
Fiscal rules	2418	.2754	.4468	0	1
Currency	2418	.1025	.3034	0	1
Inflation	2261	34.7068	262.3203	-16.1173	7481.664
Fiscal balance	2166	-2.4394	6.4945	-151.309	43.304
Checks and balances	2284	2.6917	1.5923	1	18
Financial openness	2300	-.0222	1.4597	-1.9270	2.3106
Hardit	2418	.1410	.3481	0	1
Institution	2114	2.4141	.9072	0	5

TABLE 34 – Description

Variables	Description	Source
Fiscal balance	Fiscal balance (% of GDP) is government revenue minus spending ; negative means deficit, positive means surplus.	WDI
Checks and balances	It is an index that makes it possible to capture the counter-power or the political counter-weight in a country	Badinger and Reuter (2017)
Currency	is a binary variable that indicates 1 if the country belongs to a monetary union and 0 otherwise	WDI
FDI	Foreign direct investment is the net inflow of capital to acquire at least a 10% ownership in a foreign enterprise.	WDI
Inflation	measures the ratio of the general price level	WDI
Fiscal rules	is a binary variable that indicates 1 if the country has adopted at least one fiscal rule and 0 otherwise	FMI
Hardit	is an index that captures 1 if the country has adopted inflation targeting and 0 otherwise	Roger (2009) ; Tapsoba (2012)
Institution	It is an index that captures the fight against corruption in the political system	ICRG
financial openness	is an index that captures the financial openness of a country	Chinn-Ito index (2002 ; 2006 ; 2008)

The list of sample countries		
Number	Country	Type
1	Angola	Developing country
2	Albania	Developing country
3	Armenia	Developing country
4	Azerbaijan	Developing country
5	Burkina Faso	Developing country
6	Bangladesh	Developing country
7	Bulgaria	Developing country
8	Bahrain	Developing country
9	Belarus	Developing country
10	Brazil	Developing country
11	Botswana	Developing country
12	Chile	Developing country
13	China	Developing country
14	Cameroon	Developing country
15	Colombia	Developing country
16	Costa Rica	Developing country
17	Dominican Republic	Developing country
18	Algeria	Developing country
19	Ecuador	Developing country
20	Ethiopia	Developing country
21	Ghana	Developing country
22	Guinea-Bissau	Developing country
23	Guatemala	Developing country
24	Honduras	Developing country
25	Croatia	Developing country
26	Hungary	Developing country
27	Indonesia	Developing country
28	India	Developing country
29	Iraq	Developing country
30	Jamaica	Developing country
31	Jordan	Developing country
32	Kazakhstan	Developing country
33	Kenya	Developing country
34	Kuwait	Developing country
35	Lebanon	Developing country
36	Liberia	Developing country
37	Sri Lanka	Developing country
38	Morocco	Developing country
39	Madagascar	Developing country
40	Mexico	Developing country
41	Mali	Developing country
42	Myanmar	Developing country
43	Mongolia	Developing country
44	Mozambique	Developing country
45	Malawi	Developing country
46	Malaysia	Developing country
47	Namibia	Developing country
48	Niger	Developing country
49	Nigeria	Developing country
50	Nicaragua	Developing country
51	Oman	Developing country
52	Pakistan	Developing country
53	Panama	Developing country
54	Peru	Developing country
55	Philippines	Developing country
56	Papua New Guinea	Developing country
57	Poland	Developing country

58	Paraguay	Developing country
59	Qatar	Developing country
60	Russian Federation	Developing country
61	Saudi Arabia	Developing country
62	Sudan	Developing country
63	Senegal	Developing country
64	Sierra Leone	Developing country
65	El Salvador	Developing country
66	Serbia	Developing country
67	Suriname	Developing country
68	Togo	Developing country
69	Thailand	Developing country
70	Trinidad and Tobago	Developing country
71	Tunisia	Developing country
72	Turkey	Developing country
73	Uganda	Developing country
74	Ukraine	Developing country
75	Uruguay	Developing country
76	South Africa	Developing country
77	Zambia	Developing country
78	Zimbabwe	Developing country

Chapter III

Fiscal Rules and Green Investment in Developing Countries

HISGUIMA DASSIDI Crépin^{28 29}

Abstract

This study analyzes the causal effect of fiscal rules (FR) on green investment (GI) in developing countries. Using the entropy balancing on a sample of 76 countries, we test two hypotheses : the first states that adopting fiscal rules increases green financing, and the second is related to the ability of different types of rules to attract more investment to address climate change. Our robust results show that adopting fiscal rules increases climate investment. Unlike expenditure rules, deficit, debt, and revenue rules positively affect green financing. The effect of fiscal rules on green financing is amplified in countries with strong economic performance, high levels of democracy, good-quality institutions, and a well-functioning state apparatus. However, this effect is mitigated by high natural resource rents.

Key words : Fiscal rules, green investment, fiscal policy

JEL Classification : E60 ; E62 ; Q5

I declare that I have no conflicts of interest and that the data from this study are available upon request

28. We want to take this opportunity to express our gratitude and deep appreciation to Xavier GALIEGUE, Senior Lecturer in Economics at the University of Orléans ; Djamel KIRAT, Senior Lecturer in Economics at the University of Orléans and Bao-wé BAMBE, Ph.D in Economics for their advice and guidance on the framework of this study.

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Introduction

In response to macroeconomic imbalances resulting from internal and external factors, several countries set a numerical limit to budgetary and accounting aggregates, such as inflation, deficit, debt, and public expenditure. Since the 1990s, fiscal rules have emerged as one of the main tools for fiscal policy discipline, making them a credible alternative for achieving economic stability (Fatás and Mihov, 2006; Badinger, 2009; Schaechter et al., 2012; Andrés and Doménech, 2006). International institutions such as the International Monetary Fund (IMF) have overwhelmingly recommended the adoption of fiscal rules (fiscal institutions) for countries that suffer from a credibility deficit in managing their macroeconomic framework. Fiscal rules can be national or supranational : National rules often aim to constrain macroeconomic aggregates to avoid fiscal drift and increase fiscal policy credibility. The impact of fiscal rules depends on their ability to consolidate key macroeconomic aggregates such as debt, inflation, and the budget deficit.

In developing countries, adopting fiscal rules is even more justified because of the high exposure of these countries to exogenous shocks that affect the macroeconomic balance. Adopting fiscal rules in these countries may make fiscal policy management more credible, attract more investment, and help restrain a deficit trend that could lead to excessive debt levels. Fiscal rules also prevent pro-cyclical policies that exacerbate economic cycles, thus helping to promote a more prudent fiscal path (Wyplosz, 2012; Alesina and Tabellini, 1990; Persson et al., 2000).

Green investment refers to all financial operations carried out by an economic agent to promote the energy transition, combat climate change, and promote environmental protection and management. They represent socially responsible investments (SRI or RI), which include investments in sustainable projects, green funds, and green bonds. According to the BloombergNEF report ³⁰, green investments totalled \$26 billion in the first half of 2022 (in the world).

Green investments are a way to boost the economy and meet environmental goals. For example, green investments have been essential to economic recovery in the US and South Korea. They have created more than 26,000 jobs in the US and 276,000 jobs in South Korea ³¹.

The evolution of green investment in developing countries is timid compared to that of the rest of the world. In 2022, at COP27 in Egypt, the African Development Bank presented a green banking initiative (1.5 billion dollars) to increase green investment by reducing financing costs and mobilizing private sector investment in climate action in Africa. With the implementation of this

30. Report published in August 2022 (<https://about.bnef.com/insights/finance/renewable-energy-sector-defies-supply-chain-challenges-to-hit-a-record-first-half-for-new-investment/>)

31. Ministry of Ecological Transition, France : Green investments for economic recovery for economic recovery

initiative in Africa, access to green investments is expected to increase from 3% in 2022 to 10% in 2030. According to the AfDB³², 80% of climate finance comes from public entities : the Green Climate Change Fund, the Global Environment Facility, and contributions from donor countries.

Developing countries are the least likely to benefit from green financing, even though they are the least responsible for greenhouse gas emissions and the most exposed to climate disruption³³. Hence, there is a need to find credible alternatives promoting green investments, including mobilizing internal resources and easy access to external green resources. Ease of access to external resources is proportional to the strength of factors such as a country's economic stability and repayment capacity, as well as the credibility of its macroeconomic framework, all of which can be improved by adopting fiscal rules. Fiscal rules play an essential role in attracting and accessing foreign investment (Sawadogo, 2020 ; Regling, 2022 ; Sutherland et al., 2005).

The link between fiscal rules and green investment is through the credibility of fiscal policy and the ability to attract investment. A country's fiscal rule adoption can signal to financial markets the credibility of its macroeconomic framework and lower its borrowing costs (Sawadogo (2020)). These resources can be used to finance environmental protection and management. The adoption of the rules could also encourage or influence the decision of investors to come and invest (Göndör and Nistor, 2012 ; Rădulescu and Druica, 2014) in environmental protection and management. Environmental investors have the incentive to invest in fiscally stable and credible countries.

The adoption of fiscal rules strongly influences the attractiveness of green investments by sending clear signals to investors about economic stability and political priorities. When fiscal rules are perceived as predictable and compatible with long-term policies, they strengthen financial market confidence. This is particularly true for green investments, which require long-term and consistent commitments from public authorities, particularly in the energy, transport, and construction sectors. However, if these rules are too restrictive, they can hamper the ability of governments to co-finance or support green projects, thus limiting their perceived profitability. Private investors, often reluctant to take high risks on green infrastructure projects alone, rely on public involvement to secure their investments.

Poorly calibrated fiscal rules, which excessively constrain public investment, can therefore reduce the leverage effect of public funds and discourage private investment in the ecological transition. Conversely, fiscal rules that explicitly recognize the strategic importance of green investments, for example by temporarily excluding certain green expenditures from deficit calculations, can increase their attractiveness. This creates a favorable environment for sustainable investment by demons-

32. African Development Bank

33. Declaration of the COP 21 in Paris in 2015

trating that governments are committed to supporting the green transition in the long term. By integrating sustainability into fiscal governance, governments strengthen the credibility of their climate policies and attract capital to projects with a high environmental impact.

This article is linked to two strands of literature : The first strand highlights the importance of fiscal rules ([Debrun and Kumar, 2007](#) ; [Debrun, 2007](#) ; [Debrun et al., 2008](#) ; [Debrun et al., 2009](#) ; [Rose, 2006](#) ; [Kumar and Ter-Minassian, 2007](#) ; [Beetsma et al., 2018](#) ; [Combes et al., 2021](#)) in the management of fiscal policy and the second examines the link between fiscal rules and green investment ([Eyraud et al., 2011](#) ; [Eyraud et al., 2013](#) ; [Cottarelli, 2020](#) ; [Regling, 2022](#) ; [Barabanov et al., 2021](#) ; [Jaraite et al., 2014](#) ; [Darvas and Anderson, 2020](#) ; [Darvas and Wolff, 2021](#) ; [Mathieu et al., 2022](#)). In the first strand of the literature, understanding the importance of fiscal institutions is needed to understand the contribution of fiscal policy and, more specifically, the contribution of macroeconomic stability and the credibility of fiscal policy to economic activity. The second strand explores green investments and their link with fiscal rules. Indeed, fiscal rule adoptions improve credibility, resource allocation and stability to fiscal stability, which creates a favourable environment that attracts more green investments and foreign investors ([Ranjan and Agrawal, 2011](#) ; [Shah, 2014](#) ; [Aizenman, 2003](#)).

Several studies have examined the link between fiscal rules and public finance or economic performance, but very little work has focused on the effect of fiscal rules on green investments ; hence the interest of this study, which differs from existing work ([Bergman et al., 2016](#) ; [Marneffe et al., 2010](#) ; [Annicchiarico and Giammarioli, 2004](#) ; [Bergman et al., 2013](#) ; [Schuknecht, 2004](#)) by analyzing the causal effect of fiscal rules on green investments. This study focuses on developing countries because they are both the ones that struggle to mobilize green investments and the ones that are most exposed to environmental degradation but pollute the least (compared to the rest of the world).

[Nakatani \(2021\)](#) discusses the impact of natural disasters and climate change on the long-term debt dynamics and proposes innovative fiscal rules. The author demonstrated the primacy of a recurrent expenditure rule based on nonresource and nongrant revenues, determined interdependently by public debt and balanced budget targets, taking into account expected climate shocks. According to [Nakatani \(2021\)](#), this innovative fiscal rule is referred to as a disaster-resilient fiscal rule, offering many advantages over existing fiscal rules. They also provide an analytical framework for calibrating debt and budget balance targets, as well as expenditure rules. This fiscal policy framework includes the expected impact of natural disasters (shocks) on budget balances.

The difference between the work of [Nakatani \(2021\)](#) and our analysis lies in two points. First,

[Nakatani \(2021\)](#)'s work analyzes the impact of natural disasters and climate change on long-term debt dynamics and proposes fiscal rules, while our study analyzes the impact of fiscal rules on green investments. The idea is to see to what extent the adoption of fiscal rules could contribute to mobilizing more green investments to finance the fight against climate change. Second, [Nakatani \(2021\)](#)'s study focuses only on small island developing countries, while our analysis focuses on developing countries.

In this article, we analyse the effects of fiscal rules on green investment in developing countries using the method of entropy balancing ([Hainmueller, 2012](#); [Hainmueller and Xu, 2013](#)). Secondly, we examine the fiscal rules most conducive to green investment in developing countries. An in-depth analysis we identify the transmission channels through which fiscal rules affect green investment. Since developing countries do not all have the same characteristics, a heterogeneity analysis will finally be conducted to identify the specificities between these countries.

The rest of the study is structured as follows : Section 3.1 looks at a review of the theoretical and empirical literature. Section 3.2 presents the stylized facts and identification of transmission channels. In section 3.3, we present the data. Section 3.4 presents the identification strategy, results and sensitivity analysis. Section 3.5 analyzes the heterogeneity and transmission channels. Finally, the last section concludes the study.

3.1 Literature review

Fiscal rules are adopted to reduce the country's budget deficit and inflation, making the debt more sustainable through binding rules and preventing or limiting political interference in fiscal policy management. Several solutions have been proposed in the economic literature ([Debrun et al., 2008](#)) to reduce deficit bias. [Debrun et al. \(2008\)](#) proposes four solutions to the deficit bias problem : Firstly, they argue that with fiscal rules, fiscal policymakers will be more accountable for their actions, thus bound by an obligation of results. This is consistent with the work of [Kumar and Ter-Minassian \(2007\)](#), which suggests the same thing. Secondly, like [Von Hagen and Harden \(1995\)](#), [Debrun et al., 2008](#) argue that adopting fiscal rules contributes to improving the budgetary procedures governing the preparation, approval, and implementation of the country's annual budget. Thirdly, the authors argue that adopting and implementing the fiscal rules would lead to less political interference or pressure in fiscal policy management. This argument is also developed by [Wyplosz \(2005\)](#). Finally, [Debrun et al., 2008](#) argues that adopting ex-ante fiscal rules contributes to more efficient fiscal policy management and can, therefore, reduce the discretionary power of budgetary authorities and allow the achievement of the objectives set through budgetary aggregate ceilings. This argument is also developed in the work of [Krogstrup and Wyplosz \(2010\)](#).

Fiscal rules are budgetary institutions that function as binding devices for fiscal policymakers and reduce the information asymmetry between the electorate and policymakers (Debrun and Kumar, 2007). Their binding nature prevents decision-makers from drifting in the execution of the budget Rose (2006) and enhances the credibility of fiscal policy (Combes et al., 2021).

Fiscal institutions also contribute to reducing financial risks Begg (2017). However, the economic literature suggests that proper implementation of fiscal rules requires institutions that are sufficiently independent and insulated from political interference (Debrun et al., 2009; Beetsma et al., 2018). Similarly, Bergman et al. (2016) shows that the effectiveness of rules depends on better quality institutions and explains that the quality of institutions is a necessary precondition for formulating, implementing, and monitoring fiscal rules. Debrun (2007) shows that the effectiveness of fiscal rules depends on the cost of circumventing them. A fiscal rule is effective when the cost to policymakers of circumventing it is high. The higher the cost of circumventing fiscal rules, the more discipline they bring to fiscal policy management. Adopting fiscal rules also helps send a strong signal to investors and financial markets about the credibility of the country's fiscal policy. This helps to lower the cost of borrowing on financial markets (Sawadogo, 2020).

The link between fiscal rules and public finances has been extensively discussed in the economic literature (Bergman et al., 2016; Marneffe et al., 2010; Annicchiarico and Giammarioli, 2004; Bergman et al., 2013; Schuknecht, 2004; Corbacho and Ter-Minassian, 2013). The adoption of fiscal rules contributes to increasing the efficiency of public finances. It also allows for better allocation of public resources. The rules, through their binding character, favor the excellent use and distribution of resources, thus allowing the achievement of public policy objectives.

Another strand of the literature analyzes the link between fiscal rules and green finance. For example, recent work by Cottarelli (2020) proposes a series of reforms to green the fiscal rules. They suggest excluding green public investments from the deficit and other ceilings but argue that this should be done on an accrual basis. Also, the benefits of green public investment are such that it would be helpful to accept higher costs that could result in higher deficits and debt. However, it warns that the additional public debt created by deficit-financed green public investment will likely increase fiscal sustainability risks. In contrast, the work of Regling (2022) Instead proposes a budget deficit limit of 3 per cent, which must be combined with a higher limit (above 60 per cent) on the debt/GDP target and a combination of an expenditure rule and a primary balance rule targeting debt reduction in good economic times. Cottarelli (2020) identifies green economic activities as those that contribute to the achievement of at least one of the following six objectives : climate change, mitigation, adaptation to climate change, sustainable use of water and marine resources,

circular economy, pollution prevention, and ecosystem health. However, he argues that considering one objective should not prejudice the achievement of another.

[Eyraud et al. \(2013\)](#) define green investments as those needed to reduce greenhouse gas emissions and air pollutants without significantly reducing the production and consumption of non-energy goods. They analyze the effects of macroeconomic factors on green investment and show that strong economic performance and higher income levels lead to increased green investment. As a reminder, green investments cover both public and private investments. [Eyraud et al. \(2011\)](#) identify the main determinants of green investment : economic growth, population, technical progress and innovation, interest rates, fossil fuel costs, producing green capital goods, and public policies to support green investments. [Barabanov et al. \(2021\)](#) identify them as GDP per capita, population, creditor rights, and the quality of the judiciary. These latter find that large firms are more likely to invest in the environment, while highly valued or more profitable firms invest less in the environment sector. These arguments are consistent with [Jaraite et al. \(2014\)](#) and [Haller and Murphy \(2012\)](#), which also find the same result. [Stern \(2004\)](#) find that companies in high-income countries have higher environmental spending and are more involved in environmental innovation. He finds that investment in renewable energy sources and green technologies is helping to offset the fossil fuel deficit.

[Darvas and Wolff \(2021\)](#) analyze the link between fiscal rules and green investments and propose reforming the European Union's fiscal rules to increase green investment while consolidating the budget deficit. Their reform aims to create a golden rule that excludes net green investment from the fiscal indicators used to measure compliance with fiscal rules. They suggest that better regulatory policy and higher emissions prices should encourage private green investment. The limitation of [Darvas and Wolff \(2021\)](#) is that they do not empirically analyze the link between fiscal rules and green investments. The main contribution of our study is that it considers this limitation by analyzing the causal effect of rules on green investment and identifies the channels through which fiscal rules affect green investment.

[Beetsma \(2022\)](#) warns that excluding green investments from the caps could increase the risk of "greenwashing." [Mathieu et al. \(2022\)](#) also analyzes the possibility of reforming current fiscal rules to favour green investments. They suggest replacing the current rules with a single public expenditure rule. The public expenditure rules have advantages and disadvantages, but for them to succeed, their implementation must be monitored by an independent budget committee. [Mathieu et al. \(2022\)](#) oppose the conclusions of [Mitsi and Kottaridi \(2022\)](#), who find that expenditure rules negatively affect foreign investment because these rules refer to fiscal indiscipline. In our study, as a contribution to the literature, we make the exact estimates to see whether these results are

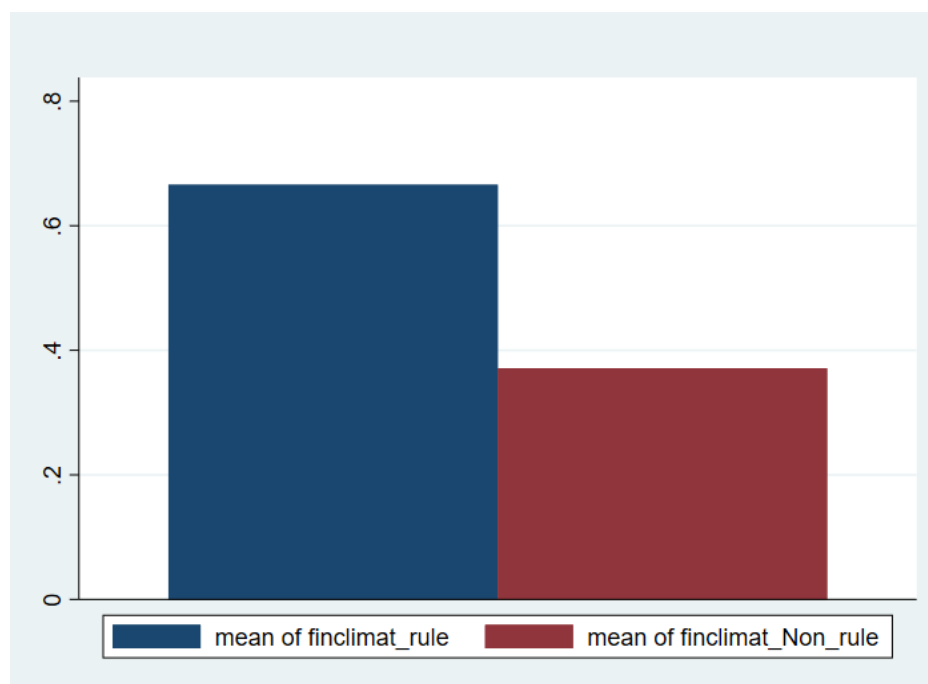
confirmed in our analysis. In the same vein of fiscal rules reforms, [Goncalves et al., 2022](#) argue instead that a risk-based medium-term fiscal framework that combines strengthened norms, rules, and institutions would strike a better balance between flexibility and credibility. In the latter case, a multi-year spending rule anchored in an appropriate public debt target is proposed, augmented by an asymmetric golden rule that provides additional fiscal space only in times of recession ([Darvas and Anderson, 2020](#)).

Following the same order of explanation of the link between fiscal rules and green investments, the work of [Nakatani, 2021](#) argued how the government can formulate fiscal rules to address climate change shocks and natural disasters, and studied the relationship between climate change and fiscal rules. He proposed investment-friendly natural disaster-resilient rule supports (re)building infrastructure to meet its needs for protecting people and property from natural disasters/climate change.

The contribution of our study to the existing literature lies in the analysis of the causal effect between fiscal rules and green investments. This study differs from the existing literature by performing the analysis for developing countries. This still needs to be addressed in the literature. In addition, this study contributes to the literature by examining the implications of policy and considering the specificities of the countries in the analysis.

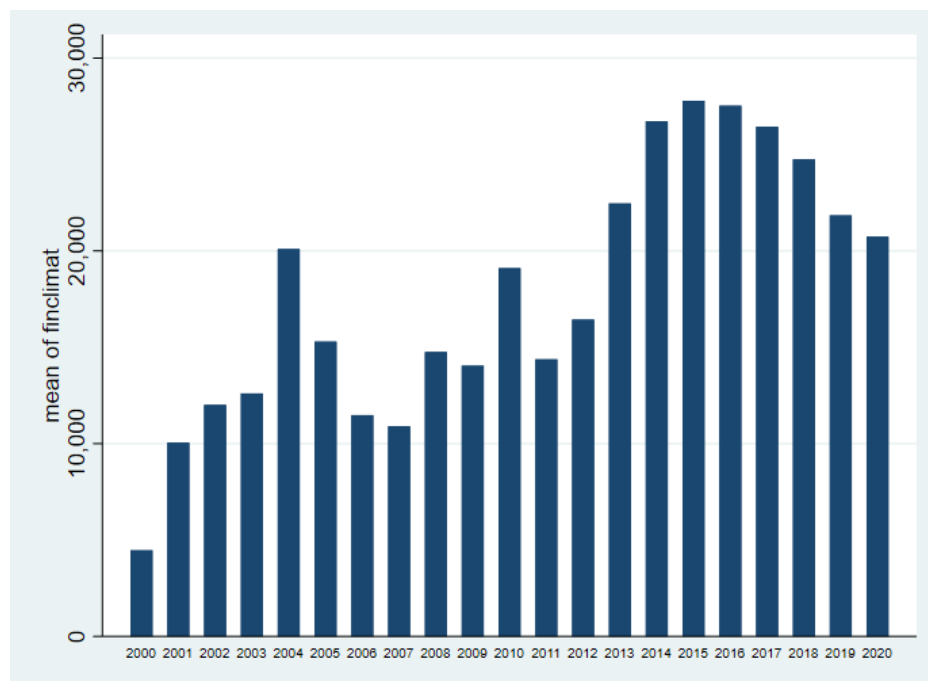
3.2 Stylized facts and identification of transmission channels

Figure 1 : Average evolution of the green investment(GI) of FR and non-FR countries (% of the GDP)



Source : Author's calculation. "mean of finclimat-rule" represents the average of green investments in countries that have adopted at least one fiscal rule. "mean of finclimat-Non-rule" represents the average of green investments in countries that have not adopted a fiscal rule.

Figure 2 : Evolution of green investment(GI) from 2000 to 2020



Source : Author's calculation. "mean of finclimat" represents the average of green investments in the developing countries in the sample.

In this section, we present the stylized facts that characterize green investments as a function of adopting fiscal rules (FR) in developing countries. Several economic studies highlight the critical contribution of fiscal rules to the dynamics of green investments ([Darvas and Anderson, 2020](#) ; [Darvas and Wolff, 2021](#)). The works of ([Darvas and Wolff, 2021](#) ; [Eyraud et al., 2011](#) ; [Barabanov et al., 2021](#)) find a positive and significant effect of fiscal rules on green investments.

Figure 1 shows the increase in the green investment ratio as a function of whether fiscal rules were adopted between 2000-2020. On average, the ratio of investment to GDP increased by more than 60% over the study period. However, this increase was more significant in countries that adopted at least one fiscal rule (around 0.7% of GDP) than in countries that did not (with 0.3% of GDP on average) (see Figure 1). A link can, therefore, be established between the adoption of fiscal rules and an increase in green investments. This link was highlighted in the works of ([Darvas and Anderson, 2020](#) ; [Darvas and Wolff, 2021](#)), which show that fiscal rules promote macroeconomic stability and create a favourable environment for attracting more climate-friendly investments. The stability of macroeconomic aggregates provided by the rules also influences investors' decision-making [Simões et al. \(2014\)](#). Countries with at least one fiscal rule attract more green investment

than countries without fiscal rules (See Figure 1).

In the wake of economic crises and other fiscal abuses, international financial institutions (e.g., IMF) have advised adopting fiscal rules to withstand exogenous shocks to the economy, allowing for better resource allocation and stability of the macroeconomic framework. As a result, several developing countries have adopted one or more fiscal rules to discipline their fiscal policy and make it more credible. Indeed, climate-friendly investments and the number of countries adopting fiscal rules increased between 2000 and 2020.

3.2.1 Identification of transmission channels

This section identifies the channels through which fiscal rules affect green investment. First, there is the credibility channel. Indeed, adopting fiscal rules increases the credibility of fiscal policy [Kopits \(2001\)](#), and this credibility, in turn, attracts more green investment ([Sawadogo \(2020\)](#)). Secondly, fiscal rules help reduce the debt ratio through fiscal policy discipline, which helps raise a country's sovereign debt rating [Sawadogo \(2020\)](#). This indication of stability, in turn, attracts more investments. Thirdly, the adoption of fiscal rules also contributes to strengthening inflation stabilization (inflation targeting) ([Svensson \(1996\)](#); [Combes et al. \(2018\)](#)). Stable inflation is a signal of economic stability and also attracts more investment to the country ([Tapsoba, 2012](#); [Mason and Vracheva, 2017](#)). Finally, the adoption of fiscal rules promotes growth [Afonso and Jalles \(2013\)](#), and the resulting economic performance attracts more green finance ([Zenghelis, 2012](#); [Zhang et al., 2022](#)). In sum, credibility, sovereign debt rating, inflation targeting, and economic performance are the channels through which fiscal rules affect climate investment.

3.3 Data

3.3.1 Data sources

Much of the data for this study comes from the World Development Indicators(WDI) database³⁴. Data on fiscal rules are taken from the International Monetary Fund (IMF) Fiscal Rules dataset³⁵. The institutional data come from the International Country Risk Guide (ICRG) database³⁶. Their measurements and methodology are contained here³⁷. The data on green investment comes from the Organisation for Economic Co-operation and Development (OECD) database. The institutional variables come from the International Country Risk Guide (ICRG)

34. <https://databank.worldbank.org/source/world-development-indicators>

35. <https://www.imf.org/external/datamapper/fiscalrules/map/map.htm>

36. <https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/4YHTPU>

37. <https://www.prsgroup.com/wp-content/uploads/2014/08/icrgmethodology.pdf>

3.3.2 Database description

This study uses the ratio of green investment to GDP as the dependent variable. Our treatment variable is a binary variable that indicates if the country has adopted a fiscal rule and 0 otherwise. We control for a series of control variables : growth, exchange rate regime, debt ratio, trade index, and bureaucracy index. The period (2000-2020) is chosen according to the availability of green investment data.

Measuring fiscal rules

Fiscal rules appeared in the middle of the 19th century in the constituent United States. They are tools for managing fiscal policy that aim to combat deficit bias, generate credibility for borrowing more cheaply on international markets, and represent a means of combating budgetary externalities resulting from excessive deficits. Several fiscal rules are identified in the economic literature, namely procedural and numerical rules. Procedural rules are budgetary procedure rules. Whatever the institutional structure of a country, two main decision-making procedures can be distinguished :

- 1- Collegial procedure : a procedure that allows several structures to participate in the budgetary decision-making process. This procedure allows for better representation of social groups but can lead to the tragedy of the commons.
- 2- Hierarchical procedure : One agent has a predominant role in budget-making in this procedure. The most effective way to reduce the tragedy of the commons is to adopt top-down or hierarchical budget procedures.

Conversely, numerical rules are targets (ceilings or floors on macroeconomic aggregates) that constrain fiscal aggregates. They are permanent constraints on the execution of budgetary policy and are expressed as a synthetic indicator of budgetary performance. However, fiscal rules also have limitations that should be noted. First, they encourage the pro-cyclicality of fiscal policy. It is easier to adhere to rules in times of expansion than in times of economic slowdown. The target is structural balance, independent of the country's economic situation. Fiscal rules can sometimes penalize investment : when fiscal constraints are imposed on the government, it will forego investment because it is easier to sacrifice investment than to reduce current expenditure. Fiscal rules can have positive endogenous effects because the countries that adopt them are generally virtuous regarding fiscal policy management. Second, these rules sometimes weaken investment spending, which often leads to limiting or prohibiting debt or deficit when the debt is generated by investment spending.

Apart from adopting fiscal rules, there is a need for independent fiscal committees, which are

structures that can monitor the budget and are responsible for making an independent forecast. Several economic studies also suggest that the control of primary budgetary aggregates should be entrusted to these independent budgetary committees (Debrun et al., 2009; Beetsma et al., 2017; Beetsma et al., 2018). In this study, fiscal rules are measured by a binary variable that takes the value one if the country has adopted a fiscal rule and 0 otherwise. The database comes from the International Monetary Fund (IMF) 's fiscal Fiscal Rules Dataset³⁸.

Measuring green investment

The data on green investment used in our study is taken from the OECD database and is the ratio of the sum of all incoming (climate) finance to GDP. According to the IMF³⁹, green investment is the investment needed to significantly reduce emissions of greenhouse gases and air pollutants and promote climate change mitigation and adaptation. This study is a new multi-country historical dataset that tracks the green investments received by developing countries. Eyraud et al. (2011) find that green investment is stimulated by economic growth and a sound financial system conducive to low interest rates and high fuel prices. Other work, such as NUMÉRO (2012), proposes solutions (sustained growth, lowering the cost of capital, and carbon pricing) to boost climate-friendly investments.

Our control variables are composed of the following : The growth represents the positive change in the production of goods and services in an economy over some time, usually an extended period. It also represents the economic performance of countries. The more a country's economy grows, the more likely it is to attract additional investment (Afonso and Jalles, 2013; Gründler and Potrafke, 2020).

The debt ratio is an indicator of the sustainability of a country's debt. Indeed, the higher the debt ratio, the less sustainable the country is, and therefore, the less attractive it is to foreign investors. Investors often choose to invest in places with stable macroeconomic aggregates, making macroeconomic stability a determinant of FDI (Ranjan and Agrawal, 2011; Vijayakumar et al., 2010). We expect the debt ratio to affect green investment negatively.

Bureaucracy : High points are given to countries where the bureaucracy has the strength and expertise to govern without drastic policy changes or government service interruptions. We expect that bureaucracy will positively affect green investment.

Trade index : captures the percentage ratio of the export unit value indexes to the import unit value indexes, measured relative to the base year 2000. The terms of trade index measures the relative prices of a country's exports and imports. When a country's net barter terms of trade index increase, its exports become more expensive, or its imports become cheaper. We expect that

38. <https://www.imf.org/external/datamapper/fiscalrules/map/map.htm>

39. <https://www.imf.org/external/pubs/ft/fandd/fre/2012/06/pdf/eyraud.pdf>

the terms of the trade index will positively affect green investments. An increase in exports proves the dynamism of the country's economic performance ([Dollar and Kraay, 2003](#)), which is essential for attracting foreign investment.

The exchange rate regime is also essential in attracting foreign investment. It reassures investors and influences their investment decisions. [Aizenman, 1992](#) shows that a fixed exchange rate regime attracts more foreign investment than a flexible exchange rate regime, as well as the importance of the exchange rate regime in the attractiveness of foreign investment. We expect the exchange rate regime to affect green investment positively.

3.4 Identification strategy, results and sensitivity analysis

3.4.1 Identification strategy

In this study, the causal effect is analyzed through the entropy balancing method ([Hainmueller, 2012](#); [Hainmueller and Xu, 2013](#)). The model developed in this study is based on the work of [Badinger and Reuter \(2017\)](#). First, referring to the work of ([Chakraborty and Mukherjee, 2013](#)), we add the trade index among the control variables. Second, we follow the work on fiscal rules ([Sawadogo, 2020](#); [Ardagna, 2004](#)), which use the debt-to-GDP ratio as a control in our model. Several economic studies ([Ardagna, 2004](#); [Badinger and Reuter, 2017](#); [Badinger, 2009](#)) provide information on the link between the adoption of fiscal rules and economic performance. Thus, we introduce the variable that captures economic performance (Growth) among the controls. Based on the work of ([Taylor, 2000](#); [Snudden, 2016](#)), we also introduce the exchange rate regime variable among our control variables. Finally, drawing on the work of ([Teles, 2009](#); [Evans and Rauch, 1999](#)), we add the institutional variable that captures the bureaucracy of the government among the controls. We use the fixed-effect model, the GMM estimator, the Mahalanobis distance balancing method, and other alternatives to test our results' robustness.

3.4.2 Entropy balancing

Based on the work of [Hainmueller \(2012\)](#), which was subsequently implemented in the economic work of [Neuenkirch and Neumeier \(2016\)](#). We use the entropy balancing method in our policy impact assessment to analyze the causal effect of fiscal rules on green investment. This is a two-step method : In the first step, we calculate weights assigned to the control units (non-FR countries/countries that have not adopted fiscal rules). In the second step, we use the weights obtained in the first step in a regression analysis with the treatment variable (FR countries/countries having adopted the fiscal rules) as the explanatory variable. Then, based on observable characteristics, we match countries that have adopted fiscal rules with countries that have not adopted fiscal rules based on observable characteristics.

Entropy Balancing is a non-parametric estimation method used primarily in quasi-experimental analyses to assess causal effects. It is particularly useful for correcting selection bias in observational studies, such as the one on the impact of fiscal rules on green investments, by balancing the characteristics of treated and control groups. Its main objective is to re-weight observations so that the distribution of covariates is identical in the treatment and control groups (e.g., countries with or without fiscal rules). It therefore seeks to ensure conditional comparability without imposing a parametric model on the treatment assignment or the outcome. In short, entropy balancing is a non-parametric re-weighting method. It is not based on a probabilistic model (like logistic regression in the case of the propensity score) but on a mathematical optimization under linear constraints. This method has four advantages, namely (i) robust to the misspecification of the treatment model; (ii) easily handles continuous and categorical covariates, (iii) avoids the bias due to the imbalance of covariates between countries with/without fiscal rules and finally (iv) it allows to estimate the average effect of the treatment on the exposed countries (ATT). The objective of this study is to analyze the causal effect between the adoption of fiscal rules and climate investments. In other words, to see whether adopting fiscal rules improves or attracts more green investments in developing countries.

The green investments used in this study are the ratio of total incoming climate investments to GDP. The treatment variable indicates if the country has adopted at least one fiscal rule and 0 otherwise. The countries that have adopted the fiscal rules constitute the treatment group. Our empirical analysis's main challenge is finding a causal relationship between fiscal rules and green investments. There are several reasons why countries adopt fiscal rules : economic stability, limiting fiscal drift, fiscal profligacy, political risk, lack of liquidity, attracting more investment, etc. These reasons could be associated with macroeconomic factors and the political situation of countries. This could trigger an endogeneity problem. In order to remedy this situation, we propose the use of the matching method. It is more reliable and sufficiently robust than the usual linear regression methods. The relation gives the average effect of the treatment on the treated (ATT) :

$$ATT = E[(Y_{i1} - Y_{i0})|FR = 1] = E[(Y_{i1}|FR = 1)] - E[(Y_{i0}|FR = 1)] \quad (17)$$

In equation (1), FR is a binary variable that represents the adoption of fiscal rules (FR) in the country I, and Y_{i1} is a variable that captures green investments when the country I have not adopted FR (Non-FR). $Y_{i0}|FR=1$ denotes the value of green investments that would have been observed if a country that did not adopt FR (Non-FR) had adopted FR. $Y_{i1}|FR=1$ denotes the green investments observed for the same Non-FR country. The above equation compares the green investments observed in the Non-FR countries and those observed in the same countries if they had adopted fiscal rules (FR). This would give us an unbiased estimate of the ATT. However, the main difficulty with this equation is that the second term on the right-hand side is unobservable.

To circumvent this difficulty, we randomly select countries that have not adopted FR(Non-FR). Using this random selection, we can compare the sample average of the non-FR countries with that of the FR countries.

$$ATT = E[Y_{i1}|FR = 1, X_i] - E[Y_{i0}|FR = 0, X_i] \quad (18)$$

Where

$$E[Y_{i0}|FR = 1, X_i] \quad (19)$$

is replaced by

$$E[Y_{i0}|FR = 0, X_i] \quad (20)$$

, and we obtain this equation.

$$ATT = E[(Y_{i1} - Y_{i0})|FR = 1] = E[Y_{i1}|FR = 1, X_i] - E[Y_{i0}|FR = 0, X_i] \quad (21)$$

There are several reasons that could explain the effectiveness of using the entropy balancing method : first, it is more efficient and reliable than classical matching methods (Propensity Score Matching) because of its non-parametric character. With this method, there is little chance of a problem with the misspecification of the model's functional form, which could bias our results. Secondly, since the treatment variable is orthogonal to the covariate due to the reweighting mechanism, it avoids the problems of multicollinearity that could eventually arise. Finally, the entropy balancing method also allows us to combine a reweighting mechanism with a regression analysis [Neuenkirch and Neumeier \(2016\)](#). This method allows controlling for country and time-fixed effects in the regression analysis. Including country-fixed effects allows for potential unobserved heterogeneity between countries with and without fiscal rules. To account for country-specific temporal and structural specificities, we also use fixed effects to capture invariant factors that explain differences in green investment attractiveness.

3.4.3 The results

In this section, we proceed to the interpretation of the main results of our study.

3.4.3.1 Entropy balancing : Results

The results of the table [\(35\)](#) show us that there is a difference in average between the group of countries that have adopted at least one fiscal rule and those that have not adopted a fiscal rule. Column (1) represents the averages of the countries that have adopted the fiscal rules, and column (2) presents the average of those that have not adopted any fiscal rules. Column (3) shows the difference between columns (2) and (1). Columns (4) and (5) present the results of the t-test and p-value statistics, respectively. The results show that developing countries that have adopted fiscal

TABLE 35 – Descriptive statistics

	(1)	(2)	3=(2-1)		
Variables	FR	Non-FR	Difference	t value	p-value
Lag Climate finance/GDP	0.665	0.371	-0.294	-4.3810	0.0000
Lag Exchange rate regime	6.377	7.086	0.709	3.0460	0.0024
Lag Growth	4.0737	4.691	0.617	2.9113	0.0037
Lag Debt ratio	45.547	53.818	8.270	3.7344	0.0002
Lag Trade Index	118.291	120.609	2.317	1.2007	0.2300
Lag Bureaucracy	1.8325	1.7200	-0.112	-2.6090	0.0092
Number of observations	416	603			

TABLE 36 – Covariate balancing

	(1)	(2)	3=(2-1)		
Variables	FR	Non-FR	Difference	t value	p-value
Lag Climate finance/GDP	0.455	0.454	-0.001	-0.002	0.999
Lag Exchange rate regime	6.404	6.483	0.079	-0.323	0.747
Lag Growth	4.451	4.495	0.044	-0.178	0.859
Lag Debt ratio	41.21	42.82	1.61	-0.992	0.322
Lag Trade Index	120.7	120.4	-0.3	0.100	0.920
Lag Bureaucracy	1.775	1.763	-0.012	0.266	0.790
Number of observations	416	603			

TABLE 37 – Entropy balancing : Baseline model

	1	2	3	4	5	6	7	8
	Estimation 1	Estimation 2	Estimation 3	Estimation 4	Estimation 5	Estimation 6	Estimation 7	Estimation 8
Variables	Dependent variable : Climate finance/GDP							
Fiscal rules	0.078*	0.059	0.045***	0.031**	0.064	0.045	0.049***	0.038**
	(0.047)	(0.046)	(0.014)	(0.014)	(0.045)	(0.046)	(0.014)	(0.015)
Lag Exchange rate regime					-0.023***	-0.024***	0.006*	0.010***
					(0.007)	(0.007)	(0.003)	(0.003)
Lag Debt ratio					0.002	0.002	0.001	-0.0001
					(0.001)	(0.002)	(0.001)	(0.001)
Lag Bureaucracy					-0.353***	-0.349***	0.082**	0.066**
					(0.060)	(0.060)	(0.041)	(0.032)
Lag Growth					-0.010	-0.007	-0.001	0.003
					(0.006)	(0.006)	(0.002)	(0.002)
Lag Trade Index					-0.001	-0.001**	-0.0001	0.0002
					(0.000)	(0.000)	(0.0002)	(0.0002)
Constant	0.377***	0.239***	0.134***	0.122***	1.186***	1.114***	-0.031	-0.093
	(0.027)	(0.044)	(0.017)	(0.021)	(0.130)	(0.147)	(0.118)	(0.099)
Observations	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019
R-squared	0.003	0.025	0.946	0.960	0.188	0.207	0.947	0.960
Country FE	No	No	Yes	Yes	No	No	Yes	Yes
Year	No	Yes	No	Yes	No	Yes	No	Yes

Notes : In this table, we use the entropy balancing method. The treatment variable indicates 1 if the country has adopted at least one fiscal rule and 0 otherwise. The dependent variable is the ratio of inward green investment to GDP. ***p<0.001, **p<0.01, *p<0.05. Standard errors in parentheses.

rules receive more green finance than those that have not. The exchange rate regime, growth, trade index, and debt ratio averages are lower in countries with fiscal rules than in countries without fiscal rules. However, it can be seen from the table (35) that the bureaucracy index is higher in countries with fiscal rules than in countries without fiscal rules. With these descriptive statistics, choosing a reliable control group before estimating the treatment effect (matching approach) is still helpful. Otherwise, the treatment effect estimated may be biased. Thus, we construct a control group and compare the means of all corresponding covariates in the treatment and control groups created earlier. The results, presented in table (36) reveal that the differences in means between these two groups are statistically insignificant. Thus, in the table, we construct a control group and compare the means of all corresponding covariates in the treatment and control groups created earlier. The results in the table (36) show us that the differences in means between these two groups are statistically insignificant.

Using the control group of the covariate table, we estimate the effect that a country's adoption of fiscal rules has on green investment. For this, we use weighted least squares regressions. The results are presented in table (37). In column (1), we run a simple regression without adding controls, country-fixed effects, and time-fixed effects. We add the time-fixed effects and country-fixed effects in columns (2) and (3). In column (4), we add the time-fixed effects and country-fixed effects to our basic equation (1). In column (5), we add only the control variables. In columns (6) and (7), in addition to the control variables, we add the time and country-fixed effects, respectively. Finally, in column (8), we add the country and time-fixed effects simultaneously in addition to the controls. The results in columns (1) to (8) show that adopting fiscal rules increases climate investment. This effect is positive and significant. Adopting fiscal rules gives fiscal policy management more credibility, and this credibility of the fiscal framework attracts more climate-friendly investments. This is consistent with the ideas developed in (Cottarelli, 2020; Eyraud et al., 2013; Darvas and Wolff, 2021; Darvas and Anderson, 2020).

These results could be explained by the fact that adopting fiscal rules sends a positive signal to investors on the economic stability of a country because they confer macroeconomic stability and make the economic environment more attractive to climate-friendly investment. It should also be added that the fiscal rule adoption allows for better allocation of a country's resources to its economic sectors, which contributes to making these sectors more attractive and favourable to green investment (Darvas and Anderson, 2020; Darvas and Wolff, 2021). Finally, adopting the rules makes it possible to reduce the cost of borrowing on the financial markets because the markets, being reassured of the credibility of the fiscal framework, reduce the cost of borrowing Sawadogo (2020). This means that with the adoption of fiscal rules, the resulting economic stability reduces the cost of borrowing and thus allows developing countries to attract sufficient investors (Sawadogo (2020)) and mobilize resources to make the economic environment more attractive to green external investment.

A major problem for developing countries remains the difficulty of borrowing cheaply on financial markets⁴⁰. Fiscal rules help reassure financial markets of economic stability and make it easier for countries to borrow to combat the effects of climate change. The positive and significant effect of fiscal rules on green investments could also be explained by the fact that developing countries, constantly exposed to the vagaries of climate change, need macroeconomic stability to attract more green finance to strengthen their resilience to the effects of climate change. However, to receive massive financing from donors, a country needs to reassure international partners of economic stability and credibility in fiscal policy management, without which donors would be reluctant

40. The studies of Sawadogo (2020) show that developing countries borrow at high costs

to invest. Fiscal rules are important because they give developing countries more credibility and stability in macroeconomic aggregates to attract more investment for the climate.

3.4.3.2 Entropy balancing : The effect of different types of fiscal rules

TABLE 38 – Robutness checks : Entropy balancing : Types of fiscal rules

	1	2	3	4	5
Variables					
Dependent variable : Climate finance/GDP					
Fiscal rules	0.038** (0.0151)				
Deficit rule		0.030** (0.0137)			
Debt rule			0.027* (0.0153)		
Expenditure rule				0.003 (0.0219)	
Revenue rule					1.805*** (0.0993)
<i>N</i>	1019	1019	1019	1019	1019
<i>r</i> ²	.9603	.9603	.9603	.9602	.9602

Notes : In this table, we use the entropy balancing method. The treatment variable(column 1) indicates 1 if the country has adopted at least one fiscal rule and 0 otherwise. The dependent variable is the ratio of inward green investment to GDP. In column 2, we measure the effect of adopting a deficit rule on green investments. In column 3, we measure the effect of adopting a debt rule on green investments. In column 4, we measure the effect of adopting an expenditure rule on green investments. Finally, in column 5, we measure the effect of adopting an income rule on green investments. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors in parentheses.

In this section, we present the results of the effect of different types of fiscal rules on green investments in the table (38). This result identifies the fiscal rules likely to attract more green investments in developing countries. In column 1, we present the results of the effect of adopting the rules on green investments. In columns (2) and (3), we present results on the effect of deficit and debt rules on climate-friendly investments. In the last two columns, we present the results of the expenditure rules and the income rules. The results (see table 38) show through column (1) that the adoption of fiscal rules positively and significantly influences green investments. In column

(2), the table 38 shows that fiscal rules on the budget deficit increase climate-friendly investments. The effect is positive and significant. Column (3) of table 38 analyses the link between debt rules and green investments and shows that debt ratio rules increase climate-friendly investments. Their effects are also positive and significant.

In column (4), the results of the table 38 show that spending rules do not affect green investments. The procyclicality of the fiscal rules could explain this. Some works (Combes et al., 2017; Bova et al., 2014) show the procyclical character of the rules in developing countries. Also, recent work by Mitsi and Kottaridi (2022) analyses the link between expenditure rules and FDI and shows that expenditure rules negatively affect foreign investment. They explain this by the fact that expenditure rules refer to fiscal indiscipline. In column (5) of the table (38), the results show that income rules positively and significantly affect green investment. Apart from expenditure rules, the other rules positively and significantly affect climate investment in developing countries.

3.4.4 Sensitivity analysis of results

To test the robustness of our results. A model is robust if it is valid under different circumstances. The robustness analysis is done in several steps.

3.4.4.1 Robustness : fixed effects and GMM estimator

In order to test the robustness of our results, we proceed by using the fixed-effects model and the Generalized Moment Method (GMM) estimator.

For the fixed effects model, the equation is as follows :

$$GI_{it} = \alpha_0 + \beta FR_{i,t} + \sum_{k=1}^k \Delta X_{i,t} + \eta i + \gamma t + \epsilon_{it}.$$

(With $i = 1, \dots, N$; $t = 1, \dots, T$). (22)

(ηi) is the fixed country effect. (γt) is the fixed effect that captures temporal characteristics and (ϵ_{it}) is the error term.

GI is the ratio of incoming green investment to GDP. It represents the dependent variable of the model. FR is the treatment variable (Fiscal rules). X is a vector that represents the set of level explanatory variables used in the model. Eta and gamma represent country-fixed effects and time-fixed effects, respectively. Epsilon is the error term. We use Arellano-Bond estimator. The results are shown in column 1 of the table (39). By incrementally adding the variables for corruption, stability, credit, internal conflict, external conflict, democracy index, fiscal balance, foreign direct

investment and Our World in Data (OWID) democracy index, we find that adopting fiscal rules increases green investment.

For the GMM (Arellano-Bond estimator), the equation is as follows :

$$GI_{it} = \alpha_0 + \beta GI_{i,t-1} + \gamma FR_{i,t} + \sum_{k=1}^k \Delta X_{i,t} + \epsilon_{it}.$$

(With $i = 1, \dots, N$; $t = 1, \dots, T$). (23)

GI represents the dependent variable of the model. It represents the ratio of incoming green investments to GDP. FR represents the treatment variable (Fiscal rules). X is a vector representing the set of explanatory variables used in the model. Epsilon is the error term. The results in column 1 of the table 40 show that fiscal rules positively and significantly affect green investments. Gradually adding the variables : foreign direct investment, official development assistance, corruption, quality of government, stability, socioeconomic index, oil rents, internal and external conflicts, remittances, inflation targeting, GDP per capita, capital openness, GDP per capita purchasing power parity and inflation we find that the effect of the rules on green investment remains unchanged.

In Table 41, we use Roodman's collapsing method. The results suggest that the adoption of fiscal rules positively and significantly affects green investments (see column 1). From column 2 to column 4, we add a new control variable, and the results remain robust.

3.4.4.2 Robustness : Additional control variables (entropy)

To test the robustness of our results, we add new control variables to see if the model is still robust despite these additions. Column 1 of the table 42 shows us that fiscal rules positively and significantly affect green investments. By progressively adding variables such as internal and external conflict, corruption, quality of institutions, investment profile, socio-economic welfare index, and democracy, we find that the effect of rules on green investments is always positive and significant at the 1% level.

3.4.4.3 Robustness : Change of variable of interest

In this section, we test the robustness of our results by changing the variable of interest by proxy variables of fiscal rule. For the first case (see table 43), the treatment variable is replaced by a proxy variable, indicating if fiscal rules are effectively implemented and 0 otherwise. The results (see table 43) show that the new treatment variable positively and significantly affects (columns 1 to 8) climate investment. In the second case, the treatment variable is replaced by a proxy variable that indicates one if the fiscal rule is flexible and 0 otherwise. The results (see table 44) show that this new treatment variable positively and significantly influences green investments. Finally, in

the third case, the treatment variable is replaced by a treatment variable that indicates one of the fiscal rules has been adopted by a legal framework (Parliament) and 0 otherwise. The results (see Table 45) show that this new variable positively and significantly affects (from columns 1 to 8) green investments.

3.4.4.4 Robustness : The strength of fiscal rules

In this section, we conduct a robustness test of our model using the strength of the fiscal rules. This variable is computed using the rule adoption procedure, the rules' character, flexibility, implementation, and nature of the rules. The results show that the strength of the rules positively and significantly affects green investment. In column 1, we keep only the treatment variable and green investments. In column 2, we add the country-fixed effects. In column 3, we add time-fixed effects. In column 4, we add country and time-fixed effects simultaneously. In column 5, we add controls only. In column 6, we add controls and country-fixed effects. In column 7, we add controls and time-fixed effects. Finally, column 8 adds controls, country-fixed effects, and time-fixed effects. From columns 1 to 8, we find (see table 46) that the strength of the rules has a positive and significant impact on climate investments.

3.4.4.5 Robustness : Alternative

In this section, we test the robustness of our results against different factors : In column (1) of the table (47), we only consider countries with an inflation rate below 40%. The results show that the effect of the rules on green investment is still positive and significant. In column (2), we exclude the financial crisis years of 2008 and 2009 from the sample. The results remain unchanged. In column (3) of the table (47), We only consider years after 1993 because the rules came into being in the 1990s, and their effects are visible in the medium and long term. By considering only the years after 1993, we want to know the effect of the rules after their adoption. The results show that the rules still positively and significantly affect climate investments.

In column (4), we consider only the least developed countries in the sample. The results show a positive and significant effect between adopting rules and green investments. In column (5), we exclude 2019 and 2020; in column (6), we only consider the years below 2020 to consider the COVID-19 effect. The results show that in these two columns, the effect of the rules on green investment is still positive and significant. Finally, in column (7), we only consider countries that have adopted inflation targeting. The results show that the rules positively and significantly affect green investment.

3.4.4.6 Change in estimation method and treatment variable

In this section, we test the robustness of our results by using an alternative matching method, "Mahalanobis distance matching (MDM)", which compares each treated unit with the closest control unit in terms of distance. The treatment variable is replaced by another proxy variable that captures the strength of the fiscal rules. [King and Nielsen \(2019\)](#) point out the limitations of using propensity scores for matching and suggest the potentially more robust MDM method instead. We use the Mahalanobis Distance Matching method to test the robustness of our primary results. We replace the treatment variable with another proxy variable that captures the strength of fiscal rules. We progressively add the control variables for electoral weight, growth, primary balance, capital openness, the binary variable on emerging countries, and the corruption variable to the basic model to see if our model is still robust. The results (see table 48) show us that there is still a positive and significant link between the strength of fiscal rules and the level of green investment.

3.5 Heterogeneity and transmission channel validation

3.5.1 Heterogeneity

We perform the heterogeneity analysis on institutional (political counterweight, quality of institutions, democracy, quality of government) and macroeconomic (growth and natural resource rents) variables.

3.5.1.1 Heterogeneity according to the quality of the institutions

Institutional quality is a factor that investors highly scrutinize in a country's business environment. Quality institutions reinforce the reliability of the entrepreneurial ecosystem and reassure economic partners. Numerous studies ([Gwartney et al. \(2006\)](#); [Yang et al. \(2023\)](#)) show the positive effects of institutional quality on growth and green investment. For this analysis, we use an index calculated by the ICRG that captures institutional quality to analyze heterogeneity among our sample countries. In column 3 of the table 49, we find that fiscal rules positively affect green investments, and in the presence of high institutional quality, this effect is amplified. These results corroborate with those obtained by ([Issoufou and Ouattara \(2011\)](#); [Ren et al. \(2022\)](#)), which highlight the vital contribution of institutional quality to the attractiveness of green investments.

3.5.1.2 Heterogeneity according to natural resource endowment

We analyze the effect of fiscal rules on green investment as a function of natural resource endowment. The results in column 2 of the table 49 show that fiscal rules affect green investments,

but with high resource rents, the effect on green investments is mitigated. This could be because developing countries with many natural resources often mismanage them. Also, there is a shift from other sectors of the economy to the natural resource sector, which could also explain this attenuation of the effect of fiscal rules. Effective management of natural resources could better contribute to mobilizing sufficient resources to combat the effects of climate change.

3.5.1.3 Heterogeneity according to economic performance

Indeed, economic performance is an essential factor in investment attractiveness in general. This is even more true for green investment. Investors invest more in countries with solid economic performance, which will likely yield a better return. The results in column 1 of the table (49) show that fiscal rules positively affect green investments, and this effect is amplified in the presence of strong economic performance. This could be explained by the fact that, beyond the credibility conferred by the rules, a solid economic performance reassures investors and contributes to attracting massive investments in favour of the climate. The work of [Wan and Sheng \(2022\)](#) shows the link between green investments and economic performance and underlines the importance of green investment for economic growth.

3.5.2 Transmission channel validation

Inspired by the work of [Neuenkirch and Neumeier \(2016\)](#), we use the same method to test our transmission channels. Indeed, we find through the descriptive statistic that there is a slight difference in the mean between the control and treated groups. In this study, we identify growth, inflation targeting, primary balance, fiscal balance, debt rating, GDP per capita, and fixed regime as factors through which fiscal rules affect green financing. The results below show that average growth in the presence of fiscal rules is lower than before the adoption ; the difference is statistically highly significant ($t = 3.3222$; $p\text{-value} = 0.0009$). For inflation targeting, the average when the rules are adopted is higher than the average before adopting the fiscal rules, the difference being statistically very significant ($t = -9.2804$; $p\text{-value} = 0.0000$). The average fiscal balance in the presence of the adoption of the fiscal rules is lower than in the period before the adoption of the rules, the difference being statistically highly significant ($t = 3.4937$; $p\text{-value} = 0.0005$).

For the primary balance, the results show that the average before the adoption of the rules is higher than in the period with the fiscal rules, the difference still being statistically highly significant ($t = 3.1352$; $p\text{-value} = 0.0017$). The average debt rating before adopting the fiscal rules is lower than that observed in the presence of the fiscal rules, with the difference between the two still statistically significant ($t = -2.3449$; $p\text{-value} = 0.0192$). On the other hand, for GDP/H, the results show that the average before the adoption of the rules is higher than that observed in the

period of the fiscal rules with a statistically significant difference ($t = 2.0186$; $p\text{-value} = 0.0437$). Finally, the mean of the fixed exchange rate regime variable is higher in the presence of the rules than that observed before adopting the fiscal rules, with the difference being statistically highly significant ($t = -7.1435$; $p\text{-value} = 0.0000$). Growth, inflation targeting, primary balance, fiscal balance, debt rating, GDP/H, and fixed exchange rate regime are transmission channels through which fiscal rules affect climate-friendly investment.

Table of results of the analysis of transmission channels

Variables	Growth	Hard-it	Fiscal balance	Primary balance	Sovereign debt	GDP per capital	Regime
Before adoption	4.349698	.133	-1.770138	.0187243	10.12991	2.471264	.1736909
During FR	3.525141	.3181818	-2.788337	-.7821559	10.59572	1.98096	.349345
Control group	4.609513	.1662859	-1.262876	0.3303537	10.52494	2.581666	.2195666

Conclusion

This analysis aims to study the causal effect of fiscal rules on green investments in developing countries from 2000 to 2020. Two hypotheses are at the heart of this study : The first states that the adoption of fiscal rules increases green investments, and the second relates to the ability of different types of fiscal rules to attract climate-friendly investments. The results are robust and show that adopting fiscal rules increases green investments. This effect is positive and significant. Apart from expenditure rules, fiscal rules on deficit, debt, and income increase green investment. The results confirm the two hypotheses stated. The study of transmission channels shows that economic performance, primary balance, fiscal balance, inflation targeting, sovereign debt rating, and fixed exchange rate regime are the main factors through which fiscal rules affect climate-friendly investments. Further analysis of the study shows that in the presence of good economic performance, a high level of political checks and balances, better quality institutions, an excellent democratic culture, and a stable government, fiscal rules' positive and significant effects on green investments are amplified. However, these effects are attenuated in the presence of a high level of natural resource rents.

This study makes several main contributions : First, it contributes to the literature analyzing the effect of fiscal rules on green investments in developing countries. Second, to our knowledge, this study is the first to identify the transmission channels through which fiscal rules affect green investments. Third, this analysis contributes to the literature by employing an innovative method of entropy balancing. Finally, this study makes a significant contribution through the policy implications.

Regarding economic policy implications, we recommend that countries consider climate change challenges when developing economic policies. Implementing social programs is paramount as they provide immediate responses and help quickly build resilience to the effects of climate change. It is also essential that developing countries put in place a green investment fund initiative. This initiative is a kind of debt each economic zone or monetary union contracted to finance climate change adaptation and mitigation strategies. The debt could be repaid according to each country's economic weight within the economic zone or monetary union, enshrining the principle of solidarity between member countries and allowing for the development of a common strategy. We recommend that countries that have not yet adopted fiscal rules put in place on inflation and budget deficit to reassure investors in their fiscal policy management and thus quickly mobilize resources to combat climate change. This would allow individual economic agents to borrow easily from the financial market and banking institutions to finance their green transition. However, the implementation of such schemes must be highly restrictive and supervised in order to avoid free-riding situations. Building countries' capacities require significant investment and an obligation to achieve results to be more effective. A carbon pricing policy would also help to stimulate green investments in developing countries. In order to boost green investment, countries need to ensure that they have dynamic and sustained economic performance, sound quality institutions, a stable and accountable government aware of climate issues, and good political and macroeconomic stability.

Developing countries could also prioritize obtaining the "Green Act certificate." An initiative that allows economic actors to demonstrate their commitment to environmental management and protection by funding sustainable projects in exchange for a certificate that can be used to raise green capital in the financial markets. The initiative falls within the framework of corporate social responsibility. Companies can also finance environmental protection and management projects in return for the certificate. This initiative allows governments to control and limit environmental degradation better.

The polluter country guarantee is the other innovative instrument that could boost green investments in developing countries. This is a sovereign guarantee (from major polluting countries to developing countries most affected by the effects of climate change) of financing public and private investments in environmental protection and management. Finally, taxation should be introduced in local value chains (cotton, wood, cocoa, cashew nuts, and all cash resources) to finance the climate change resilience of developing countries producing these resources.

To further investigate the effects of fiscal rules on green investment, exploring the possibility of a study focusing on the neighbourhood effects of fiscal rules would be worthwhile. In addition, further research on the effectiveness of green investments in developing countries would be beneficial.

TABLE 39 – Robutness : Fixed effect

	1	2	3	4	5	6	7	8	9	10	11
Dependent Variable	Climate finance/GDP										
Fiscal rules	0.066** (0.031)	0.066** (0.031)	0.066** (0.031)	0.066** (0.031)	0.084** (0.032)	0.066** (0.031)	0.071** (0.031)	0.067** (0.031)	0.064** (0.031)	0.069** (0.030)	0.065** (0.031)
Exchange rate regime	0.011** (0.005)	0.012** (0.005)	0.012** (0.005)	0.011** (0.005)	0.017** (0.007)	0.011** (0.005)	0.011** (0.005)	0.011** (0.005)	0.011** (0.005)	0.011** (0.005)	0.010** (0.005)
Debt ratio	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.002* (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)
Bureaucracy	0.032 (0.062)	0.032 (0.061)	0.033 (0.062)	0.032 (0.062)	-0.028 (0.081)	0.033 (0.061)	0.037 (0.061)	0.035 (0.061)	0.029 (0.062)	0.033 (0.060)	0.066 (0.052)
Growth	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.002)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.002 (0.001)	-0.002 (0.001)	-0.002 (0.002)
Trade Index	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)	0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)	0.0001 (0.0002)	-0.0001 (0.0002)
Socioeconomic Conditions		0.004 (0.008)									
Corruption			0.003 (0.013)								
Government Stability				-0.002 (0.007)							
Domestic credit to private sector					0.001 (0.001)						
Internal Conflict						-0.002 (0.007)					
External Conflict							-0.018* (0.009)				
Democratic Accountability								-0.014 (0.009)			
Fiscal balance									-0.002 (0.002)		
Foreign direct investment, net inflows										0.002 (0.001)	
Polity-owid											-0.001 (0.002)
Constant	0.184 (0.157)	0.170 (0.156)	0.173 (0.173)	0.209 (0.204)	0.241 (0.194)	0.196 (0.184)	0.358** (0.174)	0.232 (0.156)	0.190 (0.157)	0.173 (0.156)	0.148 (0.147)
Observations	1,006	1,006	1,006	1,006	841	1,006	1,006	1,006	1,003	1,005	998
R-squared	0.318	0.318	0.318	0.318	0.332	0.318	0.321	0.320	0.316	0.321	0.320
Number of idcoun	68	68	68	68	68	68	68	68	68	68	68
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes : In this table, we use the fixed effect model. The treatment variable indicates 1 if the country has adopted at least one fiscal rule and 0 otherwise. The dependent variable is the ratio of inward green investment to GDP.

***p<0.001, **p<0.01, *p<0.05. Standard errors in parentheses.

TABLE 40 – Robutness : GMM (Arellano-Bond estimator)

	1	2	3	4	5	6	7	8	9	10	11	12	13
Dependent variable :	Climate finance/GDP												
Lag Climate finance/GDP	0.222*** (0.030)	0.221*** (0.031)	0.226*** (0.029)	0.222*** (0.030)	0.222*** (0.031)	0.219*** (0.031)	0.222*** (0.030)	0.223*** (0.030)	0.221*** (0.030)	0.223*** (0.030)	0.210*** (0.031)	0.222*** (0.030)	0.223*** (0.030)
Fiscal rules	0.082** (0.035)	0.081** (0.035)	0.091*** (0.034)	0.080** (0.035)	0.085** (0.037)	0.076** (0.035)	0.081** (0.035)	0.081** (0.035)	0.080** (0.035)	0.082** (0.035)	0.081** (0.035)	0.081** (0.035)	0.081** (0.035)
Exchange rate regime	0.012*** (0.004)	0.013*** (0.004)	0.011*** (0.004)	0.013*** (0.004)	0.014*** (0.005)	0.012*** (0.004)	0.012*** (0.004)	0.012*** (0.004)	0.012*** (0.004)	0.012*** (0.004)	0.013*** (0.004)	0.012*** (0.004)	0.013*** (0.004)
Debt ratio	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)
Bureaucracy	0.130 (0.079)	0.130 (0.079)	0.168** (0.077)	0.125 (0.079)	0.113 (0.087)	0.124 (0.080)	0.128 (0.079)	0.128 (0.080)	0.129 (0.079)	0.130 (0.079)	0.127 (0.079)	0.125 (0.080)	0.128 (0.079)
Growth	-0.002 (0.001)	-0.002 (0.002)	-0.002 (0.001)	-0.002 (0.001)	-0.003 (0.002)	-0.002 (0.001)	-0.002 (0.001)	-0.002 (0.001)	-0.002 (0.001)	-0.002 (0.001)	-0.002 (0.001)	-0.002 (0.001)	-0.000 (0.007)
Trade Index	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)
Foreign direct investment, net inflows		-0.0003 (0.001)											
Net ODA received			0.007*** (0.002)										
Corruption				0.024 (0.019)									
ICRG Indicator of Quality of Government					0.178 (0.289)								
Government Stability						-0.005 (0.006)							
Socioeconomic Conditions							0.005 (0.014)						
Oil rents								-0.0004 (0.003)					
Internal Conflict									-0.005 (0.010)				
External Conflict										0.001 (0.014)			
Personal remittances, received											0.004 (0.004)		
Hard-it												0.023 (0.054)	
Constant	-0.118 (0.145)	-0.115 (0.146)	-0.232 (0.144)	-0.159 (0.149)	-0.159 (0.176)	-0.063 (0.162)	-0.136 (0.154)	-0.118 (0.146)	-0.063 (0.175)	-0.130 (0.213)	-0.150 (0.148)	-0.112 (0.146)	-0.119 (0.146)
Observations	844	843	844	844	790	844	844	844	844	844	839	844	844
Number of idcoun	67	67	67	67	63	67	67	67	67	67	67	67	67

Notes : In this table, we use the GMM estimator. The treatment variable indicates 1 if the country has adopted at least one fiscal rule and 0 otherwise. The dependent variable is the ratio of inward green investment to GDP.

***p<0.001, **p<0.01, *p<0.05. Standard errors in parentheses.

TABLE 41 – Robutness :GMM (Roodman’s collapsing method)

	(1)	(2)	(3)	(4)
	GMM1	GMM2	GMM3	GMM4
Variables	Climate finance/GDP			
Lag Climate finance/GDP	0.942***	0.939***	0.942***	0.936***
	(0.014)	(0.013)	(0.013)	(0.014)
Fiscal rules	0.221*	0.249*	0.205*	0.241*
	(0.128)	(0.137)	(0.120)	(0.139)
Capital openness		-0.013		
		(0.012)		
GDP per capita, PPP (2017)			-0.004*	
			(0.002)	
Hard-it				-0.070*
				(0.039)
Constant	-0.063	-0.074	-0.044	-0.052
	(0.053)	(0.057)	(0.047)	(0.052)
Observations	1,148	1,115	1,148	1,148
Number of idcoun	69	67	69	69
Country FE	Yes	Yes	Yes	Yes
ar1p	0.0575	0.0576	0.0547	0.0576
ar2p	0.575	0.569	0.606	0.586
j	120	121	121	121

TABLE 42 – Robustness : Additive controls

	1	2	3	4	5	6	7	8
Dependent Variable :	Climate finance/GDP							
Fiscale rules	0.038** (0.015)	0.038** (0.015)	0.037** (0.015)	0.039** (0.016)	0.034** (0.017)	0.037** (0.015)	0.039** (0.015)	0.038** (0.015)
Lag Exchange rate regime	0.010*** (0.003)	0.010*** (0.003)	0.010*** (0.003)	0.010*** (0.003)	0.011*** (0.004)	0.010*** (0.004)	0.010*** (0.003)	0.010*** (0.003)
Lag Debt ratio	-0.0001 (0.001)	-0.0001 (0.001)	-0.0001 (0.001)	-0.0001 (0.001)	-0.0001 (0.001)	-0.0001 (0.001)	-0.0001 (0.001)	-0.0001 (0.001)
Lag Bureaucracy	0.066** (0.032)	0.069** (0.031)	0.068** (0.032)	0.066** (0.031)	0.073** (0.035)	0.065** (0.032)	0.067** (0.031)	0.066** (0.031)
Lag Growth	0.003 (0.002)	-0.003 (0.006)	0.003 (0.002)	0.003 (0.002)	0.003 (0.002)	0.003 (0.002)	0.003 (0.002)	0.003 (0.002)
Lag Trade Index	0.0001 (0.0002)	0.0001 (0.0002)	0.0001 (0.0002)	0.0001 (0.0002)	0.0001 (0.0002)	0.0001 (0.0002)	0.0001 (0.0002)	0.0001 (0.0002)
Lag Exelec	-0.016 (0.013)							
Lag GDP per capita growth		0.005 (0.006)						
Lag Corruption			0.013 (0.009)					
Lag External Conflict				-0.003 (0.007)				
Lag Political Stability and Absence of Violence/Terrorism, Percentile Rank (0-100)					0.001 (0.001)			
Lag Personal remittances, received						-0.001 (0.006)		
Lag Socioeconomic Conditions							0.005 (0.005)	
Lag Democratic Accountability								0.002 (0.006)
Constant	-0.091 (0.099)	-0.074 (0.107)	-0.129 (0.108)	-0.063 (0.119)	-0.151 (0.113)	-0.098 (0.102)	-0.103 (0.097)	-0.098 (0.097)
Observations	1,019	1,019	1,019	1,019	977	1,006	1,019	1,019
R-squared	0.960	0.960	0.960	0.960	0.961	0.961	0.960	0.960
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes : In this table, we use the entropy balancing method. The treatment variable indicates 1 if the country has adopted at least one fiscal rule and 0 otherwise. The dependent variable is the ratio of inward green investment to GDP. ***p<0.001, **p<0.01, *p<0.05. Standard errors in parentheses.

TABLE 43 – Robustness : Enforcement rule

	1	2	3	4	5	6	7	8
	Estimation 1	Estimation 2	Estimation 3	Estimation 4	Estimation 5	Estimation 6	Estimation 7	Estimation 8
Variables	Dependent variable : Climate finance/GDP							
Enforcement (rule)	0.761*** (0.157)	0.741*** (0.156)	0.323*** (0.101)	0.296*** (0.075)	-0.158 (0.208)	-0.173 (0.202)	0.290*** (0.104)	0.324*** (0.085)
Lag Exchange rate regime					-0.024*** (0.006)	-0.025*** (0.006)	0.006* (0.003)	0.010*** (0.003)
Lag Debt ratio					0.002 (0.001)	0.002 (0.001)	0.001 (0.001)	-0.000 (0.001)
Lag Bureaucracy					-0.360*** (0.065)	-0.355*** (0.064)	0.075* (0.041)	0.059* (0.031)
Lag Growth					-0.011* (0.006)	-0.007 (0.007)	-0.001 (0.002)	0.002 (0.002)
Lag Trade Index					-0.0001 (0.0002)	-0.001** (0.0002)	-0.0001 (0.0002)	0.0001 (0.0002)
Constant	0.372*** (0.028)	0.227*** (0.041)	0.134*** (0.017)	0.121*** (0.021)	1.250*** (0.144)	1.164*** (0.157)	-0.031 (0.117)	-0.091 (0.098)
Observations	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019
R-squared	0.018	0.040	0.946	0.960	0.186	0.207	0.947	0.961
Country FE	No	No	Yes	Yes	No	No	Yes	Yes
Years	No	Yes	No	Yes	No	Yes	No	Yes

Notes : In this table, we use the entropy balancing method. The treatment variable indicates 1 if the country has adopted the enforcement rule and 0 otherwise. The dependent variable is the ratio of inward green investment to GDP. ***p<0.001, **p<0.01, *p<0.05. Standard errors are in parentheses.

TABLE 44 – Robutness : Flexibility rule

	1	2	3	4	5	6	7	8
	Estimation 1	Estimation 2	Estimation 3	Estimation 4	Estimation 5	Estimation 6	Estimation 7	Estimation 8
Variables	Dependent variable : Climate finance/GDP							
Flexibility (rule)	0.170*** (0.060)	0.154*** (0.059)	0.039*** (0.015)	0.027 (0.017)	0.113* (0.062)	0.095 (0.062)	0.040*** (0.015)	0.035** (0.017)
Lag Exchange rate regime					-0.020** (0.008)	-0.021*** (0.008)	0.006* (0.003)	0.010*** (0.003)
Lag Debt ratio					0.002 (0.001)	0.002 (0.001)	0.001 (0.001)	-0.0001 (0.001)
Lag Bureaucracy					-0.356*** (0.060)	-0.351*** (0.060)	0.081* (0.041)	0.065** (0.032)
Lag Growth					-0.010 (0.006)	-0.006 (0.007)	-0.001 (0.002)	0.002 (0.002)
Lag Trade Index					-0.001 (0.0002)	-0.001** (0.0002)	-0.0001 (0.0002)	0.0001 (0.0002)
Constant	0.361*** (0.021)	0.228*** (0.044)	0.134*** (0.017)	0.121*** (0.021)	1.178*** (0.125)	1.103*** (0.143)	-0.031 (0.118)	-0.095 (0.099)
Observations	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019
R-squared	0.013	0.034	0.946	0.960	0.191	0.210	0.947	0.960
Country FE	No	No	Yes	Yes	No	No	Yes	Yes
Years	No	Yes	No	Yes	No	Yes	No	Yes

Notes : In this table, we use the entropy balancing method. The treatment variable indicates 1 if the country has adopted the flexibility rule and 0 otherwise. The dependent variable is the ratio of inward green investment to GDP. ***p<0.001, **p<0.01, *p<0.05. Standard errors are in parentheses.

TABLE 45 – Robutness : Legal basis rule

	1	2	3	4	5	6	7	8
	Estimation 1	Estimation 2	Estimation 3	Estimation 4	Estimation 5	Estimation 6	Estimation 7	Estimation 8
Variables	Dependent variable : Climate finance/GDP							
Legal-basis (rule)	0.091*	0.068	0.028**	0.025*	0.038	0.015	0.032**	0.031**
	(0.050)	(0.048)	(0.013)	(0.013)	(0.042)	(0.042)	(0.013)	(0.015)
Lag Exchange rate regime					-0.023***	-0.024***	0.006*	0.010***
					(0.007)	(0.007)	(0.003)	(0.003)
Lag Debt ratio					0.002	0.002	0.001	-0.0001
					(0.001)	(0.001)	(0.001)	(0.001)
Lag Bureaucracy					-0.352***	-0.348***	0.081*	0.065**
					(0.059)	(0.059)	(0.041)	(0.031)
Lag Growth					-0.010	-0.006	-0.001	0.003
					(0.006)	(0.007)	(0.002)	(0.002)
Lag Trade Index					-0.001	-0.001**	-0.0001	0.0001
					(0.000)	(0.0001)	(0.0002)	(0.0002)
Constant	0.377***	0.243***	0.134***	0.122***	1.207***	1.132***	-0.027	-0.089
	(0.025)	(0.043)	(0.017)	(0.021)	(0.128)	(0.145)	(0.118)	(0.099)
Observations	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019
R-squared	0.004	0.025	0.946	0.960	0.186	0.206	0.947	0.960
Country FE	No	No	Yes	Yes	No	No	Yes	Yes
Years	No	Yes	No	Yes	No	Yes	No	Yes

Notes : In this table, we use the entropy balancing method. The treatment variable indicates 1 if the country has adopted the legal basis rule and 0 otherwise. The dependent variable is the ratio of inward green investment to GDP. ***p<0.001, **p<0.01, *p<0.05. Standard errors are in parentheses.

TABLE 46 – Robutness : Strength of fiscal rules

	1	2	3	4	5	6	7	8
	Estimation 1	Estimation 2	Estimation 3	Estimation 4	Estimation 5	Estimation 6	Estimation 7	Estimation 8
Strength rule2	0.212*** (0.0556)	0.090*** (0.0272)	0.188*** (0.0503)	0.061** (0.0241)	0.097** (0.0471)	0.089*** (0.0236)	0.068* (0.0405)	0.067*** (0.0228)
N	1019	1019	1019	1019	1019	1019	1019	1019
r2	.0207	.9528	.0409	.9637	.216	.9537	.2421	.9651
Country FE	No	No	Yes	Yes	No	No	Yes	Yes
Years	No	Yes	No	Yes	No	Yes	No	Yes

Notes : In this table, we use the entropy balancing method. The treatment variable indicates the strength of fiscal rules. The dependent variable is the ratio of inward green investment to GDP. ***p<0.001, **p<0.01, *p<0.05.

Standard errors are in parentheses.

TABLE 47 – Robutness : Alternative

	1	2	3	4	5	6	7
Dependent variable : Climate finance/GDP							
Fiscal rules	0.040*** (0.015)	0.035** (0.016)	0.038** (0.015)	0.038** (0.015)	0.038** (0.015)	0.038** (0.015)	0.036*** (0.010)
Lag Exchange rate regime	0.010** (0.004)	0.008** (0.003)	0.010*** (0.003)	0.010*** (0.003)	0.010*** (0.003)	0.010*** (0.003)	0.000 (0.001)
Lag Debt ratio	-0.000 (0.001)	0.001 (0.001)	-0.0004 (0.001)	-0.0003 (0.001)	-0.0006 (0.001)	-0.0008 (0.001)	0.001*** (0.000)
Lag Bureaucracy	0.075** (0.033)	0.077** (0.033)	0.066** (0.032)	0.066** (0.032)	0.066** (0.032)	0.066** (0.032)	0.063*** (0.015)
Lag Growth	0.003* (0.002)	0.004* (0.002)	0.003 (0.002)	0.003 (0.002)	0.003 (0.002)	0.003 (0.002)	-0.0004 (0.001)
Lag Trade Index	0.0001 (0.0002)	0.0001 (0.0002)	0.0001 (0.0004)	0.0001 (0.0005)	0.0001 (0.0003)	0.0001 (0.0002)	0.0003 (0.0001)
Constant	-0.112 (0.105)	-0.149 (0.091)	-0.093 (0.099)	-0.093 (0.099)	-0.093 (0.099)	-0.093 (0.099)	-0.210*** (0.036)
Observations	987	889	1,019	1,019	1,019	1,019	223
R-squared	0.962	0.960	0.960	0.960	0.960	0.960	0.975
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes : In this table, we use the entropy balancing method. The treatment variable indicates 1 if the country has adopted the fiscal rule and 0 otherwise. The dependent variable is the ratio of inward green investment to GDP.

***p<0.001, **p<0.01, *p<0.05. Standard errors are in parentheses.

TABLE 48 – Robutness : Mahalanobis distance matching

ATT : FR and GI

	1	2	3	4	5	6	7
Dependent variable : Climate finance/GDP							
Strength rule	0.3127*** (0.0484)	0.2810*** (0.0705)	0.3203*** (0.0528)	0.3404*** (0.0541)	0.3618*** (0.0450)	0.3028*** (0.0490)	0.2943*** (0.0554)
<i>N</i>	1019	866	1019	1015	996	1019	1019

Notes : In this table, we use the Mahalanobis distance matching method. The treatment variable indicates the strength of fiscal rules. The dependent variable is the ratio of inward green investment to GDP. ***p<0.001, **p<0.01, *p<0.05. Standard errors are in parentheses.

TABLE 49 – Heterogeneity

	1	2	3
Variables			
Fiscal rules	0.027* (0.016)	0.083*** (0.022)	0.028* (0.016)
FR-growth	0.108** (0.050)		
Growth	-0.004** (0.002)		
Lag Exchange rate regime	0.009*** (0.003)	0.010*** (0.003)	0.012*** (0.004)
Lag Debt ratio	0.0002 (0.001)	-0.0002 (0.001)	-0.0002 (0.001)
Lag Bureaucracy	0.058* (0.032)	0.072** (0.032)	0.061** (0.029)
Lag Growth	0.003* (0.002)	0.002 (0.002)	0.003 (0.002)
Lag Trade Index	0.0004 (0.0002)	0.0004 (0.0002)	0.0004 (0.0002)
FR-Total natural resources rents		-0.060*** (0.020)	
Total natural resources rents		0.002 (0.003)	
FR-ICRG Indicator of Quality of Government			0.052* (0.030)
ICRG Indicator of Quality of Government			0.332*** (0.121)
Constant	-0.069 (0.099)	-0.147 (0.138)	-0.236* (0.123)
Observations	1,019	1,019	956
R-squared	0.961	0.961	0.961
Country FE	Yes	Yes	Yes
Year	Yes	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

TABLE 50 – Descriptive statistics

Variables	Observations	Moyenne	SD	Min	Max
Climate finance/GDP	1,244	.4919163	1.028903	.0019776	10.6904
Fiscal rules	1,638	.3894994	.4877857	0	1
Exchange rate regime	1,241	6.811442	3.905525	1	15
Growth	1,636	4.028141	4.911483	-36.65815	53.38179
Hardit	1,638	.2051282	.4039186	0	1
Bureaucracy	1,398	1.763919	0.7519254	0	4
Trade index	1,638	119.8824	39.26822	21.39672	290.9305
Debt ratio	1,595	51.31518	46.75327	1.562	600.13

TABLE 51 – Description

Variables	Description	Source
Climate finance/GDP	The green investment data in this study is the ratio of the sum of all incoming (climate) finance to GDP	OECD
Exchange rate regime	is an index that captures the exchange rate regime. The higher it is, the more flexible the exchange rate regime	Reinhart et al. (2017)
Growth	This variable captures the positive change in the production of goods and services in an economy over a given period, usually a long period	WDI
Debt ratio	Debt denotes the government's total fixed-term financial liabilities, domestic and external, outstanding at a given date..	WDI
Fiscal rules	is a binary variable that indicates 1 if the country has adopted at least one fiscal rule and 0 otherwise	IMF
Hard-It	is an index that captures 1 if the country has adopted inflation targeting and 0 otherwise	Rogee (2009) ; Tapsoba (2012)
Bureaucracy	is an index that captures the quality of institutions	ICRG
Trade index	is the ratio of an index of a country's export prices to an index of its import prices	WDI

Tables of samples corresponding to Non_FR and treated		
Non_FR matching sample	Treated	
country	Country	Year
Albania	Burkina Faso	2000
Bangladesh	Bulgaria	2003
Bahrain	Brazil	2000
Belarus	Botswana	2003
China	Chile	2001
Dominican Republic	Cameroon	2002
Algeria	Colombia	2000
Ethiopia	Costa Rica	2001
Ghana	Ecuador	2003
Guatemala	Guinea-Bissau	2000
Honduras	Croatia	2009
Iraq	Hungary	2004
Jordan	Indonesia	2000
Kuwait	India	2004
Lebanon	Jamaica	2010
Morocco	Kazakhstan	2013
Madagascar	Kenya	2000
Myanmar	Liberia	2009
Mozambique	Sri Lanka	2003
Malawi	Mexico	2006
Nicaragua	Mali	2000
Oman	Mongolia	2013
Philippines	Malaysia	2000
Papua New Guinea	Namibia	2001
Qatar	Niger	2000
Saudi Arabia	Nigeria	2007
Sudan	Pakistan	2005
Sierra Leone	Panama	2002
El Salvador	Peru	2000
Suriname	Poland	2000
Trinidad and Tobago	Paraguay	2015
Tunisia	Russian Federation	2007
Turkey	Senegal	2000
Ukraine	Serbia	2011
South Africa	Togo	2000
Zambia	Thailand	2018
Zimbabwe	Uganda	2013
	Uruguay	2006

Description : In the figure above you will find the sample tables corresponding to Non-FR matching sample and the countries treated with the date of adoption of the fiscal rules. Source : Author's calculation.

Sample	
Country	
Angola	Mexico
Albania	Mali
Armenia	Myanmar
Azerbaijan	Mongolia
Burkina Faso	Mozambique
Bangladesh	Malawi
Bulgaria	Malaysia
Bahrain	Namibia
Belarus	Niger
Brazil	Nigeria
Botswana	Nicaragua
Chile	Oman
China	Pakistan
Cameroon	Panama
Colombia	Peru
Costa Rica	Philippines
Dominican Republic	Papua New Guinea
Algeria	Poland
Ecuador	Paraguay
Ethiopia	Qatar
Ghana	Russian Federation
Guinea-Bissau	Saudi Arabia
Guatemala	Sudan
Honduras	Senegal
Croatia	Sierra Leone
Hungary	El Salvador
Indonesia	Serbia
India	Suriname
Iraq	Togo
Jamaica	Thailand
Jordan	Trinidad and Tobago
Kazakhstan	Tunisia
Kenya	Turkey
Kuwait	Uganda
Lebanon	Ukraine
Liberia	Uruguay
Sri Lanka	South Africa
Morocco	Zambia
Madagascar	Zimbabwe

Description : The figure above shows the list of all countries in our sample

Sample	
Country	
Angola	Mexico
Albania	Mali
Armenia	Myanmar
Azerbaijan	Mongolia
Burkina Faso	Mozambique
Bangladesh	Malawi
Bulgaria	Malaysia
Bahrain	Namibia
Belarus	Niger
Brazil	Nigeria
Botswana	Nicaragua
Chile	Oman
China	Pakistan
Cameroon	Panama
Colombia	Peru
Costa Rica	Philippines
Dominican Republic	Papua New Guinea
Algeria	Poland
Ecuador	Paraguay
Ethiopia	Qatar
Ghana	Russian Federation
Guinea-Bissau	Saudi Arabia
Guatemala	Sudan
Honduras	Senegal
Croatia	Sierra Leone
Hungary	El Salvador
Indonesia	Serbia
India	Suriname
Iraq	Togo
Jamaica	Thailand
Jordan	Trinidad and Tobago
Kazakhstan	Tunisia
Kenya	Turkey
Kuwait	Uganda
Lebanon	Ukraine
Liberia	Uruguay
Sri Lanka	South Africa
Morocco	Zambia
Madagascar	Zimbabwe

Description : The figure above shows the list of all countries in our sample

Chapter IV

Climate shocks and sovereign debt ratings in developing countries. Do fiscal rule and inflation targeting matter ?

HISGUIMA DASSIDI Crépin ^{41 42}

Abstract

On a sample of 64 developing countries, using the instrumental variable method and entropy balancing for continuous treatments, we highlight the link between climate shocks and sovereign debt ratings (SDR). We also assess the ability of Fiscal Rules (FR) and Inflation Targeting (IT) to mitigate the effects of these shocks on sovereign debt ratings. The study is based on two hypotheses : climate shocks degrade sovereign debt ratings, and the second hypothesis relates to mitigating the effects of shocks in the presence of FR and IT. Our results show that climate instability negatively affects sovereign debt ratings. In the presence of a climatic shock, adopting FR and IT mitigate the effect of the shock on the rating of sovereign debt. Inflation and GDP per capita are the main transmission channels through which climate shocks affect debt ratings.

Key words : Climate shocks, sovereign debt, developing countries

JEL Classification : C23 ; E43 ; E62 ; F41 ; O11 ; Q54 ; Q56

41. We want to take this opportunity to thank from the depths of our hearts Xavier GALIEGUE, Senior Lecturer in Economics at the University of Orléans ; Djamel KIRAT, Senior Lecturer in Economics at the University of Orléans, and Bao-wé BAMBE, Ph.D in Economics for their advice and guidance in the framework of this study. We want to express our gratitude and appreciation to them.

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Introduction

Climate issues are some of the world's major concerns today and crystallize as much enthusiasm and passion regarding the multiplication of climatic hazards (OCDE, 2002). Climate shocks are extreme meteorological events that impact the socio-economic conditions of populations (Hansen et al., 2019; Azzarri and Signorelli, 2020), thus causing public decision-makers to react in order to limit or mitigate the effects of these shocks. This requires mobilizing internal (public expenditure) and external (debt, aid, and migrant transfers) resources. In addition to the degradation of socio-economic conditions (health, poverty, etc.), climate shocks lead to the destruction of infrastructures, as well as loss of agricultural production (Bithal and Hazrana, 2019; Mall et al., 2017; Nelson et al., 2014) and loss of human life. The poorest countries and the poorest people are the most vulnerable to the effects of climate change (Leichenko and Silva, 2014).

In developing countries, the effects of climate hazards on debt costs are even more pronounced due to the high exposure of these countries and the credibility deficit in managing their macroeconomic framework. The poorest countries and people are the most vulnerable to the effects of climate change (Leichenko et Silva, 2014). Being already poor and under-resourced, developing countries often resort to external financial resources such as debt to mitigate the effects of climate shocks. This, in turn, increases the debt ratio and, combined with macroeconomic imbalance, contributes to the downgrading of a country's sovereign debt ratings.

The effects of climate shocks on debt ratings may go through the credibility channel. Indeed, in the presence of climate shocks, the damage sent a negative signal to international financial markets regarding affected countries, thus negatively affecting their image (credibility). This credibility deficit degrades the sovereign rating, thus increasing the borrowing costs for these countries. The impact of climate instability on sovereign ratings could also be channeled through macroeconomic imbalances. Indeed, a shock causes a loss of agricultural production, thus decreasing supply and increasing the price of agricultural products. These price increases can become widespread and lead to a rise in the general price level, generating macroeconomic instability and degrading the sovereign debt ratings.

This study is linked to two strands of literature. The first part of the literature analyses the effects of climate shocks and sovereign debt ratings, and the second looks at the link between climate change and the cost of debt. The works of (Nawaz, 2021; Meierrieks, 2021; Andalon et al., 2016; Dell et al., 2008; Dell et al., 2012; Bakkensen and Barrage, 2018; Eboli et al., 2010) highlight the effects of climate hazards on economic performance and health. Other authors (Eaton and Fernandez, 1995; Aguiar and Amador, 2014) analyze the problem of sovereign debt ratings. The studies (Cevik and Jalles, 2022; Painter, 2020; Boitan and Marchewka-Bartkowiak, 2022; Ali et al., 2022;

[Zenios, 2022](#)) analyze the link between climate change and the cost of debt. The analysis of the link between climate shocks and sovereign debt ratings leads us to pose the following questions : What are the effects of climate shocks in developing countries on sovereign debt ratings ? How do fiscal rules contribute to mitigating these effects ?

The study makes four main contributions : The first is analyzing the link between climate shocks and sovereign debt ratings in developing countries using the instrumental variable method. The second contribution relates to the ability of fiscal rules to mitigate the effects of the shock using the entropy balancing method for continuous treatments. The third contribution is the identification of the channels through which climate shocks affect sovereign debt ratings. An in-depth analysis will allow us to consider the heterogeneities among countries. The fourth contribution of this study is the policy implications it offers to enable developing countries affected by climate hazards to borrow at lower costs.

The remainder of the paper is structured as follows : Section 4.1 reviews the theoretical and empirical literature. Section 4.2 looks at the theoretical identification of transmission channels. Section 4.3 presents stylized facts on temperature shocks and sovereign debt ratings in developing countries. In Section 4.4, we present the data. Section 4.5 presents the study results. Sections 4.6 and 4.7 analyze the sensitivity of the results and the validation of the transmission channels. The final section concludes the study.

4.1 Literature review

Creditors are increasingly integrating climate hazards into their lending decisions. Countries or companies with the highest exposure to climate hazards are penalized in borrowing ([Painter, 2020](#) ; [Boitan and Marchewka-Bartkowiak \(2022\)](#)). Their exposure makes them more vulnerable and makes creditors more skeptical by pushing them to increase the cost of borrowing from firms or countries in this situation.

The climate shock has numerous consequences on health ([Nawaz, 2021](#) ; [Meierrieks, 2021](#) ; [Andalon et al., 2016](#)), and negatively affects the economic performance of countries ([Dell et al., 2008](#) ; [Dell et al., 2012](#) ; [Bakkensen and Barrage, 2018](#) ; [Eboli et al., 2010](#)). This impact is the highest in poor countries ([Dell et al., 2012](#)), which are the most exposed to climatic hazards and the most lacking the resources to cope with the consequences. It typically includes a drop in agricultural production ([Birthal and Hazrana, 2019](#) ; [Mall et al., 2017](#) ; [Nelson et al., 2014](#)), which reduces supply and negatively impacts the performance of industries, generating a further drop in production. Climate shocks also push governments to increase their indebtedness to better resist climate

hazards, leading to an increase in the debt ratio, which downgrades the country's sovereign debt ratings.

Sovereign debt rating is the evaluation of the solvency of borrowing countries by rating agencies (Eaton and Fernandez, 1995; Aguiar and Amador, 2014). It also refers to a country's credibility and influences investors' decisions. A downgrading of the sovereign rating harms a country's credibility in the eyes of investors and other economic partners. The adoption of budgetary rules contributes to reducing the risks of default on the sovereign debt of countries (Gomez-Gonzalez et al., 2022). Indeed, through their binding nature, budgetary rules confer stability and credibility to the budgetary policy, which improves a country's sovereign debt ratings. Sovereign debt ratings are linked to climate change hazards because countries facing these hazards often seek external financing to increase their resilience to climate change. This financing is channeled through the debt countries incur and ultimately impacts their sovereign debt ratings.

Painter (2020) highlights the effect of climate change on municipal bonds. The results suggest that municipalities most affected by climate change pay more in underwriting fees and initial yields to issue long-term municipal bonds than municipalities least affected by climate change. This suggests that municipalities most affected by climate change pay more in underwriting fees and initial yields to issue long-term municipal bonds than those least affected by climate change. Further analysis of the same study shows that the market prices of climate change risk only concern long-term securities. Painter (2020) also finds that the higher issuance costs for climate-risk countries are due to bonds with lower credit ratings.

The work of Cevik and Jalles (2022) analyzes the impact of vulnerability and resilience to climate change on the bonds of advanced and developing countries. The results show that vulnerability significantly increases the cost of public borrowing while climate change resilience significantly decreases it. The magnitude and effects are much more significant in developing countries. Further study of the work of Cevik and Jalles (2022) shows that countries that are more resilient to climate change have higher bond yields and lower spreads than countries that are more vulnerable to the risk associated with climate change. The contribution of our study to that of Cevik and Jalles (2022) can be summarized in three points : First, our study analyses the link between climate shocks and sovereign debt ratings on the one hand, and on the other, we assess the ability of fiscal rules to mitigate the effects of the shock on sovereign debt ratings. In our study, we use temperature shocks to capture the effects of climate shocks, while the study of Cevik and Jalles (2022) instead captures vulnerability and resilience. Second, our study differs in that it analyzes the channels through which climate shocks affect sovereign debt ratings. Third, our study focuses only on developing countries because they are subject to more climate instability and are rated

poorly (sovereign debt) by rating agencies due to their macroeconomic imbalance and vulnerability to exogenous shocks.

Following the same line of thought, [Boitan and Marchewka-Bartkowiak \(2022\)](#) analyzes the link between climate change and sovereign bonds in European countries and shows that climate-vulnerable countries with weak climate disaster management capacities pay a higher risk premium on their sovereign debt. Further analysis shows that countries with reduced fiscal space and deteriorating fiscal and economic indicators pay higher yields when issuing sovereign bonds and experience wider spreads. [Ali et al. \(2022\)](#) conduct a study on a sample of SP 500 companies⁴³ over the period 2005-2020 and find that there is a negative and significant relationship between climate change action and the cost of debt. They also show that investors reward corporate climate efforts through lower-cost funds. The work of [Zenios \(2022\)](#) highlights the link between climate change and sovereign debt ratings. Using integrated assessment models (IAM) combined with stochastic debt sustainability analysis (DSA), the author shows that climate risks negatively affect sovereign debt and suggests that climate risks to public debt should be transparent as this makes economies more resilient.

Other studies ([Caragnano et al., 2020](#); [Zhou et al., 2018](#); [Pizzutilo et al., 2020](#); [Jung et al., 2018](#)) show that carbon risks also downgrade the rating of sovereign debt. Indeed, carbon risks increase the cost of debt because creditors assimilate the increase in carbon risk to a counter-performance of companies, thus generating a drop in the productivity of firms. [Maaloul \(2018\)](#) highlights the link between greenhouse gas emissions (GHG) and the cost of corporate debt and shows that GHG emissions increase the cost of corporate debt. For each additional ton of GHG emissions, the cost of debt increases by an average of 11 % to 15 %

4.2 Theoretical identification of transmission channels

In this section, we identify the channels through which climate shocks affect sovereign debt ratings in developing countries. Indeed, climate shocks negatively affect the socio-economic conditions of populations ([Hansen et al., 2019](#); [Azzarri and Signorelli, 2020](#)) and the economic performance of countries ([Dell et al., 2008](#); [Dell et al., 2012](#); [Bakkensen and Barrage, 2018](#)), generating additional expenditure which pushes states to mobilize external resources (debt) in order to cope with the shocks. This indebtedness increases their debt ratio and degrades their sovereign debt rating ([Cevik and Jalles, 2022](#)). In the presence of climate shocks, economic performance also decreases (([Dell et al., 2008](#); [Dell et al., 2012](#); [Bakkensen and Barrage, 2018](#)), leading to a further increase

43. The SP 500 is a stock market index based on 500 large companies listed on stock exchanges in the United States

in the country's sovereign debt risk. This negatively influences the sovereign debt rating. Climatic hazards reduce agricultural production (Birthal and Hazrana, 2019; Mall et al., 2017; Nelson et al., 2014), causing a decrease in supply and an increase prices which leads to macroeconomic instability, which, in turn, negatively affects the sovereign rating (De Grauwe and Ji, 2012) of countries because investors are increasingly reluctant to invest in countries experiencing strong economic instability.

Thus, the debt ratio, economic performance, and inflation are the potential factors by which climate shocks affect the sovereign debt rating of developing countries.

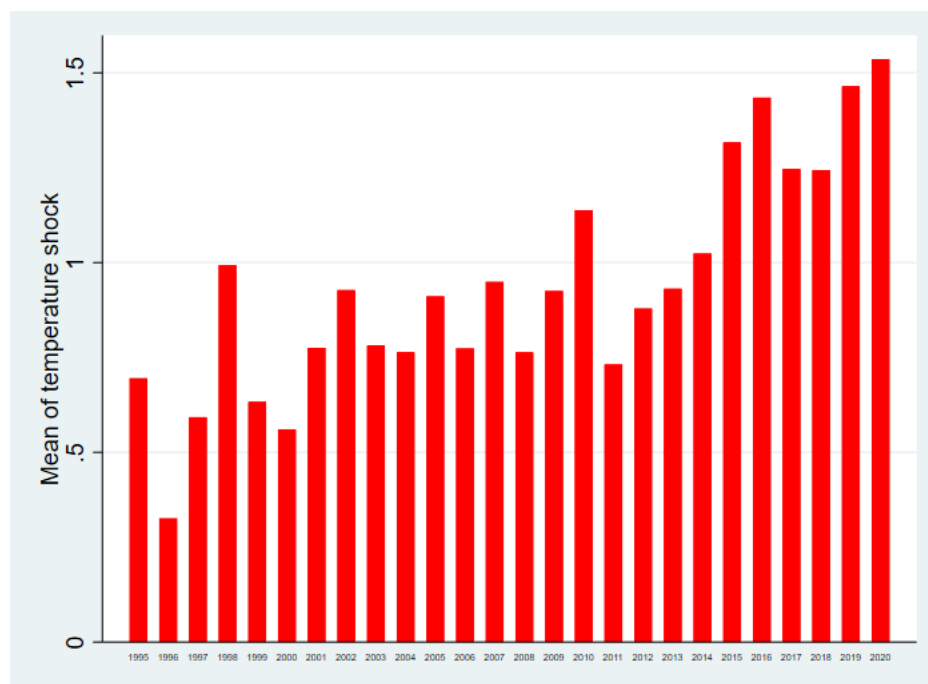
4.3 Stylized facts

Figure 1 presents the average temperature shocks in our sample from 1995 to 2020. Overall, we see an increase in temperature shock over the study period. Temperature increases are marked by a decrease in agricultural production (Birthal and Hazrana, 2019; Mall et al., 2017), the deterioration of sanitary conditions (Patz and Olson, 2006; Kotcher et al., 2021) and firm performance (Pankratz et al., 2019). On the other hand, a drop in temperature may positively affect agricultural productivity and, therefore, firms' production. From 1995-1996, the temperature shock decreased, resulting in a temperature drop, whereas over the period 1996 to 1998, the temperature shocks increased. 1998-2000 was characterized by a decrease in the temperature shock, corresponding to a decrease in temperatures. We observe an increase in temperature in the period 2000 to 2002. In the period 2002-2004, the climatic instability decreased. On the other hand, from 2004 to 2010, the temperature shock increased overall but with decreases observed in 2006 and 2008. A decrease in temperature shock marked 2010 to 2011, while an increase in temperature shock characterized 2011-2016. Between 2016 and 2018, the temperature shock decreased, and an increase in temperature shocks marked 2018-2020.

Concerning the rating of sovereign debt (Figure 2), we see a decline from 1995 to 1999, corresponding to an increase in sovereign risk over this period. Then, from 1999 to 2002, we observe an increase in the rating, followed by a decrease the following year. From 2003 to 2008, we saw an increase in sovereign debt ratings and a decrease in 2009. The decline in sovereign debt ratings over 2008-2009 may be explained by the global financial crisis, which resulted in the downgrading of many countries worldwide, including developing countries. From 2009-2013, we see an increase in sovereign debt ratings, corresponding to a decrease in sovereign risk. Finally, from 2013-2020, there was a decline in sovereign ratings, corresponding to an increase in sovereign risks. The 2019-2020 sovereign debt ratings downgrade was likely due to the COVID-19 crisis, which downgraded the sovereign ratings of many developing countries. Indeed, several developing countries had difficulty paying their creditors. The World Bank and the International Monetary Fund (IMF) put a mora-

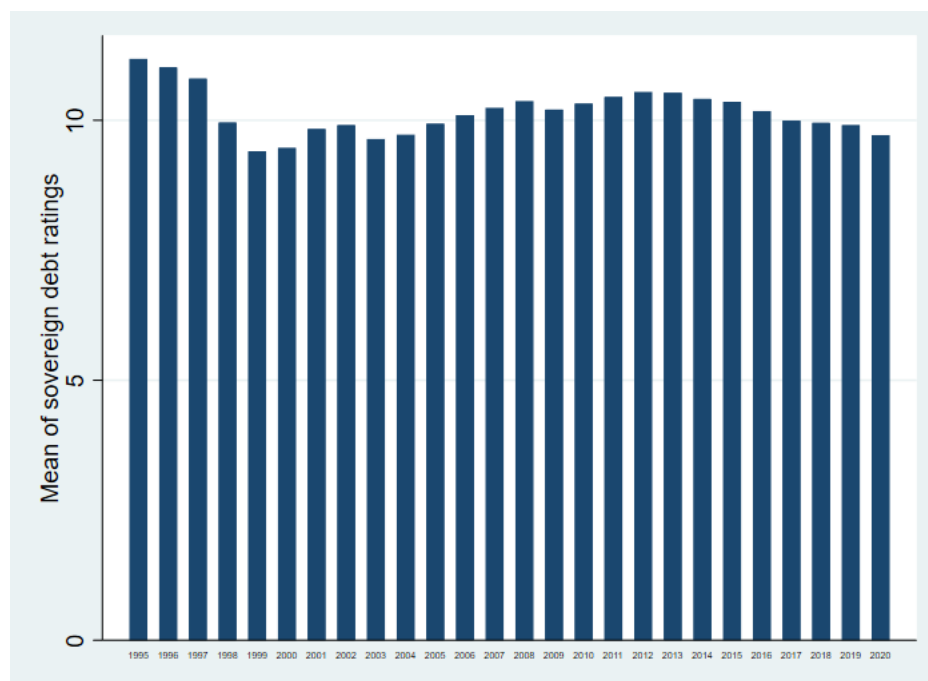
torium on debt repayment for Least-Developed Countries (LDC). This involved suspending debt service payments and sending a negative signal to investors about the inability of countries to meet their obligations to creditors. This led to an increase in sovereign risk and, hence, a downgrading of sovereign debt ratings.

Figure 1 : Evolution of temperature shocks, 1995-2020



Source : IMF, Author's calculation.

Figure 2 : Evolution of sovereign debt ratings, 1995-2020



Source : Author's calculation.

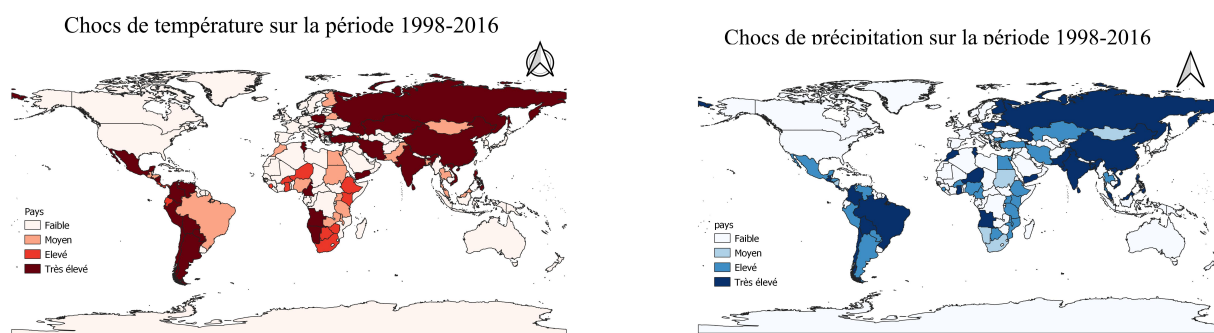
4.4 Data

4.4.1 Database description

Much of the data for this study comes from the World Bank's World Development Indicator (WDI) database. The data on fiscal rules come from the IMF Fiscal Rules dataset. The dependent variable is taken from the JP Morgan sovereign debt ratings database. The variable of interest is the climate shocks captured by the temperature shock. The controls of the model are trade openness, the public debt ratio, household consumption, fiscal rules, inflation targeting, and institutions, which are composed of an index that captures the quality of a country's institutions.

4.4.2 Database description

Measuring climate shock



Source : Author's calculation, CRU (Climate Research Unit).

Source : Author's calculation, CRU (Climate Research Unit).

The data on temperature shocks come from the IMF Climate Change Indicators Dashboard. This indicator presents the average evolution of temperature shocks. The temperature used to calculate the shock is the monthly average temperature, which was interpolated on a 0.5-degree by 0.5-degree latitude/longitude grid, where the grid nodes were centered on 0.25 degrees. The gridded fields were estimated using the monthly station means using a combination of spatial interpolation methods. This interpolation is assisted by the digital elevation method (DEM) (Willmott and Matsuura, 1995); the traditional interpolation method (Willmott et al., 1985a; Willmott et al., 1985b); and the climatology-assisted interpolation (CAI) method (Willmott and Robeson, 1995). These data are based on publicly available GISTEMP (Goddard Institute for Space Studies of Temperature) data from the National Aeronautics and Space Administration Goddard Institute for Space Studies (NASA GISS). The temperature shock at a given location and period is the change in surface temperature relative to a fixed baseline set to average temperatures recorded in 1951-1980. The GISTEMP data are adjusted to correct possible warming biases in urban centers due to heat island effects.

The sovereign debt rating variable captures the creditworthiness of countries in the eyes of external investors and economic partners. It is the dependent variable of the model. The higher this index is, the better the sovereign debt rating; the country, therefore, is closer to solvent and credible in the eyes of investors. Numerous studies (Sawadogo, 2020; Cevik and Jalles, 2022) use the same variable in their analysis. The rating of sovereign debt also gives an idea of the solvency risk of the rated countries. Rating agencies consider a country's debt ratio, political stability factors, the quality of institutions, and, more globally, the macroeconomic stability in calculating

the rating index. These ratings inform many internal and external investors and influence their investment decisions to invest in a country (Sawadogo, 2020).

The debt ratio measures a country's level of indebtedness. It plays an important role in sovereign debt rating because it indicates a country's capacity to repay the debt. The higher the ratio, the more unsustainable the country's debt. A low level of indebtedness contributes to raising the rating of the sovereign debt (Zou and Adams, 2008); it guarantees good macroeconomic framework management and encourages investor confidence. The work of Zenios (2022) shows that climate change increases the sovereign risk of countries, thus degrading the rating of their sovereign debt. Giovanis and Ozdamar (2022) analyze the link between climate change and public finances and show that climate instability increases public debt. Indeed, climatic hazards cause infrastructure losses and deterioration of socio-economic conditions. This leads to additional expenditures that are financed by public debt. The debt ratio is expected to affect the sovereign debt rating negatively.

Trade openness captures the degree of barriers to economic exchange between nations. An increase in trade openness shows the dynamism and performance of the economy. The work of Feng et al., 2021 analyzes the link between trade and the cost of debt and shows that trade friction increases the cost of debt. However, the work of Reeb et al., 2001 suggests that firms with higher international activity levels have better credit ratings. The authors show that the cost of debt financing is inversely related to the degree of internationalization of the firm beyond that incorporated in the credit ratings, suggesting that rating agencies do not fully incorporate the international activity of firms in their analysis, which leads to a downward bias in the credit ratings of international firms. The work of (Huang et al., 2011) suggests that international trade plays a vital role in offsetting, albeit only partially, the regional productivity changes induced by climate change. They show that a well-functioning international trade system can support challenges in climate change adaptation. In our study, trade openness is expected to affect sovereign debt ratings positively.

Household expenditure equals household consumption expenditure plus that of government and non-profit institutions serving households. Climate shock negatively affects household expenditure because lowering economic activity negatively influences household income. (Skoufias et al., 2011) find that climate instability reduces household expenditure. Other works (Kerkhof et al., 2009) analyze the link between environmental impact and household expenditure and find instead that an increase in environmental instability increases household expenditure because this environmental instability causes products (generally agricultural) to fall and prices to rise, leading to an increase in household expenditure. In our study, we expect household spending to improve the sovereign debt rating because increased household spending boosts economic activity.

The "Institution" variable captures institutional factors. In our model, there is one institutional factor. The World Bank's Government Effectiveness Index measures the quality of public services, civil service, policy formulation, policy implementation, and the credibility of a government's commitment to these policies. Work by [Fields et al., 2012](#) shows that companies with quality boards borrow cheaply. Other studies show that the stability of institutional ownership decreases the cost of corporate debt ([Elyasiani et al., 2010](#)). Finally, the work of [Álvarez-Botas and González, 2021](#) analyzes the link between institutions and the cost of debt and shows that it decreases with the rule of law, the protection of creditors' rights, and the weight of banks in the economy. The index is expected to have a positive influence on sovereign debt ratings.

Economic stability : considers economic stability factors in sovereign debt ratings. It comprises fiscal rules (FR) and inflation targeting(IT). The work of ([Gomez-Gonzalez et al., 2022](#) ; [Sawadogo, 2020](#)) shows the importance of fiscal rules in reducing sovereign risks. Indeed, budgetary rules increase credibility in the management of budgetary policy, and this credibility and economic stability positively influence the rating of sovereign debt. The study by ([Balima et al., 2017](#)) suggests that adopting IT improves the risk of sovereign debt in emerging countries. We expected that adopting FR and IT would positively influence sovereign debt ratings.

4.5 Identification strategy

4.5.1 Empirical model

The empirical model of this study is based on that of [Cevik and Jalles \(2022\)](#). We use the instrumental variable method together with the entropy balancing method with continuous treatments of [Tübbicke, 2021](#) (This method is an extension of [Hainmueller, 2012](#)) to analyze respectively the causal effect between the climate shock and the sovereign debt rating and the ability of fiscal rules to mitigate the effects of temperature shocks on the sovereign debt rating. As a prelude to entropy balancing, we lag all control variables. The dependent variable is the sovereign debt rating, and the treatment variable is the temperature shock. Inspired by the work of ([Afonso et al., 2011](#) ; [Afonso, 2003](#)), we use the determinants of the sovereign debt, which is the debt ratio as the control variable. Following the work of [Feng et al., 2021](#), we add trade openness among the control variables. To consider the institutional factor, we use the index that captures the quality of institutions. Finally, given the importance of economic stability in the rating of sovereign debt and inspired by the work of ([Gomez-Gonzalez et al., 2022](#) ; [Balima et al., 2017](#)), we add FR and IT among our control variables.

$$SDR_{it} = \alpha_i + \beta Shock_{si,t} + \sum_{k=1}^k \Delta X_{i,t} + \eta_i + \gamma t + \epsilon_{it} \quad (24)$$

With SDR representing the dependent variable of the model. It represents the sovereign debt rating index. Shocks represent the treatment variable, which denotes the temperature shock. η_i captures the individual fixed effect, and γt captures the time-fixed effect. Epsilon is the error term. X is a vector that represents the set of explanatory variables used in the model, which is composed of trade openness, household consumption, public debt ratio, fiscal rules, inflation targeting, and institutions, composed of an index that captures the efficiency of the government, hence the quality of institutions.

4.5.2 Interpretation of results

We start the empirical analysis with the standard fixed-effects model (in column 1), which provides consistent results, but the variable of interest is insignificant. The results in column 1, therefore, do not allow us to conclude the causal effect or even quantify the sound effect of climate change on sovereign debt ratings. We suspect an endogeneity problem that could arise from other omitted variables (unobserved heterogeneity and selection effects), measurement errors in the variables, and reverse causality (simultaneity). Also, since causality can work both ways, some right-hand side regressors may correlate with the error term.

To consider the potential endogeneity problem and the persistence of the sovereign debt rating, we perform in column 2 the analysis of our baseline results by estimating the static model with the Two Stage Least Squares (2SLS) estimator. We use lagged temperature shock indices and the climate change vulnerability index (CCVI) as instruments validated by the Kleibergen-Paap and Hansen statistics. Looking at the diagnostic statistics to assess the validity of the instrumental variable strategy, the under-identification test p-values generally reject the null hypothesis that the different equations are under-identified. Also, the Hansen test statistics reveal that the instrument sets contain valid instruments. That means it is uncorrelated with the error term and that the excluded instruments are correctly excluded from the estimated equation.

The results in column 2 of the table (52) show the effect of temperature shocks on sovereign debt ratings. We find a negative and significant relationship between the temperature shock and the sovereign debt rating. A one-unit increase in the temperature shock decreases the sovereign debt rating index by 2.72 percentage points. These results show that climate shocks degrade debt ratings. These results are in line with those of (Cevik and Jalles, 2022; Painter, 2020; Boitan and Marchewka-Bartkowiak, 2022; Ali et al., 2022; Zenios, 2022) who find that climate change increases the cost of debt, thus negatively impacting sovereign debt ratings.

Three factors can explain this negative impact on sovereign debt ratings : Firstly, the occurrence of climate shocks causes the degradation of agricultural production (BIRTHAL and HAZRANA, 2019; MALL et al., 2017; NELSON et al., 2014), thus generating a decrease in market supply and leading to a rise in the prices of agricultural products. This price increase can spread throughout the economy and increase the general price level, leading to macroeconomic instability. Secondly, in the presence of climate shocks, there is an increase in expenditure financed by debt, increasing the debt's unsustainability. Finally, climate shocks lead to a drop in economic performance (DELL et al., 2008; DELL et al., 2012; BAKKENSEN and BARRAGE, 2018; EBOLI et al., 2010), which hurts the country's credibility. Following the interpretation of the economic magnitude, we can say that there is a 26.91% chance that the occurrence of a temperature shock in a country will lower its sovereign debt ratings. Inflation targeting and the quality of institutions positively affect the rating of sovereign debt.

4.5.3 Entropy balancing for continuous treatments (EBCT)

Referring to the recent literature on impact assessment, we use the entropy balancing method for continuous treatments (EBCT) of Tübbicke (2021). This method is based on Hainmueller (2012), which was later implemented in the work of Neuenkirch and Neumeier (2016). Here, the aim is to analyze the extent to which FR can mitigate the effect of the temperature shock on the rating of sovereign debt. To do so, we cross-check the rules with the temperature shocks in our sample countries. However, it must be said that the reasons countries adopt fiscal rules (economic stability, limiting fiscal drift, fiscal profligacy, political risk, lack of liquidity, desire to attract more investment, etc.) could be associated with macroeconomic factors and the country's political situation which could trigger an endogeneity problem. However, to remedy this situation, we use the matching method. This matching method is more reliable and sufficiently robust than simple linear regression methods. The relationship gives the average treatment effect on the treated (ATT) :

$$ATT = E[(Y_{i1}Y_{i0})|FR = 1] = E[(Y_{i1}|FR = 1)] - E[(Y_{i0}|FR = 1)] \quad (25)$$

In equation (1), FR is a binary variable that represents the adoption of fiscal rules (FR) in country i, Y_{i1} is a variable that captures the sovereign debt rating (SDR) when country i has not adopted FR (non-FR). $Y_{i0}|FR=1$ denotes the value of the SDRs that would have been observed if a country that has not adopted FR (non-FR) had adopted FR. $Y_{i1} |FR=1$ denotes the RDSs observed for the same non-FR country. Eq. (1) above tells us that comparing the observed RDSs in the Non-FR countries with the RDSs observed in the same countries if they had adopted the fiscal rules (FR) would give us an unbiased estimate of the ATT. However, the main difficulty with this equation is that the second term on the right-hand side is unobservable. To get around this difficulty, we

randomly select countries that have not adopted FR(non-FR). Using this random selection, we can compare the sample average of the Non-FR countries with that of the FR countries.

In equation(2), we replace $E[Y_{i0} | FR=1, X_i]$ with the term $E[Y_{i0} | FR=0, X_i]$, and we obtain this equation.

$$ATT = E[(Y_{i1} - Y_{i0}) | FR = 1] = E[Y_{i1} | FR = 1, X_i] - E[Y_{i0} | FR = 0, X_i] \quad (26)$$

The entropy balancing method has several advantages : Its efficiency and reliability are compared to classical matching methods (e.g., PSM) through its non-parametric character. With this method, there is little chance of a problem with the misspecification of the model's functional form, which could bias our results. Secondly, as the treatment variable is orthogonal to the covariates due to the reweighting mechanism, it avoids the multicollinearity problems that could eventually arise. Finally, the entropy balancing method combines a reweighting mechanism with a regression analysis [Neuenkirch and Neumeier \(2016\)](#). This method allows controlling for country and time-fixed effects in the regression analysis. Including country-fixed effects allows for potential unobserved heterogeneity between countries with and without fiscal rules. To account for country-specific temporal and structural specificities, we use fixed effects to capture the invariant factors that explain differences in sovereign debt ratings. The entropy balancing method for continuous treatments (EBCT) is important because it solves a globally convex optimization problem and obtains balancing weights by minimizing the deviation from the baseline (uniform) weights subject to zero correlation and normalization constraints, allowing a very efficient implementation. The EBCT also makes the treatment variable uncorrelated with the covariates and allows for balancing weights that reweight the sample so that the higher orders of the treatment variable are also uncorrelated with the covariates.

4.5.3.1 Interpretation of results

This section assesses fiscal rules' ability to mitigate the effects of temperature shock on sovereign debt ratings. The dependent variable is the sovereign debt ratings. The treatment variable is the intersection between the temperature shock and the fiscal rules. The results (53) in column 1 show that in the presence of a temperature shock, adopting fiscal rules mitigates the effect of the shock on the sovereign debt rating. The work of [Cevik and Jalles \(2022\)](#) shows that climate shocks increase the sovereign risk and, therefore, downgrade the sovereign debt rating. Thus, the adoption of fiscal rules would contribute to mitigating the effect of climate shocks on the rating of sovereign debt because the binding nature of the rules contributes to increasing the credibility of the fiscal policy and also allows for a better allocation of resources, which could improve the economic environment and make it more attractive to foreign investors.

The work of [Sawadogo \(2020\)](#) also shows that adopting rules reduces sovereign risk, thus improving the rating of sovereign debt to attract foreign investments. Adopting the rules allows economic stability, which is important in the sovereign debt rating criterion. The rules are also very effective against exogenous shocks ([Kopits \(2001\)](#) ; [Ardanaz et al. \(2021\)](#)). All this reinforces the country's credibility in the eyes of foreign investors and mitigates the effect of climatic instability on the sovereign debt rating. In column 2, we cross the temperature shock with the deficit rule. The results show that in the presence of a temperature shock, adopting the deficit rules reduces the effect of the shock. The effect of the temperature shock on the sovereign debt rating is attenuated. In column 3, the cross-tabulation between the temperature shock and the expenditure rule is positive but insignificant. In column 4, we cross the temperature shock with the debt ratio rule.

The results (Table [53](#)) show that in the presence of the temperature shock, adopting the debt rule mitigates the effect of the shock on the debt rating. Column 5 is the cross between the temperature shock and the income rule. The results show that in the presence of the temperature shock, adopting an income rule mitigates the effect of the shock on the sovereign debt rating. In column 6, we cross the temperature shock with the strength of the rules and find that the cross variable is always positive and significant. This reinforces the robustness of our results obtained in columns 1,2,3,4,5. In extension, we cross in column 7 the temperature shock with inflation targeting. The result (Table [53](#)) shows that the cross-over variable is positive and significant. This also shows that in the presence of the temperature shock, adopting inflation targeting helps mitigate the shock's effects on the sovereign debt rating. The work of [Balima et al. \(2017\)](#) also shows that adopting inflation targeting improves the rating of sovereign debt. Inflation targeting helps to strengthen economic stability and contributes to reassuring foreign investors. It is, therefore, effective in mitigating the effect of the shock on sovereign debt ratings.

4.6 Sensitivity analysis of results

4.6.1 Robustness Check

In this section, we analyze the sensitivity of our results through the robustness analysis. In order to take into account the inertia of the sovereign debt rating, we use the GMM model to test the robustness of our results. In column 1, we measure the effect of the temperature shock on the sovereign debt rating without adding controls. The results ([54](#)) show that climate shock negatively and significantly affects the sovereign debt rating. In column 3, we add the controls. The results ([54](#)) show that there is still a negative and significant relationship between the temperature shock and the sovereign debt rating. From columns 3 to 10, we progressively add corruption, stability, fractional government, socio-economic welfare index, investment profile index, GDP per capita, financial openness, and inflation. The results remain unchanged, showing that the climate shock

(temperature) harms the sovereign debt rating.

Concerning the table (55), we change the variable of interest of the model. We replace the temperature shock with the climate change vulnerability index from the ND-GAIN Country Index database. In column 1, we first present the result of the effect of the temperature shock on the sovereign debt rating without adding the controls. The results (55) show that the vulnerability index negatively and significantly affects the sovereign debt rating. In column 2, we add the controls. The results remain unchanged and show that the climate vulnerability index negatively and significantly affects the sovereign debt rating, thus corroborating the basic results of the study. From column 3 to column 9, we progressively add the variables stability index, democracy index, institutional quality, political stability, GDP per capita, inflation, and a political counterweight. The results show that the vulnerability index negatively affects the sovereign debt rating.

In the table (60), we use the Arrelano-Bond (Roodman, 2009) method to test the robustness of our results. In column 1, we analyze the effect of the temperature shock on the sovereign debt rating without adding the control variables. The results show a negative and significant relationship between the temperature shock and the sovereign debt rating. In column 2, we add the controls. The results remain unchanged. From column 3 to column 8, we progressively add the variables measuring the index of socio-economic well-being, the quality of the state apparatus, stability, the index measuring the quality of the judicial system, corruption, and the index of political stability. The results show that the temperature shock negatively impacts the sovereign debt rating.

In the table (61), we also use the Arellano-Bond (Roodman, 2009) method, but we change the variable of interest by the vulnerability index (ND-Gain). In column 1, we analyze the effect of vulnerability on the sovereign debt rating. In column 2, we add the model controls. From column 3 to column 8, we gradually add the additional control variables. The results in columns 1 to 8 show us that there is a negative and significant relationship between economic vulnerability and sovereign debt rating.

4.6.2 Heterogeneity

In order to take into account the specificities between countries, we carry out an analysis of heterogeneity according to the different factors. First, we distinguish according to the quality of the state apparatus (see columns 1 and 2 of Table (56)). Column 1 presents the results when the country has a well-functioning state apparatus, and in column 2, we consider the aspect of a low-quality state apparatus. The results show that in the presence of the temperature shock, adopting fiscal rules allows mitigating the effect of the shock more in countries with a well-performing state apparatus than in countries with a weak state apparatus. In columns 3 and 4, we distinguish ac-

according to the level of political stability. In column 3, we present the results for countries with high political stability, and column 4 considers countries with low political stability. The results show that in the presence of climate shock, the adoption of the rules mitigates the shock the most in countries with high political stability compared to countries with low political stability. Columns 5 and 6 represent the effects for countries with high democracy and those with low democracy. The results suggest that in the presence of the temperature shock, the adoption of the rules mitigates the effects of the shock most in countries with a solid democratic culture compared to countries with a low level of democracy.

The work of [Debrun, 2007](#) also shows that adopting fiscal rules with strong democratic accountability leads to good fiscal discipline. In columns 7 and 8, we distinguish according to the level of debt management. Column 7 presents the results for countries with good debt ratio management, and column 8 for countries with poor debt ratio management. The results ([56](#)) show that in the presence of the temperature shock, the adoption of the rules mitigates the shock the most in the countries that distinguish themselves by good management of their debt ratio, compared to the countries that poorly manage their debt ratio.

In the table ([57](#)), we cross-tabulate the further rule adoption and rulemaking types with the temperature shock variable. The results (columns 1 and 2) show that in the presence of the temperature shock, the adoption of statutory rules and written rules in an international treaty also mitigates the effect of the shock on the sovereign debt rating. In columns 3 and 4, the results suggest that in the presence of the temperature shock, the adoption of flexible rules and the strength of the rules mitigate the effect of the shock on sovereign debt ratings. In columns 5 and 6, the results show that in the presence of the temperature shock, the adoption of rules embedded in the constitution and statutory rules also mitigates the effect of the shock on sovereign debt ratings. Finally, in columns 7 and 8, the results suggest that, in the presence of the temperature shock, adopting rules elaborated in international treaties and rules containing the budget balance target in cyclically adjusted or multi-year terms helps mitigate the shock's effects.

4.7 Validation of transmission channels

This section analyzes the channels through which climate shocks affect sovereign debt ratings. In table [58](#), we present the results. We find that the debt ratio negatively and significantly affects the sovereign debt rating (column 1) and that inflation degrades the sovereign debt rating (column 2). The GDP per capita in purchasing power parity positively and significantly affects the sovereign debt ratings (column 3). Table 10 shows that climate shock is correlated with inflation and GDP per capita in purchasing power parity. The results of the two tables ([58](#) ; [59](#)) validate the theoretical

identification of the channels made earlier. Thus, inflation and GDP per capita in purchasing power parity are the channels through which climate shocks affect the sovereign debt rating of developing countries.

Conclusion

This study analyzes the causal effect of climate shocks on sovereign debt ratings on the one hand and the extent to which fiscal rules can mitigate these effects on the other. Using the instrumental variable method, we determined the link between climate change and sovereign debt ratings. Using the entropy balancing method for continuous treatments, we determined the ability of fiscal rule adoption to mitigate a climate shock's effect on a country's sovereign debt ratings. The results show climate (temperature) shocks significantly negatively impact sovereign debt ratings. Apart from expenditure rules, the other types of rules (revenue, debt, and deficit) mitigate the effects of a temperature shock on a country's sovereign debt ratings.

The channel analysis showed that inflation and GDP per capita in purchasing power parity are the channels through which climate (temperature) shocks affect sovereign debt ratings. Further analysis showed specific effects across countries. In the presence of a temperature shock, adopting fiscal rules is more effective in mitigating the shock's effect in countries with a well-functioning state apparatus, solid political stability, a solid democratic base, and a well-managed debt ratio.

In terms of policy implications, even in the presence of a climate shock, it is desirable to have good-quality institutions and a well-functioning state apparatus to enhance a country's credibility in the eyes of investors and economic partners. To increase the capacity of fiscal rules to mitigate the shock's effects, a binding legal and institutional framework that can sufficiently increase the cost of circumventing the rules must be put in place. Indeed, the higher the cost of circumventing fiscal rules, the more valuable and practical they are. Also, fiscal rules adoption helps a country strengthen its economic stability, effective management of fiscal policy, and a reasonable allocation of resources in order not only to mitigate the effects of exogenous shocks such as climate shocks but also to make the country more attractive and economically stable in the eyes of investors and economic partners.

Another innovative instrument is the "Polluter Pays Guarantee". This is a sovereign guarantee (from major polluting countries to developing countries that are most affected by climate change) on the financing of public and private investments in environmental protection and management. This solution is designed to help mobilize sufficient resources to combat the effects of climate change and boost green investments in developing countries. Finally, taxation in local value chains

(cotton, wood, cocoa, cashew nuts, etc.) is needed to allow developing countries producing these resources to use the profits generated by these value chains to finance their resilience to the effects of climate change.

To deepen the exploration of climate change and sovereign debt rating, it would be desirable to analyze the neighboring effect of fiscal rules and the determinants of sovereign debt ratings of developing countries.

TABLE 52 – Baseline model

	2SLS	
DEPENDENT VARIABLE	SDR	SDR
Temperature shock	-0.035	-2.727**
	(0.098)	(1.287)
Debt ratio	-0.048***	-0.053***
	(0.006)	(0.004)
HardIT	0.656	0.565**
	(0.414)	(0.222)
Fiscal rules	0.104	0.259
	(0.280)	(0.199)
Trade	-0.008	-0.001
	(0.005)	(0.005)
Health Expenditure	0.0005***	0.0004***
	(0.0001)	(0.0001)
Government effectiveness	1.591***	1.902***
	(0.583)	(0.331)
Constant	13.020***	17.260***
	(1.135)	(2.197)
Observations	920	919
R-squared	0.459	0.847
Number of idcoun	55	64
Country FE, Years	Yes	Yes

Notes : In this table, we analyze the effect of the temperature shock on the sovereign debt rating. The variable of interest is the temperature shock, and the dependent variable is the sovereign debt rating. We use in column 1, a simple linear regression with fixed effects. In column 2, we use the Two Stage Least Squares (2SLS) method.

***p<0.001, **p<0.01, *p<0.05. Standard errors are in parentheses.

TABLE 53 – The crossing table

Variables	SDR	SDR	SDR	SDR	SDR	SDR	SDR
Temperature-Deficit rules	0.418***						
	(0.140)						
Deficit rules	0.260						
	(0.205)						
Temperature shock	-0.213**	-0.212**	-0.088	-0.123	-0.050	-0.094	-0.036
	(0.105)	(0.101)	(0.102)	(0.110)	(0.090)	(0.098)	(0.090)
Debt ratio	-0.048***	-0.048***	-0.048***	-0.048***	-0.047***	-0.048***	-0.047***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Hard-IT	0.673***	0.673***	0.678***	0.702***	0.692***	0.693***	0.472**
	(0.188)	(0.184)	(0.185)	(0.188)	(0.187)	(0.188)	(0.187)
Fiscal rules	-0.152	-0.329**	0.024	0.093	0.117	0.048	-0.054
	(0.154)	(0.163)	(0.128)	(0.168)	(0.133)	(0.135)	(0.145)
Trade	-0.008***	-0.009***	-0.010***	-0.008***	-0.008***	-0.009***	-0.008***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Health Expenditure	0.0005***	0.0005***	0.0005***	0.0005***	0.0005***	0.0005***	0.0005***
	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
Government effectiveness	1.675***	1.709***	1.629***	1.695***	1.704***	1.693***	1.680***
	(0.260)	(0.262)	(0.261)	(0.260)	(0.261)	(0.260)	(0.262)
Temperature-Shock	0.366***						
	(0.116)						
Temperature-Expenditure rules			0.080				
			(0.169)				
Expenditure rules			0.342				
			(0.267)				
Temperature-Debt rules				0.228*			
				(0.134)			
Debt rules				-0.220			
				(0.215)			
Temperature-Revenue rules					0.512*		
					(0.264)		
Revenue rules					-2.645***		
					(0.489)		
Temperature-Strenght rule						0.074*	
						(0.044)	
Hardit-rule							0.536**
							(0.223)
Constant	13.503***	13.677***	13.464***	13.425***	13.320***	13.444***	13.285***
	(0.565)	(0.564)	(0.571)	(0.568)	(0.561)	(0.570)	(0.557)
Observations	920	920	920	920	920	920	920
R-squared	0.926	0.927	0.926	0.925	0.925	0.925	0.925

Notes : We use the entropy balancing method for continuous processing in this table. The dependent variable is the sovereign debt rating. The variable of interest is the intersection between the temperature shock and the fiscal rules (and inflation targeting for the last column). ***p<0.001, **p<0.01, *p<0.05. Standard errors are in parentheses.

TABLE 54 – Additional robustness analysis

Variables	SDR	SDR	SDR	SDR	SDR	SDR	SDR	SDR	SDR	SDR
L.SDR	0.845*** (0.029)	0.672*** (0.044)	0.702*** (0.042)	0.712*** (0.037)	0.659*** (0.044)	0.671*** (0.047)	0.651*** (0.047)	0.633*** (0.045)	0.667*** (0.042)	0.685*** (0.043)
Temperature shock	-0.237*** (0.055)	-0.116*** (0.041)	-0.102** (0.050)	-0.104** (0.047)	-0.112** (0.046)	-0.121*** (0.045)	-0.109** (0.052)	-0.147*** (0.048)	-0.124*** (0.042)	-0.115*** (0.041)
Debt		-0.030*** (0.004)	-0.029*** (0.005)	-0.025*** (0.004)	-0.030*** (0.004)	-0.023*** (0.006)	-0.022*** (0.005)	-0.029*** (0.006)	-0.030*** (0.005)	-0.028*** (0.005)
Hard-IT		-0.067 (0.212)	-0.047 (0.215)	0.126 (0.257)	-0.006 (0.245)	0.027 (0.268)	0.037 (0.239)	0.000 (0.192)	-0.040 (0.240)	0.024 (0.241)
Fiscal rules		0.142 (0.132)	0.144 (0.148)	0.289** (0.141)	0.204 (0.150)	0.114 (0.146)	0.262* (0.156)	0.032 (0.114)	0.155 (0.134)	0.046 (0.104)
Trade		-0.003 (0.003)	-0.005 (0.003)	-0.003 (0.002)	-0.003 (0.003)	-0.005 (0.004)	-0.003 (0.003)	-0.004 (0.004)	-0.003 (0.003)	0.001 (0.002)
Health Expenditure		0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	-0.0001 (0.0002)	0.0001 (0.0002)	0.0001 (0.0001)
Government effectiveness		1.404*** (0.391)	1.331*** (0.384)	1.105*** (0.335)	1.512*** (0.363)	1.107*** (0.315)	1.104*** (0.277)	1.339*** (0.380)	1.470*** (0.370)	1.208*** (0.302)
Corruption			-0.027 (0.127)							
Government stability				0.100*** (0.034)						
Government Fractionalization Index					-0.159 (0.221)					
Socioeconomic conditions						0.245** (0.099)				
Invest-qual							0.217*** (0.070)			
GDP per capita								0.0007*** (0.0002)		
Capital openness									-0.018 (0.091)	
Inflation										-0.030*** (0.008)
Constant	1.813*** (0.277)	5.114*** (0.534)	4.891*** (0.568)	3.472*** (0.503)	5.196*** (0.528)	3.623*** (0.758)	2.962*** (0.854)	4.847*** (0.754)	5.165*** (0.514)	4.716*** (0.632)
Observations	1,156	879	826	826	837	826	826	879	866	878
Number of idcoun	57	55	55	55	53	55	55	55	54	55

Notes : We use the GMM estimator in this table. The dependent variable is sovereign debt rating. The variable of interest is the shock of temperature. In column 1, we present the results without controls. In column 2, we present the results of our baseline model by adding controls. We add additional control variables from column 3 to column 10 to see if the model is still robust. ***p<0.001, **p<0.01, *p<0.05. Standard errors are in parentheses.

TABLE 55 – Robustness with change of the variable of interest

Variables	SDR	SDR	SDR	SDR	SDR	SDR	SDR	SDR	SDR
L.SDR	0.984*** (0.006)	0.913*** (0.010)	0.918*** (0.011)	0.921*** (0.011)	0.902*** (0.011)	0.921*** (0.011)	0.927*** (0.009)	0.910*** (0.010)	0.914*** (0.010)
Vulnerability	-0.737*** (0.230)	-0.742** (0.315)	-0.826** (0.333)	-0.819** (0.336)	-0.957*** (0.318)	-0.873** (0.347)	-0.783*** (0.278)	-0.862*** (0.308)	-0.738** (0.315)
Debt ratio		-0.008*** (0.001)	-0.007*** (0.001)	-0.008*** (0.001)	-0.009*** (0.001)	-0.008*** (0.001)	-0.006*** (0.001)	-0.008*** (0.001)	-0.008*** (0.001)
Hard-IT		0.016 (0.042)	0.041 (0.045)	0.003 (0.045)	-0.031 (0.045)	0.002 (0.046)	0.034 (0.037)	0.003 (0.041)	0.011 (0.044)
Fiscal rules		-0.054* (0.032)	-0.039 (0.035)	-0.046 (0.034)	-0.028 (0.034)	-0.053 (0.035)	0.006 (0.028)	-0.069** (0.032)	-0.069** (0.032)
Trade		0.0003 (0.001)	-0.0003 (0.001)	0.0003 (0.001)	-0.0003 (0.001)	0.0003 (0.001)	-0.0003 (0.001)	0.0003 (0.001)	0.0003 (0.001)
Health Expenditure		0.0007*** (0.0001)	0.0007*** (0.0001)	0.0007*** (0.0001)	0.0007*** (0.0001)	0.0007*** (0.0001)	0.0007*** (0.0001)	0.0007*** (0.0001)	0.0007*** (0.0001)
Government effectiveness		0.348*** (0.053)	0.323*** (0.057)	0.361*** (0.061)	0.299*** (0.058)	0.322*** (0.057)	0.304*** (0.046)	0.331*** (0.051)	0.351*** (0.053)
Government stability-icrg			0.026** (0.010)						
Political Stability				-0.036 (0.030)					
Bureaucracy					0.173*** (0.040)				
Index of Democratization						0.001 (0.002)			
GDP per capita growth							0.038*** (0.004)		
Inflation								-0.016*** (0.002)	
Checks									-0.003 (0.010)
Constant	0.522*** (0.155)	1.609*** (0.229)	1.383*** (0.244)	1.540*** (0.240)	1.547*** (0.233)	1.567*** (0.250)	1.289*** (0.211)	1.807*** (0.231)	1.588*** (0.228)
Observations	1,192	905	849	808	849	807	905	904	866
Number of idcoun	58	56	56	53	56	53	56	56	54

Notes : We use the GMM estimator in this table. The dependent variable is sovereign debt rating. The variable of interest is the vulnerability index(ND-Gain country index). In column 1, we present the results without controls.

In column 2, we present the results of our baseline model by adding controls. We add additional control variables from column 3 to column 9 to see if the model is still robust. ***p<0.001, **p<0.01, *p<0.05. Standard errors are

TABLE 56 – Heterogeneity

	1	2	3	4	5	6	7	8
	Gov effectiveness	Gov effectiveness	Stability	Stability	Democracy	Democracy	Debt Management	Debt Management
Variables	SDR	SDR	SDR	SDR	SDR	SDR	SDR	SDR
Temperature-shocks 2	0.496*** (0.152)	0.252 (0.238)	0.373*** (0.120)	1.054 (1.437)	0.445*** (0.144)	0.095 (0.219)	0.373*** (0.126)	1.219 (0.902)
Temperature shock	-0.275* (0.144)	-0.130 (0.178)	-0.229** (0.106)	-1.202 (1.292)	-0.406*** (0.148)	-0.023 (0.164)	-0.204* (0.116)	-0.963 (0.448)
Debt ratio	-0.045*** (0.005)	-0.048*** (0.006)	-0.048*** (0.003)	0.005 (0.020)	-0.051*** (0.004)	-0.048*** (0.005)	-0.046*** (0.004)	-0.009 (0.013)
HardIT	0.554 (0.358)	0.836*** (0.285)	0.725*** (0.192)	4.893* (2.515)	0.779*** (0.230)	0.786* (0.440)	0.678*** (0.192)	-28.529 (11.957)
Fiscal rules	-0.164 (0.186)	-0.121 (0.326)	-0.173 (0.160)	-4.675 (3.458)	-0.196 (0.174)	-0.226 (0.371)	-0.128 (0.158)	-12.505* (3.363)
Trade	-0.008** (0.004)	-0.014*** (0.005)	-0.008*** (0.003)	-0.005 (0.024)	-0.006** (0.003)	-0.019*** (0.006)	-0.009*** (0.003)	0.057 (0.021)
Health Expenditure	0.0004*** (0.0001)	0.0004*** (0.0001)	0.0004*** (0.0001)	-0.0004 (0.0001)	0.0004*** (0.0001)	0.0004*** (0.0001)	0.0004*** (0.0001)	0.0004 (0.0001)
Government effectiveness	1.885*** (0.406)	0.745** (0.368)	1.598*** (0.271)	2.910 (1.868)	1.523*** (0.312)	1.180** (0.554)	1.624*** (0.278)	3.965 (2.543)
Constant	13.179*** (0.971)	13.473*** (0.751)	13.443*** (0.573)	14.467*** (1.400)	12.872*** (0.834)	14.118*** (1.282)	13.335*** (0.631)	-8.211 (4.171)
Observations	511	409	844	67	637	283	847	29
R-squared	0.937	0.914	0.926	0.987	0.923	0.958	0.920	0.999
Country FE, Years	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes : We use the entropy balancing method for the continuous method in this table. The dependent variable is sovereign debt rating. The variable of interest is the cross between temperature shock and fiscal rules. In this table, we use the entropy balancing method for continuous processing. In the different columns, the distinction is made according to the quality of the state apparatus (columns 1 and 2), the political stability (columns 3 and 4), the level of democracy (columns 5 and 6), and the management of the debt ratio (columns 7 and 8). ***p<0.001,

**p<0.01, *p<0.05. Standard errors are in parentheses.

TABLE 57 – Heterogeneity

Variables	SDR	SDR	SDR	SDR	SDR	SDR	SDR	SDR
Temp-legal(normalized)	0.603*** (0.172)							
Temperature shock	-0.159 (0.097)	-0.154 (0.095)	-0.102 (0.096)	-0.094 (0.098)	-0.076 (0.092)	-0.155 (0.096)	-0.077 (0.094)	-0.052 (0.090)
Debt ratio	-0.048*** (0.003)	-0.048*** (0.003)	-0.048*** (0.003)	-0.048*** (0.003)	-0.047*** (0.003)	-0.048*** (0.003)	-0.047*** (0.003)	-0.048*** (0.003)
HardIT	0.684*** (0.187)	0.674*** (0.188)	0.713*** (0.189)	0.693*** (0.188)	0.688*** (0.186)	0.683*** (0.188)	0.676*** (0.188)	0.704*** (0.186)
Fiscal rules	-0.021 (0.136)	-0.105 (0.154)	-0.019 (0.147)	0.048 (0.135)	0.122 (0.132)	-0.138 (0.153)	0.094 (0.132)	0.064 (0.134)
Trade	-0.010*** (0.003)	-0.008*** (0.003)	-0.009*** (0.003)	-0.009*** (0.003)	-0.008*** (0.003)	-0.009*** (0.003)	-0.009*** (0.003)	-0.008*** (0.003)
Health Expenditure	0.0005*** (0.0007)	0.0005*** (0.0007)	0.0005*** (0.0007)	0.0005*** (0.0007)	0.0005*** (0.0007)	0.0005*** (0.0007)	0.0005*** (0.0007)	0.0005*** (0.0007)
Government effectiveness	1.681*** (0.259)	1.669*** (0.260)	1.695*** (0.260)	1.693*** (0.260)	1.718*** (0.259)	1.621*** (0.262)	1.718*** (0.261)	1.747*** (0.257)
Temperature-legal		0.296*** (0.108)						
Temperature-flexibility			0.224* (0.116)					
Temperature-strength rules				0.074* (0.044)				
Temperature-constitution					0.524** (0.259)			
Temperature-statutory						0.343*** (0.102)		
Temperature-treaty							0.236* (0.138)	
Temperature-invest								0.400** (0.193)
Constant	13.598*** (0.566)	13.430*** (0.562)	13.466*** (0.564)	13.444*** (0.570)	13.415*** (0.558)	13.386*** (0.563)	13.444*** (0.566)	13.416*** (0.556)
Observations	920	920	920	920	920	920	920	920
R-squared	0.926	0.926	0.925	0.925	0.925	0.926	0.925	0.925
Country FE, Years	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes : We use the entropy balancing for continuous treatments ***p<0.001, **p<0.01, *p<0.05. Standard errors are in parentheses.

TABLE 58 – Transmission channels

	1	2	3
Variables	SDR	SDR	SDR
Inflation	-0.026**		
	(0.010)		
Debt ratio	-0.048***	-0.048***	-0.047***
	(0.006)	(0.006)	(0.006)
HardIT	0.624*	0.519	0.599
	(0.370)	(0.369)	(0.369)
Fiscal rules	0.089	0.028	0.116
	(0.279)	(0.279)	(0.282)
Trade	-0.008	-0.007	-0.008
	(0.005)	(0.005)	(0.005)
Health Expenditure	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
Government effectiveness	1.585***	1.476***	1.622***
	(0.561)	(0.556)	(0.552)
GDP			0.037**
			(0.019)
Constant	12.998***	13.297***	13.031***
	(1.108)	(1.117)	(1.096)
Observations	948	944	948
Number of idcoun	56	56	56
Country FE, Years	Yes	Yes	Yes

Notes : ***p<0.001, **p<0.01, *p<0.05. Standard errors are in parentheses.

TABLE 59 – Correlation table

Pairwise correlations

Variables	1	2	3	4
(1) Temperature shock	1.000			
(2) Inflation-0.0648*		1.000		
(3) GDP per capita-0.0655*-0.0233			1.000	
(4) Debt -0.00380.0764*-0.2060*				1.000

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

TABLE 60 – Robustness check with Arrelano-Bond

	1	2	3	4	5	6	7	8
Variables	SDR	SDR	SDR	SDR	SDR	SDR	SDR	SDR
L.SDR	0.953***	0.837***	0.820***	0.856***	0.847***	0.832***	0.843***	0.866***
	(0.024)	(0.038)	(0.039)	(0.043)	(0.042)	(0.039)	(0.043)	(0.042)
Temperature shock	-0.154**	-0.190**	-0.219**	-0.231***	-0.156**	-0.304***	-0.201**	-0.253***
	(0.074)	(0.080)	(0.085)	(0.071)	(0.079)	(0.092)	(0.083)	(0.082)
Debt ratio		-0.014***	-0.013***	-0.013***	-0.009*	-0.012**	-0.015***	-0.013***
		(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)
HardIT		0.315	0.280	0.571*	0.556*	0.586	0.298	0.428
		(0.318)	(0.258)	(0.347)	(0.305)	(0.382)	(0.324)	(0.467)
Fiscal rules		-0.383*	-0.291	-0.514**	-0.082	-0.253	-0.371*	-0.472*
		(0.210)	(0.206)	(0.255)	(0.207)	(0.208)	(0.206)	(0.247)
Trade		0.0001	-0.001	-0.0001	0.002	-0.003	0.0001	0.001
		(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
Health Expenditure		0.0001*	0.0001	0.0001	0.0001**	0.0001	0.0001	0.0001
		(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Government effectiveness		0.764***	0.652**	0.211	0.395	0.569*	0.798**	0.620**
		(0.268)	(0.263)	(0.447)	(0.306)	(0.318)	(0.336)	(0.308)
Socioeconomic conditions			0.125**					
			(0.050)					
ICRG Indicator of Quality of Government				2.814				
				(1.753)				
Government stability				0.164***				
				(0.052)				
Law and Order					0.303**			
					(0.122)			
Corruption						-0.046		
						(0.195)		
Index of Democratization								0.002
								(0.015)
Constant	0.662***	2.533***	2.190***	0.957	0.516	1.789**	2.650***	2.125***
	(0.248)	(0.536)	(0.615)	(0.997)	(0.850)	(0.714)	(0.684)	(0.594)
Observations	1,156	879	826	785	826	826	826	784

Notes : We use the Arrelano-Bond(1991) method in this table. The dependent variable is sovereign debt rating. The variable of interest is the Temperature shock. In column 1, we present the results without controls. In column 2, we present the results of our baseline model by adding controls. We add additional control variables from column 3 to column 9 to see if the model is still robust. ***p<0.001, **p<0.01, *p<0.05. Standard errors are in parentheses.

TABLE 61 – Robustness check with Arrelano-Bond

	1	2	3	4	5	6	7	8
Variables	SDR	SDR	SDR	SDR	SDR	SDR	SDR	SDR
L.SDR	0.951*** (0.026)	0.933*** (0.030)	0.931*** (0.035)	0.918*** (0.033)	0.947*** (0.035)	0.916*** (0.034)	0.939*** (0.033)	0.938*** (0.032)
Vulnerability	-2.567** (1.055)	-2.391** (1.131)	-3.736** (1.528)	-3.239** (1.335)	-3.511** (1.641)	-3.418** (1.619)	-2.529** (1.153)	-2.580** (1.180)
Debt ratio		-0.004 (0.007)	-0.005 (0.008)	-0.001 (0.007)	-0.0001 (0.008)	-0.0001 (0.006)	-0.004 (0.008)	-0.004 (0.008)
HardIT		0.194 (0.301)	0.265 (0.330)	0.299 (0.332)	0.440 (0.343)	0.433 (0.278)	0.260 (0.328)	0.222 (0.319)
Fiscal rules		-0.111 (0.185)	-0.241 (0.225)	-0.101 (0.194)	-0.247 (0.213)	0.126 (0.239)	-0.078 (0.201)	-0.102 (0.190)
Trade		-0.006* (0.003)	-0.008* (0.004)	-0.008** (0.004)	-0.010** (0.004)	-0.006* (0.003)	-0.007* (0.004)	-0.006* (0.003)
Health Expenditure		-0.0003 (0.0001)	-0.0003 (0.0001)	-0.0003 (0.0001)	-0.0003 (0.0001)	-0.0003 (0.0001)	-0.0003 (0.0001)	-0.0003 (0.0001)
Government effectiveness		0.271 (0.237)	-0.141 (0.304)	0.463 (0.318)	-0.223 (0.458)	0.111 (0.278)	0.206 (0.322)	0.244 (0.360)
Bureaucracy			0.400* (0.207)					
Democracy				-0.164 (0.101)				
ICRG Indicator of Quality of Government					1.901 (1.593)			
Government stability						0.256*** (0.077)		
Law and Order							0.045 (0.125)	
Corruption								0.013 (0.168)
Constant	1.417** (0.679)	2.216** (0.918)	2.380** (1.005)	3.555*** (1.048)	1.778 (1.378)	0.698 (0.959)	2.178** (1.100)	2.344** (1.103)
Observations	1,192	905	849	849	808	849	849	849
Number of idcoun	58	56	56	56	53	56	56	56

Notes : We use the Arrelano-Bond method(1991) in this table. The dependent variable is sovereign debt rating.

The variable of interest is the vulnerability index(ND-Gain country index). In column 1, we present the results without controls. In column 2, we present the results of our baseline model by adding controls. From column 3 to column 9, we add additional control variables to see if the model is still robust.. ***p<0.001, **p<0.01, *p<0.05.

Standard errors are in parentheses.

TABLE 62 – Descriptive statistics

Descriptive statistics					
Variables	Observations	Moyenne	SD	Min	Max
Sovereign Debt Ratings(SDR)	1259	10.132	3.1925	1.666	18.275
Temperature Shock	1600	0.936	0.533	-0.794	3.693
Debt ratio	1482	50.773	44.407	1.562	600.13
HardIT	1664	0.204	0.403	0	1
Fiscal rules	1664	0.350	0.477	0	1
Trade	1538	71.292	33.391	0.756	220.406
Health Expenditure	1600	396650.8	1042681	451.1807	1.07e+07
Government effectiveness	1280	-0.290	0.583	-1.884	1.337

TABLE 63 – Description

Variables	Description	Source
Sovereign Debt Rating(SDR)	An index of sovereign risk; higher means better debt rating.	S& P Ratings
Temperature Shock	Temperature shock measures the average of temperature variability over a given period	IMF
Debt/GDP	Debt is the government's total fixed-term financial liabilities at a given date.	WDI
Trade	It is the measure of trade openness	WDI
Fiscal rules	It is a binary variable that indicates 1 if the country has adopted at least one fiscal rule and 0 otherwise	IMF
HardIT	It is a binary variable that indicates 1 if the country has adopted inflation targeting and 0 otherwise	(Roger, 2009 ; Tapsoba, 2012)
Health Expenditure	Household spending is the final consumption expenditure by resident households for daily needs.	OECD
Government effectiveness	The government effectiveness index measures the quality of public services	WDI, (Cevik and Jalles, 2022)

The list of sample countries		
Number	Country	Type
1	Angola	Developing country
2	Albania	Developing country
3	Armenia	Developing country
4	Azerbaijan	Developing country
5	Burkina Faso	Developing country
6	Bangladesh	Developing country
7	Belarus	Developing country
8	Brazil	Developing country
9	Botswana	Developing country
10	China	Developing country
11	Cameroon	Developing country
12	Colombia	Developing country
13	Costa Rica	Developing country
14	Dominican Republic	Developing country
15	Algeria	Developing country
16	Ecuador	Developing country
17	Ethiopia	Developing country
18	Ghana	Developing country
19	Guatemala	Developing country
20	Honduras	Developing country
21	Indonesia	Developing country
22	India	Developing country
23	Jamaica	Developing country
24	Jordan	Developing country
25	Kazakhstan	Developing country
26	Kenya	Developing country
27	Kuwait	Developing country
28	Lebanon	Developing country
29	Sri Lanka	Developing country
30	Morocco	Developing country
31	Madagascar	Developing country
32	Mexico	Developing country
33	Mali	Developing country
34	Myanmar	Developing country
35	Mongolia	Developing country
36	Mozambique	Developing country
37	Malawi	Developing country
38	Malaysia	Developing country
39	Namibia	Developing country
40	Niger	Developing country
41	Nigeria	Developing country
42	Nicaragua	Developing country
43	Pakistan	Developing country
44	Panama	Developing country
45	Peru	Developing country
46	Philippines	Developing country
47	Poland	Developing country
48	Paraguay	Developing country
49	Qatar	Developing country
50	Russian Federation	Developing country
51	Saudi Arabia	Developing country
52	Sudan	Developing country
53	Senegal	Developing country
54	El Salvador	Developing country
55	Togo	Developing country
56	Thailand	Developing country
57	Trinidad and Tobago	Developing country

58	Turkey	Developing country
59	Uganda	Developing country
60	Ukraine	Developing country
61	Uruguay	Developing country
62	South Africa	Developing country
63	Zambia	Developing country
64	Zimbabwe	Developing country

Conclusion générale

Le changement climatique représente aujourd'hui l'un des défis majeurs pour le développement durable à l'échelle mondiale. Ses effets se manifestent à travers la multiplication des catastrophes naturelles, l'augmentation des températures moyennes, la dégradation des écosystèmes et l'insécurité alimentaire, touchant particulièrement les pays en développement dont les capacités d'adaptation restent limitées. Cette thèse a mis en lumière l'interdépendance complexe entre les enjeux environnementaux, les politiques budgétaires et les mécanismes de financement du développement. Elle montre que le changement climatique n'est pas seulement une problématique environnementale, mais également un défi économique, social et institutionnel, qui exige une approche intégrée articulant gestion des finances publiques, mobilisation des ressources et stratégies de croissance durable.

À travers l'analyse, il apparaît clairement que la politique budgétaire joue un rôle central dans la mobilisation et l'allocation des ressources nécessaires pour répondre efficacement aux effets du changement climatique dans les pays en développement. En effet, une politique budgétaire adaptée permet non seulement de financer des mesures d'atténuation, telles que le développement des énergies renouvelables ou l'amélioration de l'efficacité énergétique, mais aussi des mesures d'adaptation comme la construction d'infrastructures résilientes, la protection des zones côtières ou le soutien aux secteurs agricoles vulnérables. Par ailleurs, une gestion budgétaire crédible et transparente renforce la confiance des partenaires internationaux et des investisseurs privés. Elle contribue ainsi à améliorer la soutenabilité de la dette publique et à accroître l'attractivité des investissements directs étrangers, indispensables au financement du développement et au transfert de technologies propres.

Par ailleurs, le financement du développement, qu'il soit public ou privé, local ou international, doit être repensé pour intégrer pleinement les impératifs climatiques. Les mécanismes traditionnels de financement montrent aujourd'hui leurs limites face à l'ampleur des besoins liés à la transition écologique. Il devient donc essentiel de promouvoir des instruments innovants, tels que les obligations vertes, les fonds climatiques ou les partenariats public-privé orientés vers la durabilité. L'efficacité des stratégies de lutte contre le changement climatique dépend largement de la capacité des États et des institutions financières à mobiliser des ressources substantielles, à garantir leur allocation efficace et à assurer la transparence dans leur utilisation. Cela suppose également un changement de paradigme, impliquant une remise en cause de certaines approches économiques classiques qui privilégient la croissance à court terme au détriment des équilibres environnementaux et intergénérationnels.

En somme, relever les défis du changement climatique exige une coordination renforcée entre les politiques budgétaires et les mécanismes de financement du développement dans les pays en développement. Cette synergie doit s'appuyer sur une planification stratégique de long terme, une gouvernance renforcée et une coopération internationale accrue. Elle est essentielle pour instaurer

rer un modèle de croissance inclusif, respectueux de l'environnement et capable de répondre aux besoins des générations présentes sans compromettre ceux des générations futures. Une telle approche permettrait de concilier impératifs économiques, justice sociale et durabilité écologique, en inscrivant l'action publique dans une perspective de résilience et de transformation structurelle.

Trois limites sont toutefois à relever dans cette thèse. La première concerne la difficulté d'analyser de manière approfondie les effets différenciés du changement climatique sur les catégories socio-professionnelles et, plus largement, sur les différents types de ménages, notamment à travers une approche microéconomique. Une telle analyse aurait permis de mieux comprendre les inégalités climatiques et distributives. La deuxième limite réside dans la difficulté d'évaluer l'impact des règles budgétaires sur les différents types d'investissements directs étrangers (chinois, américains, européens, etc.), en raison du manque de données désagrégées et comparables. Enfin, la troisième limite tient à la complexité d'intégrer pleinement les externalités environnementales dans les modèles d'analyse, ainsi qu'au décalage temporel entre les cycles budgétaires et électoraux, généralement de court terme, et les effets du changement climatique, qui s'inscrivent dans le long terme. Ces contraintes soulignent la nécessité d'améliorer les outils méthodologiques et les bases de données disponibles.

Cette thèse ouvre ainsi la voie à des perspectives de recherche futures visant à approfondir l'étude des instruments innovants de financement climatique et à promouvoir des politiques budgétaires plus responsables, transparentes et adaptées aux réalités environnementales. Il serait notamment pertinent d'examiner les effets de voisinage des règles budgétaires et d'autres instruments de politique budgétaire, afin d'évaluer les dynamiques régionales et les phénomènes d'imitation ou de concurrence fiscale. De plus, des recherches plus approfondies sur l'efficacité réelle des investissements verts, leur rentabilité socio-économique et leur impact à long terme sur la croissance et la réduction des inégalités seraient particulièrement souhaitables pour éclairer la prise de décision publique.

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Crépin HISGUIMA DASSIDI

Essais sur la politique budgétaire, le changement climatique, et le financement du développement

Les effets du changement climatique font peser des menaces réelles sur les conditions de vie de l'Homme. Dans les pays en développement, ces effets sont encore plus prononcés en raison de la forte vulnérabilité et de la faible capacité de ces pays à y faire face. Ainsi, cette thèse se propose de contribuer à la littérature existante en présentant quatre chapitres afin d'analyser le lien entre le changement climatique, la politique budgétaire et le financement du développement dans les pays en développement. Dans le premier chapitre, nous nous penchons sur l'effet du changement climatique sur la pauvreté et interrogeons la capacité des dépenses publiques à atténuer ces effets. Les résultats indiquent que le choc climatique aggrave les conditions socio-économiques, donc la pauvreté. Cet effet est mis en évidence par la relation positive et significative entre le choc climatique et la pauvreté. Les résultats suggèrent également que l'utilisation des dépenses publiques permet d'atténuer les effets du choc. Ce chapitre met aussi en lumière des facteurs clés de résilience, donc d'atténuation du choc, tels que les dépenses sociales et de santé. Le deuxième chapitre s'intéresse à l'analyse de la relation entre les règles budgétaires et les Investissements Directs Étrangers (IDE). Il en ressort que l'adoption des règles budgétaires par les pays en développement permet d'augmenter les IDE, nécessaires au financement du développement. Plus intéressant encore, en dehors des règles sur les dépenses, les autres types de règles budgétaires, à savoir celles sur le revenu, le ratio d'endettement, le déficit et l'inflation, contribuent à attirer davantage d'IDE. Dans le troisième chapitre, nous menons une réflexion sur la relation entre l'adoption des règles budgétaires et le financement vert. Les résultats montrent que l'adoption de règles budgétaires permet d'attirer plus d'investissements verts. Le dernier chapitre met en évidence le lien entre le choc climatique et la notation de la dette souveraine, puis interroge l'efficacité de la politique budgétaire dans l'atténuation des effets du choc sur cette notation. Très souvent, cette notation souveraine correspond à l'évaluation de la solvabilité de chacun de ces pays par les agences de notation. Elle permet de mesurer la capacité du pays à mobiliser des ressources externes pour le financement du développement. Les résultats montrent que le choc climatique affecte négativement et significativement la notation de la dette souveraine. En présence du choc, l'adoption des règles budgétaires permet d'atténuer cet effet sur la notation.

Mots clés : changement climatique, chocs climatiques, pauvreté, règles budgétaires, pays en développement, Investissements Directs Étrangers, financement vert.

Essays on Fiscal Policy, Climate Change, and Financing for Development

The effects of climate change pose real threats to human living conditions. In developing countries, this effect is even more pronounced due to the high vulnerability and low capacity of these countries to cope with it. Thus, this thesis aims to contribute to the existing literature by proposing four chapters to analyze the link between climate change, fiscal policy, and development financing in developing countries. In the first chapter, we look at the effect of climate change on poverty and we question the capacity of public spending to mitigate the effects. The results indicate that the climate shock worsens socio-economic conditions, therefore poverty. The effect is captured by the positive and significant relationship between the climate shock and poverty. The results also suggest that the use of public spending helps to mitigate the effects of the shock. The results of this chapter also highlight key factors of resilience, therefore shock mitigation such as social and health spending. Chapter 2 focuses on the analysis of the relationship between fiscal rules and Foreign Direct Investment (FDI). It emerges from this chapter that the adoption of fiscal rules by developing countries helps increase FDI, which is necessary to finance development. More interestingly, apart from expenditure rules, other types of budgetary restrictions, namely rules on income, debt ratio, deficit, and inflation, contribute to attracting more FDI. Subsequently, in the third chapter, we reflect on the relationship between the adoption of fiscal rules and green financing. The results of this chapter show that the adoption of fiscal rules helps attract more green investment. The last chapter highlights the link between climate shock and sovereign debt rating and then questions the effectiveness of fiscal policy in mitigating the effects of the shock on this sovereign rating of developing countries. Very often, this sovereign rating is the assessment of the solvency of each of these countries by rating agencies. It measures the country's ability to mobilize external resources to finance development. The results show that climate shock negatively and significantly affects sovereign debt rating. In the presence of the shock, the adoption of the fiscal rules helps to mitigate the effect of the shock on this rating.

Keywords: climate change, climate shocks, poverty, fiscal rules, developing countries, Foreign Direct Investment, green financing.

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