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Stabilité bancaire, digitalisation financière, économie informelle et catastrophes naturelles : quatre enjeux de politique économique

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A ma famille

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Résumé

Cette thèse propose quatre essais empiriques portant respectivement sur la stabilité bancaire, la digitalisation financière, l'économie informelle et les catastrophes naturelles. Ces thèmes représentent tous des enjeux de politique économique. Le premier chapitre s'intéresse à l'impact de la concurrence bancaire sur le risque de crédit en Afrique subsaharienne. Nous montrons que le développement de la concurrence est susceptible à la fois d'améliorer et de dégrader la qualité des portefeuilles bancaires. Le deuxième chapitre examine si la rapide expansion des services financiers mobiles contribue à réduire le poids du secteur informel dans les pays émergents et en développement. Nos résultats indiquent notamment qu'une telle innovation financière peut être considérée comme un puissant outil de formalisation des économies. Le troisième chapitre étudie, pour sa part, l'effet de l'éducation sur l'économie informelle en Afrique. Nous soulignons ici l'intérêt d'un système éducatif équilibré entre l'enseignement général et l'enseignement professionnel pour faire reculer la taille de l'économie informelle. Le dernier chapitre traite des déterminants des catastrophes naturelles. Il met en lumière le rôle des conditions climatiques, du réchauffement de la planète, et des facteurs économiques et structurels dans l'incidence des catastrophes naturelles.

Mots-clés : Stabilité bancaire ; Concurrence bancaire ; Services financiers mobiles ; Économie informelle ; Éducation ; Catastrophes naturelles

Abstract

This dissertation proposes four empirical essays on bank stability, financial digitalisation, the informal economy, and natural disasters. These themes represent economic policy challenges. The first chapter looks at the impact of bank competition on credit risk in Sub-Saharan Africa. We show that increased competition is likely to both enhance and lessen the quality of banks' loans portfolios. The second chapter investigates whether the rapid expansion of mobile financial services helps reduce the informal sector in emerging and developing countries. Our results indicate that such financial innovation can be considered as a powerful tool to formalize economies. The third chapter examines the effect of education on the informal economy in Africa. We underline the importance of a balanced educational system between general and vocational education to reduce the size of the informal sector. The last chapter focuses on the determinants of natural disasters. It highlights the role of weather, economic and structural factors, and climate change in the incidence of natural disasters.

Keywords: Bank stability; Bank competition; Mobile financial services; Informal economy; Education; Natural disasters

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Introduction générale

Contexte général

La présente thèse a été réalisée dans le cadre institutionnel de la Banque de France (avec le bénéfice d'un dispositif CIFRE, au Service de la Zone franc et du financement du développement) principalement puis, de manière plus brève, du Fonds monétaire international (dans le cadre du « *Fund internship program* », au Département Afrique) et en réponse à des besoins de recherche dictés par des impératifs de politique économique.

Les pays avancés et en développement font actuellement face à des défis auxquels il convient d'apporter des réponses en termes de politiques publiques. Premièrement, l'émergence de groupes bancaires régionaux, qui s'est traduite par un accroissement du nombre d'établissements de crédit, a considérablement modifié le paysage bancaire en Afrique subsaharienne. A ce mouvement s'ajoute, dans de nombreux pays, une diminution du risque de crédit longtemps considéré comme un frein au développement des systèmes bancaires. Dans les pays émergents et en développement (PED), le secteur informel représente une part considérable de l'activité économique, constituant par ce fait une entrave réelle au développement inclusif et durable. Parallèlement, la rapide expansion des services financiers mobiles a révolutionné à la fois le paysage de l'inclusion financière, ainsi que les habitudes de consommation et de production. En Afrique, l'analyse de l'informalité à travers le prisme de l'éducation prend une dimension importante à mesure que la population croît. Enfin, la recrudescence des catastrophes naturelles et leurs conséquences néfastes sur les plans économique, social et environnement, représentent le nouveau défi mondial. Fort de ces constats, cette thèse propose quatre études empiriques portant respectivement sur la stabilité du secteur bancaire, la digitalisation financière, l'économie informelle et les catastrophes naturelles.

Stabilité et concurrence bancaires

La stabilité du secteur bancaire est une condition essentielle non seulement pour la stabilité des prix, l'objectif de politique monétaire de la banque centrale, mais également pour un développement prospère de l'économie. Par stabilité du secteur bancaire, on entend une situation dans laquelle les établissements de crédit sont suffisamment sains (ou résistants) pour absorber les chocs économiques et s'acquitter dans de bonnes conditions de leur fonction d'intermédiation financière. La stabilité du secteur bancaire représente ainsi un enjeu de politique économique majeur, particulièrement prégnant en Afrique subsaharienne (ASS), une région caractérisée à la fois par une profondeur financière toujours faible et un développement rapide des systèmes bancaires.[1] Le niveau d'accès au crédit par les entreprises et les ménages, mesuré par le ratio des crédits au secteur privé en pourcentage du PIB, était par exemple égal à 28 % en 2015, et sensiblement inférieur à celui des pays émergents et avancés (respectivement 55 % et 120 %).[2]

Les systèmes bancaires se sont considérablement transformés dans toute l'ASS au cours des deux dernières décennies.[3] La mutation s'est opérée à la faveur du processus de libéralisation financière entamé dès la fin des années 80[4] (Beck et Cull, 2014) d'une part, et de la période de forte croissance économique induite par le super-cycle du prix des matières premières du début des années 2000 (Jacolin et Noah, 2017), d'autre part. Il s'en est suivi une reconfiguration des marchés bancaires africains, dominés jusqu'au milieu des années 2000, par les filiales de banques occidentales en faveur des banques panafricaines ou régionales. Ces groupes bancaires (Attijariwafa Bank, Bank of Africa, Ecobank, Standard Bank, United Bank for Africa, etc.) sont devenus des acteurs

[1] Le financement de l'économie en Afrique subsaharienne reste encore pour l'essentiel assuré par le secteur bancaire malgré un développement rapide mais assez hétérogène des marchés financiers.

[2] D'après les données de la Banque mondiale.

[3] Pour plus de détails, voir l'étude (co-écrite avec L. Jacolin sur le mouvement de déconcentration des systèmes bancaires en Afrique (Bulletin de la Banque de France, No. 212, 2017).

[4] La période de 1980-90 a été marquée par une vague de privatisations des banques publiques dans de nombreux pays d'ASS, conséquemment à plusieurs crises bancaires sur la même période.

incontournables en quelques années seulement, à l'instar du Groupe bancaire Ecobank, originaire du Togo, et présent dans 34 pays d'ASS en 2015 (d'après le rapport annuel de la même année).

L'essor de groupes bancaires panafricains s'est notamment traduit par l'accroissement du nombre d'établissements bancaires (de 445 établissements en 2005 à 560 en 2015), signe d'une forte intensification de la concurrence bancaire.

Le niveau de concurrence entre les établissements bancaires est un déterminant important de leur comportement microéconomique, en matière de fixation de prix, de contrôle des coûts et donc profitabilité ou encore de leur capacité à innover. Il est également un facteur important de dynamisme des marchés bancaires, le développement bancaire, avec ses effets sur la profondeur financière et l'inclusion financière, étant associé à une plus forte croissance du secteur privé et un développement économique plus rapide (Beck et al., 2004 ; Leon, 2015 ; Chauvet et Jacolin, 2017 ; etc.)[5].

Le développement des systèmes bancaires de l'ASS a longtemps été bridé par l'importance du risque de crédit. Le ratio des prêts non-performants en pourcentage des crédits bruts (indicateur de stabilité bancaire) était, en moyenne, égal à 10 % sur la période de 2000 à 2015, contre moins de 7 % dans les PED (FSI-FMI). La qualité des portefeuilles en ASS a toutefois eu tendance à converger vers ceux des PED au fur et mesure du développement bancaire et de l'intensification de la concurrence bancaire.

La relation entre la concurrence et le risque de crédit (et partant de la stabilité bancaire) fait actuellement l'objet d'un débat dans la littérature.[6] Alors que certains travaux concluent à l'existence d'effets positifs de la concurrence bancaire sur la stabilité, d'autres font, cependant, valoir les effets adverses d'une concurrence accrue. Cette

[5] Contrairement aux pays avancés où l'hypertrophie des systèmes financiers fait parfois débat (« Too much finance ? » - Arcand et al., 2015), le développement du crédit et l'inclusion financière peuvent être considérés comme des leviers du développement pour les pays d'ASS.

[6] Pour plus de détails, voir la méta-analyse de Zigraiova et Havranek (2015).

divergence de points de vue s'est traduite par une structuration de la littérature en deux paradigmes. D'après le premier paradigme, communément connu sous l'anglicisme « *competition-fragility* » et soutenu par les travaux pionniers de Marcus (1984) et Keeley (1990), une concurrence accrue en érodant le pouvoir de marché des établissements de crédit, réduit les marges bénéficiaires de ces derniers. Afin de maintenir leur capacité à réaliser des profits (on parle aussi de « *franchise value* »), les banques sont dès lors incitées à une prise de risque croissante qui dégrade la qualité de leurs portefeuilles de crédits. Le deuxième paradigme, connu sous l'anglicisme « *competition-stability* » et développé par Boyd et De Nicolo (2005), défend l'idée suivant laquelle un pouvoir de marché accru des banques pourrait se traduire par une augmentation du risque de crédit. En effet, les taux d'intérêt élevés sur les prêts rendent plus difficile leur remboursement et incitent les emprunteurs à prendre plus de risque, renforçant ainsi l'aléa moral et leur probabilité de défaut. Plus récemment, Martinez-Miera et Repullo (2010) proposent une extension du modèle de Boyd et De Nicolo (2005) et établissent l'existence d'une relation non-linéaire entre la concurrence et la stabilité bancaire. Le développement de la concurrence bancaire est susceptible d'aboutir à deux effets opposés : i) la réduction des taux d'intérêt sur les crédits, induite par l'augmentation de la concurrence, se manifeste par une baisse de la probabilité de défaut des emprunteurs et, partant, une amélioration des portefeuilles de prêts (« *risk-shifting effect* »; ii) la baisse des revenus d'intérêts sur les crédits érode, quant à elle, les marges bénéficiaires, et exerce en définitive un effet négatif sur la stabilité bancaire (« *margin effect* »). Le poids relatif de chacun de ses effets dépendra du niveau d'intensité de la concurrence.

Plusieurs évidences empiriques sous-tendent chacune des approches, dont Dick (2006), Jimenez et al. (2007), Turk Ariss (2010), Agoraki et al. (2011), etc., pour le premier paradigme ; Salas et Saurina (2003), Beck et al. (2006), Schaeck and Čihák (2014), Goetz (2018), etc., pour le deuxième paradigme. Les travaux de Tabak et al. (2012), Liu et al. (2013), ou encore González et al. (2017), permettent pour leur part de confirmer l'existence d'une relation non-linéaire entre la concurrence et le risque bancaire.

A l'analyse de ces travaux, il apparait un nombre limité d'études portant sur les pays d'ASS (Kouki et Al-Nasser, 2017 ; Akande et al., 2018).[7] Eu égard à cet état de choses et au rôle central des questions de stabilité bancaire pour les autorités monétaires, il s'est avéré pour nous intéressant d'examiner l'impact du développement de la concurrence bancaire sur le risque de crédit en ASS. Cette question fera l'objet du chapitre 1. Ce sera par ailleurs, l'occasion d'explorer d'autres déterminants pouvant également servir d'indicateurs d'alerte pour se prémunir contre l'instabilité bancaire en Afrique subsaharienne.

Innovation financière dans les pays émergents et en développement (PED) : l'économie des services financiers mobiles

S'il existe un domaine dans lequel les pays en développement créent actuellement leur propre modèle, c'est bien celui des services financiers mobiles, plus connus sous le nom de « *mobile money* » ou « *mobile banking* ». Ils incluent l'ensemble des services de transactions financières (transfert, moyens de paiement, crédit ou épargne) potentiellement accessibles à toute personne utilisant un téléphone mobile.[8] Ils présentent par ailleurs l'avantage d'être accessibles indépendamment d'une connexion à internet. Adopté pour la première fois aux Philippines en 2001 et mondialement reconnu après son introduction réussie au Kenya en 2007[9], le « mobile money » est aujourd'hui disponible dans près de deux tiers des PED, et utilisé par 866 millions de personnes (*Global Mobile Money Dataset*, GSMA). Initialement portés sur les services de transfert et de paiement mobiles, l'offre des services s'est considérablement diversifiée sur la période récente avec l'émergence d'une nouvelle gamme de produits : crédits, épargnes et micro-assurances mobiles.[10]

[7] Ces deux travaux soutiennent le premier paradigme.

[8] Selon la définition de l'Association des constructeurs et opérateurs de téléphonie mobile (GSMA).

[9] Le « *mobile money* » a notamment permis l'inclusion financière de plus de 70 % de la population adulte au Kenya (Global Findex).

[10] Le marché des services financiers mobiles est un écosystème qui englobe un large éventail d'acteurs différents, notamment les opérateurs de téléphonie mobile, les institutions financières, les agents de distribution et les organismes de réglementation.

Cette innovation a non seulement révolutionné le paysage de l'inclusion financière, mais elle a également profondément modifié les habitudes de consommation et de production des populations et des entreprises. Alors qu'à peine 43 % d'adultes possèdent un compte bancaire dans les PED (Global Findex), les SFM ont permis aux personnes et aux entreprises qui étaient jusqu'ici exclues des systèmes bancaires traditionnels, d'accéder aux services financiers de base via leur téléphone mobile, et ce à moindre coût. Le processus de digitalisation financière qui s'en est suivi a permis aux PED de bénéficier d'importants effets de rattrapage. Les PED accusent d'importants retards dans le développement des infrastructures et des réseaux bancaires, et possèdent de faibles niveaux d'accès au crédit pour les entreprises. En profitant du déploiement à moindre coût des réseaux de téléphonie mobile, les SFM sont donc parvenus à proposer une solution accessible à l'exclusion financière.

L'émergence des SFM est, de manière générale, considérée comme une réponse aux défaillances des marchés bancaires traditionnels. Comme l'a récemment souligné Aron (2018), l'un des avantages de l'adoption des SFM consiste en la réduction des coûts de transaction, notamment dans les zones enclavées du fait d'infrastructures de transport inadéquates et non couvertes par les réseaux d'agences bancaires. L'adoption des SFM permet par ailleurs d'atténuer la contrainte d'asymétrie d'information à laquelle sont généralement confrontées les banques traditionnelles lorsqu'elles désirent établir une relation de crédit avec les ménages et/ou firmes ne présentant aucune garantie ou documentation. L'utilisation des SFM génèrent aussi des quantités de données considérables qui simplifient l'évaluation du risque ou de la solvabilité des emprunteurs.

Suite au succès de l'expérience kenyane, un nouveau pan de la littérature, pour l'essentiel microéconomique, a vu le jour. Jack et Suri (2016) ont par exemple montré que l'adoption du « *mobile money* » a permis de sortir 194 000 ménages kenyans (soit 2% du total des ménages), de l'extrême pauvreté. Pour Jack et al. (2013), et Jack et Suri (2014), le « *mobile money* » peut être considéré comme un mécanisme de partage des

risques et d'atténuation des chocs. Islam et al. (2017), tout comme Beck et al. (2018) ont mis en exergue l'effet positif du « *mobile money* » sur l'investissement et la productivité des entreprises. D'autres travaux se sont par la suite intéressés à l'impact de l'adoption du « *mobile money* » sur l'efficacité des programmes de lutte contre la pauvreté (Aker et al., 2016), les performances agricoles (Aker et Ksoll, 2016), les transferts de fonds de migrants (Munyegera et Matsumoto, 2016), ou encore la résilience aux chocs climatiques (Riley, 2018).

L'essor des SFM dans les pays en développement est facilité par le faible développement financier et une prédominance des services financiers informels pour financer la consommation et certains projets d'investissement. Aussi, les PED se distinguent par une forte préférence pour les transactions financières en espèces (on parle aussi d'économie monétaire ou « *cash economy* »). Comme l'ont souligné La Porta et Shleifer (2014), il s'agit là d'un signe clairement révélateur de l'importance du secteur informel.

La définition du secteur informel fait l'objet d'un débat, qui tient aussi bien des problèmes méthodologiques pour le mesurer, que des différents vocables employés comme synonymes et son importance relative. Dans la présente thèse, nous faisons nôtre la définition de Buehn et Schneider (2012) qui considèrent le secteur informel comme l'ensemble des activités de production légale et marchande des biens et services qui échappent à l'inclusion dans les comptes nationaux, une exclusion est donc faite des activités illicites. Ces activités économiques légales sont généralement exprimées en pourcentage du PIB.[11] Le poids du secteur informel qui représente en moyenne 35% du PIB dans les PED (contre moins de 10% dans les économies avancées, Medina et Schneider, 2018), constitue pour ces pays une contrainte de développement majeure.

[11] A l'instar de Dell'anno (2016), les vocables économie informelle, souterraine ou non-officielle sont utilisés comme synonymes.

Les coûts de l'informalité sont nombreux et relativement bien répertoriés dans la littérature : faible productivité du travail et du capital, intermédiation financière inefficace, concurrence déloyale, distorsions de l'investissement, dissuasion de l'innovation, transmission de la politique monétaire relativement inefficace en raison de la finance informelle, création des trappes à pauvreté et augmentation des inégalités de revenu (Bhattacharya et al., 2011 ; Blackburn et al., 2012 ; Elbahnasaw et al., 2016). En raison des carences de compétences managériales et d'un accès limité aux capitaux, la productivité des entreprises informelles est généralement faible. En conséquence, les revenus ont tendance à être plus faibles et volatils que dans le secteur formel (La Porta et Shleifer, 2014). Un secteur informel important pèse également sur la mobilisation des ressources fiscales domestiques, indispensables pour financer les services publics de base ou projets d'infrastructures, pourtant essentiels pour atteindre les objectifs de développement durable. Le tableau n'est cependant pas tout noir. Le secteur informel peut également jouer un rôle stabilisateur en absorbant les chocs qui affectent le secteur formel. Il représente également une source de revenus et d'inclusion économique pour les segments les plus vulnérables de la population. Cette discordance d'effets place les décideurs publics face à un dilemme et limite la pertinence de l'approche répressive de certaines politiques publiques en faveur de la formalisation des économies (La Porta et Shleifer, 2014).

Le choix d'opérer dans le secteur informel est motivé par un large éventail de considérations économiques, financières et institutionnelles. La première a trait à la fuite devant l'impôt et les cotisations sociales (Djankov et al., 2010 ; Goel et Nelson, 2016 ; Mitra, 2017). Le faible développement financier, et en particulier, un accès limité au crédit peut également favoriser le secteur informel (Blackburn et al., 2012 ; Bose et al., 2012 ; Berdiev et Saunoris, 2016). La globalisation politique, sociale et économique ainsi que la qualité de la réglementation et du cadre institutionnel peuvent quant à elles freiner l'appétit pour l'économie informelle (Dreher et al., 2009 ; Goel et Saurinos, 2014 ; Berdiev et Saunoris, 2018). Enfin, l'attrait relatif du secteur informel dépend du cycle économique dans la mesure où les activités informelles fournissent des revenus

alternatifs en période de récession économique ou de chômage élevé (Schneider et Enste, 2000).

Au regard de l'enjeu que présente le secteur informel pour les politiques publiques, évaluer l'impact des services financiers mobiles sur l'économie informelle constitue dès lors une question d'intérêt majeur, qui n'a jusqu'à présent fait l'objet d'aucune étude. Nous tenterons dans le chapitre 2 de cette thèse, en construisant un nouvel indicateur mesurant l'adoption des SFM, d'apporter une réponse à ce vide empirique en mettant en exergue les différents canaux de transmission à travers lesquels les SFM peuvent influer sur le secteur informel.

Economie informelle et système éducatif en Afrique

D'ici à 2050, un quart de la population mondiale vivra en Afrique d'après les dernières prévisions démographiques de l'Organisation des Nations Unies (ONU). La moitié de cette population sera constituée de jeunes de moins de 25 ans, ce qui représente un potentiel considérable en termes de dividende démographique.[12] Cette évolution démographique n'en demeure pas moins un défi de premier rang que le continent ne relèvera qu'en mettant en œuvre de nombreuses réformes structurelles, notamment dans le domaine de l'éducation. Selon un rapport de la Banque mondiale en 2017[13], la population africaine en âge de travailler devrait croître de 70% entre 2015 et 2035, soit approximativement de 450 millions de personnes et en moyenne de 22,5 millions par an. Si aucune priorité n'est donnée à l'éducation, ces nouvelles personnes ne pourront pas acquérir les compétences et qualifications nécessaires pour trouver un emploi dans le secteur formel. En effet, il est généralement admis que les personnes peu instruites sont souvent incapables de trouver un emploi dans le secteur formel. Dans de

[12] Le Fonds des Nations Unies pour la population définit le dividende démographique comme « la croissance économique potentielle liée à l'évolution de la pyramide des âges, principalement lorsque la proportion de la population active (15 à 64 ans) est supérieure à celle des personnes n'étant pas ou plus en âge de travailler (14 ans et moins, 65 ans et plus) ».

[13] Banque mondiale (2017): "*The Africa Competitiveness Report 2017: Addressing Africa's Demographic Dividend*".

nombreux cas, le secteur informel représente la seule option dont elles disposent pour s'assurer des moyens de subsistance souvent précaires.

L'analyse de l'économie informelle à travers le prisme du capital humain a fait l'objet de plusieurs travaux. Pour La Porta et Shleifer (2014), les entreprises informelles sont particulièrement peu productives en raison du faible niveau de capital humain des personnes qui les dirigent. Berrittella (2015) souligne pour sa part qu'une augmentation des dépenses publiques en faveur de l'éducation a pour effet de réduire la taille du secteur informel. Buehn et Farzanegan (2013) aboutissent aussi à une relation décroissante entre le niveau d'éducation et l'économie informelle dans un environnement caractérisé par une meilleure qualité des institutions.

La prépondérance du secteur informel est relativement plus grande dans les économies africaines (38 % du PIB), comparée à celle des autres pays en développement (32 %). En sus des déterminants évoqués plus haut, ce poids important de l'informalité pourrait s'interpréter comme le reflet d'une inadéquation entre le marché du travail et le secteur éducatif en Afrique. Cette question fera l'objet de notre chapitre 3 dans lequel nous analyserons l'effet du niveau d'éducation, et plus particulièrement des systèmes éducatifs (général ou professionnel) sur l'informalité en Afrique. L'enseignement général est un système éducatif conçu pour développer les connaissances générales des apprenants, sans nécessairement les préparer à un emploi ou profession particulière. L'enseignement professionnel renvoie quant à lui à un système éducatif conçu pour permettre aux apprenants d'acquérir les connaissances, aptitudes et compétences propres à une catégorie de professions ou métiers particuliers.

L'éducation semble également essentielle pour faire face au changement climatique. Une population instruite est notamment plus armée pour anticiper et s'adapter aux événements climatiques extrêmes qui seront de plus en plus fréquents avec le réchauffement de la planète.

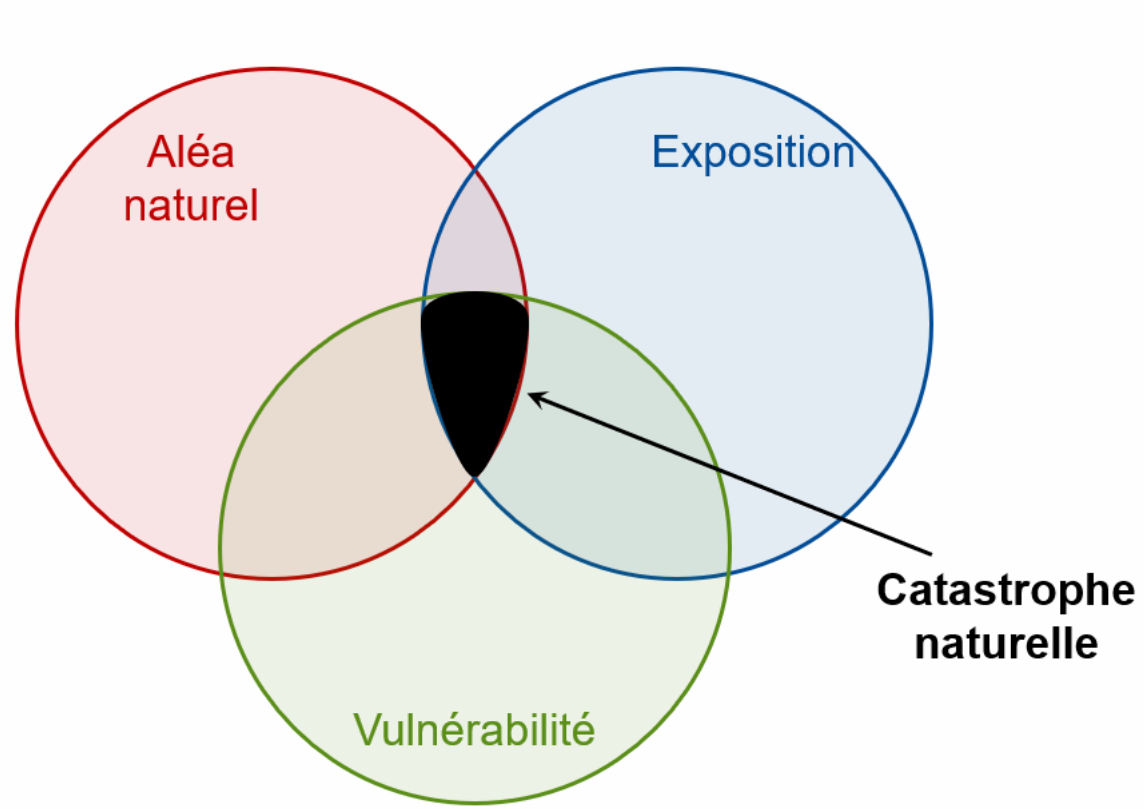
Catastrophes naturelles et changement climatique : le nouveau défi mondial

D'après EM-DAT (The International Disaster Database), le monde a été frappé par plus de 9 000 catastrophes naturelles sur la période de 1990 à 2014, soit 367 catastrophes en moyenne par an. Ces événements extrêmes ont causé la mort de plus de 1,8 million de personnes et perturbé la vie de plus de 5 milliards d'individus. Les coûts économiques sont également considérables à la fois pour les pays développés et en développement, estimés à près de 2800 milliards de dollars constants de 2010. En termes de fréquence, la plupart des catastrophes naturelles ont été recensées dans les PED (47 %) et les pays à faible revenu (30 %), contre 21 % dans les économies avancées. Au niveau régional, l'Asie de l'est et Pacifique (26 %) et l'Afrique subsaharienne (19 %) sont les régions les plus affectées. Avec le réchauffement climatique et la montée du niveau des océans, tout porte à croire que la fréquence et l'intensité des catastrophes naturelles devraient encore augmenter aux cours des prochaines années, causant plus de décès, de dommages et d'instabilités macroéconomiques.

Le Centre de recherche sur l'épidémiologie des désastres (CRED) de l'Université de Louvain définit une catastrophe naturelle comme un événement déclenché par un phénomène ou aléa naturel, souvent soudain et imprévisible, qui cause de graves dommages, des destructions et des souffrances humaines. Pour qu'un événement soit qualifié de catastrophe naturelle par le CRED, il doit vérifier au moins l'un des quatre critères suivants : (i) au moins dix personnes décédées, (ii) cent personnes ou plus blessées, affectées ou sans abri, (iii) déclaration d'un état d'urgence, (iv) demande d'assistance internationale. Si aucun de ces critères ne s'applique, la situation sera simplement considérée comme un aléa naturel et non comme une catastrophe naturelle. Plus précisément, les pluies torrentielles, tempêtes ou séismes ne sont pas considérées comme des catastrophes naturelles en soi, mais plutôt comme des phénomènes ou aléas naturels. Ainsi, un séisme frappant une île déserte ne sera pas considéré comme une catastrophe naturelle, en raison de l'absence de populations ou de biens matériels exposés. Le degré d'exposition aux aléas naturels se réfère aux

valeurs à risque, c'est-à-dire les personnes ou biens matériels présents à l'endroit touché ou menacé. La notion de vulnérabilité est toute aussi importante. Elle renvoie à une condition résultant de processus ou facteurs physiques, environnementaux et socio-économiques, qui réduisent la résistance aux forces dommageables. Comme l'illustre le graphique ci-après, les catastrophes naturelles peuvent être considérées comme une fonction de trois ingrédients : l'aléa naturel, l'exposition et la vulnérabilité

Graphique 0.1 : les trois ingrédients clés des catastrophes naturelles



Source : auteur.

Face à la recrudescence des événements climatiques extrêmes, associée aux projections pour le moins alarmantes du GIEC[14] sur l'évolution des températures, les économistes ont fortement investi la question. Plusieurs travaux se sont tour à tour intéressés à l'impact des chocs climatiques (hausse des températures) et des désastres naturels sur l'activité économique (Noy, 2009 ; Dell et al., 2012 ; Loayza et al., 2012 ; Strobl, 2012 ; Cavallo et al., 2013 ; Felbermayr et Gröschl, 2014 ; Mohan et al., 2018 ;

[14] Groupe d'experts intergouvernemental sur l'évolution du climat.

Acevedo et al., 2018)[15], le secteur financier (Klomp, 2014, 2018 ; Dafermos et al., 2018 ; Brei et al., 2019 ; Albuquerque et Rajhi, 2019), les inégalités et la pauvreté (Carter et al., 2007 ; Keerthiratne et Tol, 2018 ; Warr et Aung, 2019) ou encore les mouvements migratoires (Beine et Jeusette, 2019). Dans l'ensemble, la plupart de ces travaux conclut à un effet adverse des catastrophes naturelles, plus marqué dans les pays en développement. La résilience aux événements climatiques extrêmes est par la suite devenue un sujet d'intérêt majeur pour les décideurs publics. La résilience renvoie à la capacité de résistance, d'absorption et d'adaptation d'un pays ou d'une communauté face à un choc. S'il paraît nécessaire, voire urgent de renforcer la résilience des économies face aux catastrophes naturelles, encore faudrait-il identifier, avec plus de précision les déterminants d'occurrence de ces dernières. Dit autrement, quels sont les facteurs climatiques, physiques, environnementaux et socio-économiques qui expliquent le passage d'un aléa naturel à une catastrophe naturel ? Peu d'études se sont intéressées à cette question (Kahn, 2005 ; Thomas et Lopez, 2015) et présentent pour la plupart, le désavantage de raisonner de manière agrégée. C'est ce que nous essayerons de développer dans le chapitre 4 de cette thèse, en adoptant une approche désagrégée, l'impact d'un facteur pouvant différer selon le type de catastrophes.

Plan et contribution scientifique

Au total, la présente thèse se subdivise donc en 4 chapitres empiriques portant tous sur des enjeux de politiques économiques pour l'Afrique, les pays émergents et en développement, et le monde.

Dans le chapitre 1, **Credit Risk and Bank Competition in Sub-Saharan Africa**[16], travail réalisé conjointement avec M. Brei et L. Jacolin, nous mettons en évidence l'existence d'une relation non-linéaire entre le risque de crédit, mesuré par le ratio des prêts non-performants, et la concurrence bancaire, mesurée par l'indice de Lerner (indicateur de

[15] Pour plus de détails, voir les méta-analyses de Klomp et Valckx (2014) ainsi que Lazzaroni et al. (2014) sur l'impact macroéconomique des désastres naturels.

[16] Cet article fait actuellement l'objet d'une révision dans la revue académique « *Emerging Markets Review* ».

pouvoir de marché). Cette relation suggère notamment que le développement de la concurrence bancaire en Afrique sub-saharienne a, dans un premier temps, contribué à l'amélioration de la qualité des portefeuilles de crédits via notamment la baisse du coût du crédit et la réalisation de gains opérationnels. L'exacerbation de la concurrence a, dans un second temps, induit une dégradation de la qualité des prêts, en raison de la réduction des marges bénéficiaires et d'une prise de risque accrue des banques. Nous montrons par ailleurs que le risque de crédit en ASS dépend du cadre macroéconomique, notamment de la croissance économique, des niveaux de diversification économique et de la dette publique, tout comme de l'environnement réglementaire (existence de bureaux de crédit, qualité de la supervision). Alors que peu de travaux se sont intéressés jusqu'ici aux secteurs bancaires en ASS, nos résultats fournissent des indications utiles pour renforcer les cadres prudentiels et réglementaires, mais surtout pour adapter ces derniers aux spécificités de la région.

Dans le chapitre 2, **Informal Sector and Mobile Financial Services in Emerging and Developing Countries: Does Financial Innovation Matter?**[17], avec comme co-auteurs L. Jacolin et J. Keneck-Massil, nous nous intéressons à l'impact des services financiers mobiles sur l'économie informelle. A notre connaissance, nous sommes la première étude qui établit le lien entre les deux. A la différence des précédents travaux, principalement microéconomiques, sur la digitalisation financière, nous adoptons une approche macroéconomique en construisant un nouvel indicateur sous forme de variable binaire pour capturer l'introduction des services financiers mobiles dans un pays. Sur cette base, nous parvenons à une relation décroissante entre la diffusion des SFM et la taille du secteur informel. L'approche d'appariement par les scores de propension relève une diminution de l'ordre de 2 à 4 points de pourcentage du secteur informel à la suite du lancement des SFM. L'adoption de SFM peut contribuer à la réduction de l'économie informelle via plusieurs canaux. L'usage des moyens de paiement mobiles permet par exemple aux entreprises de réaliser d'importants gains

[17] Cet article fait actuellement l'objet d'une révision dans la revue académique « *The World Economy* ».

de productivité/rentabilité par rapport à l'utilisation de la monnaie fiduciaire via la sécurisation, la fluidité et une baisse des coûts de transaction. L'utilisation des SFM engendre également des quantités de données considérables simplifiant l'évaluation de la solvabilité des emprunteurs. En réduisant les asymétries d'information, le déploiement des SFM permet d'améliorer l'accès au crédit des entreprises, ce qui constitue pour elles une incitation puissante à entrer dans le secteur formel. Une autre explication possible aurait trait à la croissance plus rapide du secteur formel qui bénéficie lui aussi des externalités positives liées à l'adoption des SFM. Nos résultats confirment par ailleurs le rôle de certains facteurs comme le développement économique, les infrastructures, l'ouverture internationale, ou encore la qualité du cadre institutionnel, sur l'attrait ou non des activités économiques informelles. Dans l'ensemble, notre étude jette les bases d'une littérature, encore peu développée, sur l'impact macroéconomique des services financiers mobiles, une dimension majeure de la digitalisation croissante des échanges économiques.

Dans le chapitre 3, **Shadow Economy and Educational Systems in Africa**[18], avec J. Keneck Massil, nous étudions l'effet de l'éducation sur le secteur informel en Afrique. Comparé aux précédents travaux, trois dimensions de l'éducation sont couvertes par notre étude : l'enseignement secondaire au global, l'enseignement secondaire général et l'enseignement secondaire professionnel. Nous constatons une plus forte prépondérance de l'économie informelle dans les pays africains où le système éducatif est principalement porté sur l'enseignement général. Cette relation met en lumière l'inadéquation entre l'offre de formation et les besoins du secteur privé dans certains pays africains. A contrario, la taille du secteur informel est relativement plus faible dans les pays où le système éducatif est axé sur l'enseignement professionnel. Ce qui suggère qu'une personne aurait plus de chance de trouver un emploi dans le secteur formel lorsqu'elle a été formée pour un métier ou catégorie de professions particulières. En termes de recommandations de politique économique, nos résultats

[18] Ce chapitre a fait l'objet d'une publication dans la revue académique « Economics Bulletin » : Keneck-Massil, J. et Noah, A., (2019) "Shadow economy and educational systems in Africa", *Economics Bulletin*, Vol. 39, pp. 1467-1478.

soulignent la nécessité d'un système éducatif équilibré afin de réduire la part du secteur informel en Afrique.

Le chapitre 4, **What Causes Natural Disasters? The Role of Weather, Policies, and Climate Change**, avec comme co-auteur S. Acevedo, s'applique à étudier les principaux facteurs qui déterminent l'incidence des catastrophes naturelles. Notre analyse présente l'avantage d'être plus granulaire que les précédentes études, dans la mesure où nous nous intéressons à près d'une dizaine de types de catastrophes. Nos résultats indiquent que l'incidence des désastres naturels est liée aux conditions climatiques, au développement économique, à l'environnement macroéconomique, de même qu'au cadre institutionnel. Plus précisément, de meilleures conditions de vie, l'accès au crédit, ainsi que de bonnes institutions réduisent la fréquence des désastres naturels induits par la sécheresse, les épidémies, inondations et glissements de terrain. A l'inverse, la croissance démographique, l'urbanisation, la dégradation des sols (déforestation et augmentation des surfaces agricoles) et les conflits armés augmentent l'occurrence de certaines catastrophes naturelles. La hausse des températures induite par le changement climatique se manifestera quant à elle par une croissance de la probabilité d'occurrence de certains désastres comme les cyclones, les sécheresses ou encore les épidémies. En identifiant les facteurs qui expliquent le passage d'un aléa naturel à une catastrophe, nos résultats concourent ainsi à la définition et la mise en œuvre de politiques publiques visant à renforcer la résilience face aux catastrophes naturelles et au changement climatique.

Données et méthodologie

La présente thèse s'appuie sur plusieurs échantillons de données et méthodes empiriques, différents d'un chapitre à l'autre.

L'échantillon du chapitre 1 est un panel de 221 banques de 33 pays d'Afrique subsaharienne sur la période de 2000 à 2015. Il s'agit de données bancaires fournies par l'agence de notation Fitch, à partir desquelles ont été construits plusieurs

indicateurs dont l'indice de Lerner et le ratio des prêts non-performants. L'approche économétrique retenue ici est celle d'un modèle dynamique (GMM-System) qui permet notamment de capturer la persistance du risque de crédit à travers le temps et de pallier à un possible problème d'endogénéité.

Le chapitre 2 utilise un échantillon de 101 pays émergents et en développement sur la période de 2000 à 2015. A partir des données de la GSM Association, un nouvel indicateur sous forme de variable binaire a été construit pour capturer l'adoption des SFM dans un pays. Les données sur le secteur informel proviennent, elles, des travaux de Medina et Schneider (2018). Il s'agit de l'estimation la plus récente du secteur informel, fondée sur les données satellitaires (Henderson et al., 2012). L'approche empirique adoptée inclut à la fois les méthodes paramétriques (modèle à effets fixes et variables instrumentales) et non-paramétriques (appariement par les scores de propension ou propensity score matching). Notre variable d'intérêt étant binaire, la dernière approche nous permet notamment d'interpréter avec plus d'aisance, l'impact économique de l'adoption des services financiers mobiles sur l'économie informelle.

Le chapitre 3 porte sur un échantillon de 30 pays africains sur la période de 2000 à 2015. Les données sur l'éducation sont tirées de la base de données de l'UNESCO sur le sujet. Les données sur le secteur informel sont une fois de plus issues de Medina et Schneider (2018). La méthode empirique employée est une approche par les moindres carrés ordinaires (MCO) et les variables instrumentales indispensables pour faire face au problème d'endogénéité.

Enfin dans le chapitre 4, l'échantillon compte près de 200 pays sur la période de 1990 à 2014. L'étude porte sur près d'une dizaine de types de catastrophes. Les données mensuelles, combinées aux données annuelles sont utilisées. Les données mensuelles sur les catastrophes naturelles et conditions climatiques (température et précipitation) sont respectivement issues de EM-DAT et du Climatic Research Unit (CRU). Nos variables dépendantes étant binaires, l'approche empirique adoptée est celle d'un modèle de régression binomiale en panel (modèle logit) afin de déterminer la

probabilité d'incidence d'une catastrophe naturelle. La régression de Poisson en panel est par ailleurs employée avec le passage des variables dépendantes de la forme binaire aux variables de comptage.

Pour finir, il convient de noter que dans chacun des chapitres, plusieurs autres bases de données principalement issues de la Banque mondiale, du Fonds monétaire international, d'Heritage Foundation, de Fraser Institute, d'International Country Risk Guide (ICRG) et de la CNUCED, ont en outre été utilisées.

Chapter 1

Credit Risk and Bank Competition in Sub-Saharan Africa[19]

[19] *This chapter was co-authored with M. Brei and L. Jacolin, and published as Banque de France Working paper No. 664/2018. The paper is currently under revision at Emerging Markets Review.*

Abstract

This paper investigates the relationship between bank competition and stability in Sub-Saharan Africa. Using financial statements on 221 banks from 33 countries over the period 2000-15, we provide evidence for a U-shaped relationship between bank competition and credit risk. Up to a certain threshold, higher levels of bank competition are associated with lower credit risk. Above this threshold, more competition increases credit risks as the positive effects of competition are outweighed by the adverse effects of rising competition. We also find that credit risk in Sub-Saharan Africa is not only related to macroeconomic determinants, such as growth, public debt, economic concentration, financial deepening and inclusion, but also to the business and regulatory environment. In particular, bank risks appear to be lower in countries where credit registry coverage is higher and the tenure of supervisors is shorter.

Keywords: Bank competition, Credit risk, Bank stability, Sub-Saharan Africa

JEL classification: G21, G28, D4, O55

1.1. Introduction

The purpose of this study is to determine how competition among banks affects credit risk in Sub-Saharan Africa (SSA). Banking sectors in SSA have been growing rapidly during the last two decades in the wake of the super-cycle of commodity prices and high growth on the continent. Regional or pan African bank conglomerates have emerged and contributed to higher, albeit still limited, financial integration. The concerns about financial stability have grown accordingly, notably as a result of the Nigerian banking crisis of 2009-10. Whereas considerable attention has been devoted to financial stability in developed countries affected by the global financial crisis, few empirical studies have focused on Sub-Saharan Africa (SSA) so far. With credit risk being relatively high and rising since the drop in commodity prices and the ensuing African economic slowdown in 2014 (Figure 1.1), analyzing the determinants of credit risk seems both relevant and timely.

A growing strand of theoretical and empirical research highlights the importance of financial deepening and inclusion to support economic growth in Sub-Saharan African countries (Chauvet and Jacolin, 2017; Leon, 2015; Ncube, 2007). In such countries characterized by high levels of economic growth, the reliance on banking sectors to ensure adequate financing is increasing, however, at the same time there are high risks of macroeconomic instability which often arises from external shocks. In this context, the linkages between growing competition in SSA banking sectors and credit risk have become salient. Even if banking systems remain weak and isolated in SSA (Marchettini and Maino, 2015), banking crises arising from financial development and credit booms may become an increasing source of concern for regulatory and supervisory authorities, to the extent that the interactions between credit and economic cycles become stronger, similarly to the trends observed in the advanced economies.

The relationship between bank competition and credit risk is less than straightforward. Bank competition might arguably spur efficiency gains (through, for example, lower credit costs, improved operational and risk management practices, or better allocation

of capital), and it thus might contribute to higher potential growth and translate into sounder credit portfolios. However, it might also encourage additional risk taking by financial intermediaries, making banks more fragile in the face of economic fluctuations and deterioration in the quality of credit books.[20] Shedding light on the bank competition and stability nexus, a large body of theoretical and empirical literature produced mixed conclusions (Keeley, 1990; Salas and Saurina, 2003; Boyd and De Nicolo, 2005; Beck et al., 2006; Martinez-Mierra and Repullo, 2010; Turk Ariss, 2010; Fungáčová and Weill, 2013; Jiménez et al., 2013; Beck et al., 2013a).

The main contribution of our research is to provide evidence that higher competition is not always detrimental for bank stability in developing countries. More specifically, our findings point to a U-shaped relationship between competition and risk in Sub-Saharan Africa: higher competition is associated with lower credit risks, and once a certain threshold is reached more competition is associated with higher risks. Our finding thus complements the results obtained by Turk Ariss (2010) who finds that competition is associated with higher risks in developing countries.[21] Our results are based on the financial statements of 221 banks (of which 140 are foreign-owned) from 33 countries in SSA over the period 2000–15. According to our results, increased competition can be beneficial from a financial stability perspective in 7 countries with low levels of competition, whereas the optimal level of competition has been outreached in the remaining 26 countries. Our study also highlights the importance of macroeconomic variables in determining credit risks, such as growth, financial deepening and economic concentration, as well as bank portfolios and the regulatory

[20] As Brock and Rojaz Suarez (2000) argue in the case of the Latin American experience, regulators overly permissive attitude towards the entry of new banks can pose a threat to financial system stability, especially, when many or large entrants compete aggressively with the existing banks for costumers by lowering loan rates and increasing deposit rates to levels that are unsustainable.

[21] The empirical findings of Turk Ariss (2010) are based on 821 banks from 60 developing (14 African) countries over the period 1999-2005, which means that her results might be driven by banks from the other (non-African) developing countries. The only paper that focuses on a large sample of banks from Sub-Saharan Africa is that of Kouki and Al-Nasser (2017), but the authors obtain conflicting results when using cross-sectional regressions. We believe that our dynamic panel setting is better suited to study the competition-risk relationship within banks by taking into account bank-fixed effects and by using the system GMM estimator to reduce endogeneity bias.

environment. More specifically, we find that credit risks have been lower in countries where there operate more branches, credit registry coverage is higher, and the tenure of supervisors is shorter. Finally, we show that public indebtedness has an adverse impact on bank credit risk in these countries, where government and public enterprises make up a significant portion of the formal economy.

The remainder of the paper proceeds as follows. Section 2 provides an extensive review of the related literature. Section 3 discusses and reports summary statistics for the sample data. Section 4 describes the empirical model and discusses the definitions of the variables selected in parameterizing the empirical model. The empirical results are reported in Section 5, and Section 6 discusses the robustness checks. The final section concludes.

1.2. Literature review on bank competition and stability: *Competition-fragility versus competition-stability view*

The theoretical literature provides conflicting predictions on the relationship between competition and stability (Beck, 2008). One strand of the literature suggests that less competitive banking systems are more stable (competition-fragility view). A central argument is that higher oligopoly rents provide banks a cushion against unexpected shocks and reduce incentives for risk-taking (Marcus, 1984; Keeley, 1990). In systems with limited competition, banks tend to have better profit opportunities, higher franchise values and capital cushions, and thus fewer incentives to take on risks. Other arguments in favour of this view are based on differences in informational rent extraction (Boot et al., 1993), interbank market competition (Allen and Gale, 2000), deposit market competition (Hellmann et al., 2000), economies of scale (Diamond, 1984), and banking supervision (Allen and Gale, 2000).

In contrast, other theoretical models predict that more competitive banking systems are more stable (competition-stability view). Boyd and de Nicolo (2005), who introduce in their model loan market competition, argue that higher loan rates in more

concentrated systems induce bank borrowers to assume greater risk which results in increased loan defaults. This effect can be amplified if competition is associated with credit rationing, adverse selection and larger loans (Stiglitz and Weiss, 1981; Caminal and Matutes, 2002). Other models suggest that less competitive environments with larger banks are distorted by implicit government guarantees (Mishkin, 1999; Cerasi and Daltung, 2000; Farhi and Tirole, 2012) and subject to higher systemic risk (Kroszner, 2010).

Martinez-Miera and Repullo (2010) extend the model of Boyd and de Nicolo (2005) and introduce imperfect correlation of loan defaults. Their model implies a U-shaped relationship between bank competition and bank failure: at the beginning, more competition leads to more stability but after a certain threshold it can lead to more fragility. The authors highlight two opposing effects of competition: (i) it leads to lower loan rates, lower borrower default probabilities, and thus sounder loan books (risk-shifting effect), and (ii) lower interest revenues from performing loans erode bank cushions (margin effect) and have an adverse effect on bank stability. The model implies that beyond a certain threshold of competition the risk-shifting effect is always dominated by the margin effect, so competition leads to more fragility by eroding interest revenues. Below this threshold with less competition the effect is ambiguous but numerical simulations suggest that the risk-shifting effect dominates and that competition leads to more stability by improving borrowers' repayment capacity.

The competition-stability relationship will also depend on other factors including the financial structure of banks (Freixas and Ma, 2014), regulatory environment (Hellmann et al., 2000), deposit insurance (Diamond and Dybvik, 1983), and market structure (Beck, 2008).

A large body of empirical studies has produced ambiguous results (see Zigraiova and Havranek (2016) for a meta-analysis). In favour of the competition-fragility view are the results reported by Keeley (1990) and Dick (2006) for the United States, Yeyati and Micco (2007) for Latin America, Jiménez et al. (2013) for Spain, Agoraki et al. (2011) for

Central and Eastern Europe, Fungáčová and Weill (2013) for Russia, Turk Ariss (2010) for developing countries, Soedarmono and Tarazi (2016) for Asia-Pacific, and Beck et al. (2013a) for countries with stricter activity restrictions, lower systemic fragility, better developed stock exchanges, more generous deposit insurance and more effective systems of credit information sharing. Studies supporting the competition-stability view include Jayaratne and Strahan (1998) and Goetz (2018) on the United States, Salas and Saurina (2003) on Spain, Schaeck and Čihák (2014) on the United States and Europe, Craig and Dinger (2013) on Central and Eastern Europe, Kasman and Kasman (2015) on Turkey, Fu et al. (2014) on Asia-Pacific, and Beck et al. (2006) for developed and developing countries. IJtsma et al. (2017) do not find any economically significant effect of competition on stability for the European Union.

A number of empirical studies have tested for the presence of a U-shaped relationship between competition and stability. In Turk Ariss (2010), the non-linear term is statistically not significant and in Berger et al. (2009) and Beck et al. (2013a) it is significant only for a small fraction of countries. While Liu et al. (2013) and González et al. (2017) confirm Martinez-Miera and Repullo (2010)'s hypothesis of a U-shaped relationship for European and Middle East and North African (MENA) countries, respectively, Tabak et al. (2012) find evidence of an inverted U-shaped relationship in Latin America.

The recent literature has also emphasized the role of bank-specific characteristics and the macroeconomic environment (e.g., Salas and Saurina, 2002; Louzis et al., 2012; Castro, 2013; Klein, 2013; etc.), as well as the regulatory framework (e.g., Jappelli and Pagano, 2002; Houston et al., 2010; Chen et al., 2017a; etc.) in explaining bank stability. Our paper will also draw from these studies.

1.3. Data description

We obtain bank-level data on financial statements from Fitch Connect over the period 2000-15. Our initial sample covers 526 financial institutions located in 37 Sub-Saharan

Africa countries. Where possible, we gather consolidated financial statements and if no consolidated statement exists (e.g. for foreign subsidiaries) or the reporting period is substantially larger on an unconsolidated basis (mainly small banks), we use the unconsolidated financial statement.[22] Since our study focuses on the credit risk of deposit-taking institutions, we exclude non-deposit-taking institutions from the sample.[23] Further, we eliminate banks and countries from the study for which we were unable to obtain relevant information to compute non-performing loans[24] or the macroeconomic and regulatory variables to parameterise the empirical model. Finally, where possible we use end-of-year financial statements (90% of the sample), while in the remaining cases we use financial information as of March (4%) and June (6%). After applying our filters, the final sample covers 221 deposit-taking institutions from 33 Sub-Saharan African countries.[25] Of the 221 banks, 81 are domestically owned (17 are public banks) and 140 are subsidiaries of foreign banks (86 are banks from African countries, 48 from advanced economies, and 6 from other emerging markets).

Table 1.1 reports the list and summary information for the sampled countries. As can be seen, total assets of the banks amounted to 310 billion USD at the end of 2015, corresponding to an average of 21.5 percent of GDP (or 72% of the entire SSA banking sector).[26] The lowest asset-to-GDP ratios are observed in Gabon, Equatorial Guinea, Chad and Democratic Republic of the Congo (below 5%), whereas in Cape Verde and Kenya bank assets amounted to more than 65% of GDP. These numbers clearly point to the fact that the banking sectors in the region are still in the early stage of

[22] Due to the small size of many of the banks in our sample, the consolidated and unconsolidated statements are very similar and the latter often possess better reporting quality. Overall, our final sample mainly consists of unconsolidated statements (75% of the total).

[23] We cross-referenced the list of financial institutions obtained from Fitch Connect with the registry of licensed banking entities reported on the websites of the various central banks in the region in order to distinguish between deposit-taking entities from the other types of financial firms.

[24] Some banks do not publicly disclose certain balance sheet items including impaired loans.

[25] Republic of Congo, Guinea-Bissau, Gambia and the Seychelles were excluded from the sample due to poor data quality. In addition, in order to focus on developing countries, we did not include South African banks in our sample.

[26] At the end of 2015, total assets of the entire banking sector (excluding South Africa) amounted to 429 billion USD (Jacolin and Noah, 2017).

development and that financial deepening is low compared to an average of 123% of bank assets relative to GDP in high-income countries (based on information from the Global Financial Development Database). Banks in the region faced a much higher fraction of non-performing loans compared to advanced economies (see Figure 1.1). On average, 8.4% of loans have become non-performing in SSA (compared to 1.8% in the advanced economies) over the entire sample period, even though there is important cross-country variation (see also Table 1.1).[27] Moreover, as can be observed non-performing loans have declined importantly during the period 2000-08, however, since 2009 credit risks have increased and peaked in 2010 and 2015, respectively. The recent development is likely to be associated with the drop in commodity prices, the Nigerian banking crisis of 2009, and the regional slowdown in economic growth. In parallel, Figure 1.2 shows that the average level of banks' market power (measured by the Lerner index) has fallen over time suggesting that banking markets in the region have become more competitive over the last two decades. The relative increase in bank competition is with 15% economically important, especially since 2007-08. This pattern reflects the establishment of new banks and the expansion of pan-African banks in the region in recent years (Enoch et al. 2015; Jacolin and Noah, 2017).

1.4. Econometric framework

1.4.1. Baseline model

To examine the determinants of credit risks, we use a dynamic panel regression. The baseline model is specified as follows:

$$\boldsymbol{NPL_{ijt} = \alpha_0 + \alpha_i + \alpha_1 NPL_{ijt-1} + \varphi_1 Lerner_{ijt} + \beta X_{ijt} + \gamma M_{jt} + \delta O_{jt} + \varepsilon_{ijt}} \quad (1.1)$$

[27] The non-performing loan ratio in the region showed some heterogeneity across banks of different ownership with foreign banks headquartered in Africa recording the lowest levels (7.6% on average) followed by foreign banks from developed countries (8.0%) and domestic banks (9.0%).

where NPL_{ijt} denotes the non-performing loan ratio[28] of bank i located in country j in year t, $Lerner_{ijt}$ represents the bank competition indicator, X_{ijt} is a vector of bank-specific characteristics, and M_{jt} and O_{jt} denote the vectors of macroeconomic and other (structural and institutional) control variables. We also include bank fixed-effects α_i to account for time-invariant and unobserved differences in the loan quality across banks. The model is estimated in dynamic form by including a lagged value of non-performing loans to capture the persistence of credit risk over time (Salas and Saurina, 2002; Louzis et al., 2012; Jiménez et al., 2013).

The non-performing loan ratio is measured by impaired loans as a proportion of total loans. The vector X_{ijt} includes a set of bank-specific indicators that have been highlighted in the empirical literature as important drivers of credit risk, notably the net interest margins (net interest income divided by total assets), the loan-to-assets ratio, income diversification (non-interest income divided by total assets), capitalization (total equity divided by total assets), and bank size (logarithm of total assets). We instrument all these variables by their lagged values in order to mitigate any possible endogeneity problem, we may have in our model specification (Roodman, 2009).

To capture a possible non-linear relationship between bank competition and non-performing loans, we augment our baseline model with a quadratic term for the competition measure. The augmented model is thus specified as follows:

$$\boldsymbol{NPL_{ijt} = \alpha_0 + \alpha_i + \alpha_1 NPL_{ijt-1} + \varphi_1 Lerner_{ijt} + \varphi_2 Lerner_{ijt}^2 + \beta X_{ijt} + \gamma M_{jt} + \delta O_{jt} + \varepsilon_{ijt}} \quad (1.2)$$

The relationship between credit risk and bank competition can then be summarized by:

$$\boldsymbol{\frac{\partial NPL_{ijt}}{\partial Lerner_{ijt}} = \varphi_1 + 2\varphi_2 \cdot Lerner_{ijt}} \quad (1.3)$$

[28] For our robustness checks, we use two alternative measures of bank risk, namely the impaired loans reserves ratio and Z-Score (distance-to-default). It is widely agreed that bank failures and credit risk are highly correlated, especially in small and retail-oriented banking systems.

For example, if we find that $\varphi_1 < 0$ and $\varphi_2 > 0$, there would be evidence of a U-shaped relationship between credit risk and bank competition (as measured inversely by the Lerner index). In such a case, at lower levels, increased competition would be associated with lower credit risks (competition-stability view). However, once a certain threshold of competition is reached, heightened competition would lead to higher credit risks (competition-fragility view).

1.4.2. Bank competition indicator

We decided to measure bank competition by the Lerner index.[29] It is a measure of a bank's market power and defined as the ratio between the mark-up (price minus marginal cost) and price, and it should be zero in perfect competition but will increase in less competitive banking markets. By taking this measure, we assume that there is a one-to-one mapping between market structure and competitive behaviour of banks: less competitive banking markets enhance market power and are associated with a higher Lerner index. The conventional form of Lerner index can be computed as follows:

$$\boldsymbol{Lerner_{it}} = \frac{\boldsymbol{P_{it} - MC_{it}}}{\boldsymbol{P_{it}}} \tag{1.4}$$

where P_{it} is the average price of the banking output of bank i at time t, and MC_{it} is the marginal cost. The price is measured by the implicit interest rate on loans (interest income divided by total loans), whereas banking output is measured by the stock of outstanding loans, as has been done in Solís and Maudos (2008), Williams (2012) and Lapteacru (2017). Marginal costs are calculated via the estimation of the following trans-log cost function:

[29] We cross-check our results and use the Herfindahl-Hirschman index (HHI) as a measure for bank competition in the robustness tests. Our preferred measure is, however, the Lerner index to the extent that banks of different sizes and types are not treated equally in its computation (Berger et al., 2004). Moreover, as argued by Claessens and Laeven (2004) the HHI may not necessarily capture the degree of effective competition depending on the contestability of the system.

$$\ln(TC_{it}) = \alpha_0 + \alpha_1 \ln(Q_{it}) + \frac{1}{2}\alpha_2 \ln(Q_{it})^2 + \sum_{n=1}^{3} \beta_n \ln(w_{int}) +$$
$$\sum_{m=1}^{3}\sum_{n=1}^{3} \beta_{mn} \ln(w_{imt} w_{int}) + \sum_{n=1}^{3} \gamma_n \ln(Q_{int}) \ln(w_{int}) + \delta_1 T + \frac{\delta_2}{2} T^2 +$$
$$\delta_3 T \ln(Q_{it}) + \sum_{k=1}^{3} \varphi_k T \ln(w_{ikt}) + \varepsilon_{it} \quad (1.5)$$

Total costs TC_{it} are measured by the sum of personnel expenses, other non-interest and interest expenses, output Q_{it} by total loans, and w_{int} are three input prices (i.e., for labour, capital and funding). The price of labour is hereby measured by the ratio of personnel expenses to total assets, the price of physical capital by the ratio of other non-interest expenses to fixed assets, and the price for borrowed funds is measured by the ratio of interest expenses to total deposits and money market funding. We also include a time trend (T) and various interaction terms to control for unobserved determinants of total costs that are common to all banks over the time (such as technical progress) and other time-variant factors (Maudos and Fernández de Guevara, 2004, 2007; Turk Ariss, 2010).

The estimated coefficients of the total cost function are then applied to compute marginal cost:

$$MC_{it} = \frac{\partial TC_{it}}{\partial Q_{it}} = \frac{TC_{it}}{Q_{it}} \left(\alpha_1 + \alpha_2 \ln(Q_{it}) + \sum_{n=1}^{3} \gamma_n \ln(w_{int}) + \delta_3 T\right) \quad (1.6)$$

Koetter et al. (2012) argue that the conventional approach of computing the Lerner index fails to consider the possibility that banks may choose not to exploit pricing opportunities resulting from market power. It also assumes both profit and cost efficiencies. Consequently, if banks do not set their prices optimally and do not make optimal choices regarding their inputs, the conventional Lerner index would not measure correctly the true market power. In order to capture such effects, the authors suggest an adjustment in form of the efficiency-adjusted Lerner index:

$$\text{Adjusted Lerner}_{it} = \frac{\widehat{PBT}_{it} + \widehat{TC}_{it} - \widehat{MC}_{it}}{\widehat{PBT}_{it} + \widehat{TC}_{it}} \quad (1.7)$$

where $\widehat{PBT}_{it}$ and $\widehat{TC}_{it}$ are the predicted values of pre-tax profit and total cost, respectively, scaled by bank output (total loans). We estimate Equation (5) by

employing a Stochastic Frontier Approach (SFA) with the cost efficiency option and extract $\widehat{TC}_{it}$ and $\widehat{MC}_{it}$. To estimate $\widehat{PBT}_{it}$, we use pre-tax profit as the dependent variable in the Equation (5) and run the SFA with the production efficiency option (Berger and Mester, 2003; Bos and Koetter, 2011).[30]

1.4.3. Other control variables

The net interest margin (NIM) is calculated as the ratio of gross interest and dividend income minus total interest expenses to total assets. The effect of the net interest margin on credit risks is ambiguous. On the one hand, higher margins could be an indication of higher credit risks, because they may point to banks that charge high interest rates due to a risky credit portfolio and/or the anticipation of losses (Angbazo, 1997; Salas and Saurina, 2002; Maudos and Fernández de Guevara, 2004; Fofack, 2005; Carbó-Valverde and Fernández, 2007). On the other hand, higher margins provide banks with an additional cushion to absorb adverse shocks, increase franchise values and thus lead to lower risk-taking incentives.

Loan growth is considered as a major determinant of loan defaults (Podpiera and Weill, 2008). Rapid credit growth is not problematic in itself, especially in African countries where financial development is low and economic development may go hand in hand with strong credit growth. But excessive growth can result in a reduction of credit screening and monitoring quality, that subsequently increases the probability of loan defaults. We expect credit growth to positively affect credit risk. We use the loan-to-assets ratio to measure banks' credit growth history, as banks with larger loan portfolios are likely to have grown faster in the past, similar to Ghosh (2015) and Klein (2013).

Income diversification is measured by non-interest income as a proportion of total assets. The relationship between non-performing loans and income diversification is not clear. Whereas Ghosh (2015) and Louzis et al. (2012) document that more diversification reduces risk and improves loan quality, Lepetit et al. (2008) point out

[30] The adjusted version of the Lerner index has also been used by Clerides et al. (2015), Kasman and Kasman (2015) and Lapteacru (2017).

that some banks may also neglect screening and monitoring of borrowers when focusing on non-banking activities.[31]

Capitalization is measured by the leverage ratio (total equity as a proportion of total assets), much like Louzis et al. (2012), Klein (2013), Gosh (2015), and Zhang et al. (2016). The impact of bank capitalization on credit risk is ambiguous. On the one hand, a higher capitalization may reflect that the bank is more risk averse and thus operates with higher capital buffers and potentially with less non-performing loans. On the other hand, higher capitalization may be an indication that a bank's regulatory capital requirements are high due to a riskier asset portfolio. Managers in banks with low equity ratios (high leverage) may have incentives to engage in riskier banking activities, while releasing expenses on credit scoring and the monitoring of borrowers (Keeton and Morris, 1987; Berger and DeYoung, 1997).

Bank size (natural logarithm of total assets) is another potential determinant of credit risks. Salas and Saurina (2002) show that larger banks with more credit diversification opportunities can decrease the level of bad loans. Hu et al. (2004) argue that larger banks are in a better position to assess loan quality due to superior access to resources and economies of scale in information processing. The "*too big to fail*" hypothesis, on the other hand, highlights that larger banks may take more risks due to their implicit bail-out guarantee (Louzis et al., 2012; Brei and Gadanecz, 2012), and they hence may operate with higher non-performing loan ratios.

In addition to the bank-specific variables, macroeconomic factors are likely to influence non-performing loans. Following the current literature, we include real GDP growth to capture business cycle conditions and expect a negative relationship between economic activity and non-performing loans (Al-Khazali and Mirzaei, 2017; Castro, 2013; Louzis et al., 2012; Salas and Saurina, 2002; Carey, 1998; Ruckes, 2004; Nkusu, 2011). The impact of inflation is ambiguous (Klein, 2013), as higher inflation reduces

[31] Also see Wagner (2010).

the real value of loans and can make debt servicing easier but also reduces the real income of borrowers, hence their ability to service debt. We also include public debt as a share of GDP (Louzis et al., 2012; Klein, 2013). Public debt may positively affect non-performing loans both through expenditure (wage bill, investment) or revenue effects to soften fiscal deficits (Perotti, 1996). In Sub-Saharan African economies, where a high share of public receipts may depend on commodity price fluctuations, we expect a feedback loop between public revenue, spending and public debt on the one hand and defaults of both households and firms (through the accumulation or arrears for instance) on the other.

We control for both economic structure and the institutional environment. Following Fofack (2005), we include a measure of economic concentration[32] to capture macroeconomic vulnerability to external shocks. We expect a positive link between economic concentration and credit risk in Sub-Saharan Africa where most export sectors depend on external commodity demand. Finally, following the literature on *law and finance* (La Porta et al., 1998), we include in our model the quality of institutions by using an indicator on the rule of law to capture the quality of contract enforcement, property rights, and the political and legal system (Kaufmann et al., 2011).

1.5. Results

We estimate four separate models for non-performing loans. The first includes the bank-specific control variables and simple term of the adjusted Lerner index, the second in addition its square, and the third includes on top macroeconomic variables. The final specification incorporates all four sets of determinants: bank competition, bank-specific variables, macroeconomic and institutional indicators. The summary statistics for the regression variables are shown in Table 1.3, and the regression results are reported in Table 1.4.

[32] Economic concentration is a measure of the degree of product concentration provided by UNCTAD. An index value closer to 1 indicates that a country's trade sector is highly concentrated on a few products. On the contrary, values closer to 0 reflect diversification.

In all of our models, the lagged dependent variable is significant, confirming the persistence of credit risk over time. This reflects that non-performing loans remain on the balance sheet for a certain time before they are written off. The Hansen test also validates the instruments used in all model specifications since we cannot reject the null hypothesis that the instruments are exogenous.

In the linear specification I shown in Table 1.4, a higher Lerner index (i.e. lower bank competition) is associated with better loan quality, giving support to the competition-fragility view. In specifications II, III and IV, the coefficient of the bank competition indicator is negative for the linear term but positive for the quadratic term and both coefficients are statistically significant. This implies that bank competition has been associated with more bank stability, but only up to a certain threshold after which more competition has increased bank fragility in Sub-Saharan Africa. The U-shaped relationship between competition and bank risk is in line with the theoretical predictions of Martinez-Miera and Repullo (2010) who argue that initially the reduction in the cost of credit brought about by more competition reduces borrowing costs, improves borrower repayment capacity and hence the non-performing loan ratio. However, as competition further increases, the loss of revenue stemming from price competition across banks erodes their cushions stemming from revenues (margin effect) with adverse effects on risk-taking incentives (Berger et al., 2009; Liu et al., 2013). In specification IV, the inflection point at which credit risks are lowest is equal to a Lerner index of 0.59 (compared to an average of 0.49 and a standard deviation of 0.15, see Table 1.3), which corresponds to the 75th percentile and it represents a significant part of the distribution. Figure 3 visualizes the estimated relationship between bank competition (lower Lerner index) and credit risk. For instance, on average banks from Swaziland, Madagascar, Central African Republic, Chad, Equatorial Guinea, Sierra Leone, and Ethiopia recorded a higher market power than this threshold over the sample period (see Table 1.1). For these countries, enhanced bank competition would be associated with lower credit risks up to the optimal level of 0.59. For the other 26 countries, the optimal level of competition has been reached and restrictions in bank

competition would be associated with lower credit risks, again only up to the optimal level.

Apart from the market power of banks, the only significant bank-specific determinant in Sub-Saharan Africa is the loan-to-assets ratio. Banks that are more involved in lending also report relatively more non-performing loans. This could be related to a high past growth of the loan book or lower screening standards due to the relatively higher cost of borrower screening and monitoring compared to other types of investments. The coefficient of real GDP growth is negative as expected, confirming the impact of the business cycle on loan quality (Castro, 2013; Louzis et al., 2012; Salas and Saurina, 2002; Carey, 1998; Ruckes, 2004; Nkusu, 2011). Government debt is positively related to non-performing loans, suggesting a feedback loop between the fiscal stance of public sector, credit ratings for corporates, and credit risk (Louzis et al., 2012; Klein, 2013). Economic concentration has an adverse effect on non-performing loans pointing to the vulnerability of highly concentrated economies to external shocks (Fofack, 2005).

Next, we examine whether the ownership of banks and their size has an impact on the relationship between bank competition and credit risk. To this purpose, we interact the Lerner index and its square with different indicator variables on: (i) foreign banks, (ii) foreign banks with headquarters in the advanced economies, (iii) foreign banks from the African region, (iv) government-owned banks, and (v) large banks. The different bank types are identified using a dummy variable that is equal to one if a bank is controlled by a foreign institution (48 entities are from the advanced economies, 86 from Africa) or a governmental institution (17 entities). The bank size variable is measured by a dummy variable that is equal to one if the relative size of a bank (total assets to the country's total assets) is larger than the 75^{th} percentile of the distribution.

There is no consensus in the empirical literature on the impact of foreign bank entry on stability. On the one hand, foreign banks might be a source of stability in periods of local stress by virtue of their geographic diversification and access to internal capital

markets (Dages et al., 2000; Crystal et al., 2001; De Haas and Van Lelyveld, 2010). Set against those benefits are fears of contagion from external crises, aggressive growth strategies, or the crowding-out of domestic lending to small firms (Peek an Rosengren, 2000; Clarke et al., 2005; Claessens and van Horen, 2012; De Haas and Van Lelyveld, 2014; Mian, 2006; Gormley, 2010; Chen et al., 2017a). The results reported in columns V to VII of Table 1.5 suggest that in Sub-Saharan Africa foreign ownership (independent of the headquarters' origin) did not influence the U-shaped relationship between bank competition and credit risk.

Recent research also has focused on differences in the way private and state-owned banks may compete, a topic of interest in developing nations where state-owned institutions often hold substantial market shares (see Cull et al., 2017 for an extensive review). State-owned banks may have objectives other than profit maximization, such as fostering export, sectoral or regional development, or they may take into account lending externalities (Brei and Schclarek, 2015). In addition to their impact on these market segments where lending can be unprofitable and risky, these institutions usually operate with government subsidies and may be subject to politically connected lending problems, reducing market discipline and the incentives of these to compete (Krueger, 1974; La Porta et al., 2002; Berger et al., 2004). However, as has been highlighted in the literature this depends on the institutional background of a country (Adrianova et al., 2010). As can be observed in column VIII of Table 1.5, government ownership does not affect the relationship between competition and credit risk in Sub-Saharan Africa after controlling for the quality of public institutions.

The literature has also investigated the impact of bank size on competitive conditions. Relative to large banks, small banks in developed nations tend to serve smaller local customers and provide more retail-oriented financial services (DeYoung et al., 2004). Banks of different sizes may also deliver their services using different technologies, with large banks developing costlier lending technologies (i.e. credit scoring) based on "hard" quantitative data, whereas small banks may rely more on technologies (i.e.

relationship lending) based on "soft" information (Stein 2002). As can be observed in column IX of Table 1.5, we do not find evidence that the competition-stability relationship is affected by the relative size of the banks.

The next set of regressions investigates the impact of external shocks on credit risks. To this end, we include a variable identifying the global financial crisis (equal to one during 2008-10) and the commodity price shock of 2015 (equal to one in 2015). Our findings confirm the view that the African banking sector has been spared by the global financial crisis which might be due to the lower international exposure of local financial systems (Table 1.5, column X), but it has been vulnerable to the recent reversal in commodity prices (Table5, column XI).

We also inspect the effect of financial development on loan quality by using a measure on financial depth (domestic credit to the private sector divided by GDP) like Chen et al. (2017b), and the number of bank branches that operate in a given country (as a financial inclusion measure). As suggested by Honohan and Beck (2007), small financial systems are usually associated with inefficiencies in financial intermediation (e.g. due to high fixed costs). A more extensive coverage of bank branches helps reducing information asymmetries through better monitoring of borrowers. A large network of branches also provides better geographical coverage of banking services and thus diversification of local shocks, and it facilitates the transition from the informal to the formal sector. Our results indicate that both indicators reduce credit risks (Table 1.5, columns XII and XIII) suggesting that policies aimed at improving financial deepening and financial inclusion both lead to improvements in loan quality.

Finally, the literature has considered the regulatory framework as an important determinant of bank stability (e.g., Jappelli and Pagano, 1993, 2002; Houston et al. 2010, Barth et al., 2013a; Laeven and Levine, 2009). As suggested by Jappelli and Pagano (1993, 2002), information sharing among lenders attenuates the problems of information asymmetries, and can therefore increase lending activity and reduce default probabilities. In line with these studies, we investigate the impact of information

sharing using data provided by the World Bank (Doing Business database).[33] We find that credit bureau (registry) coverage is associated with lower credit risk in SSA (Table 1.5, column XIV). This implies that loan quality is higher in countries where lenders share information, irrespective of the public or private character of the information sharing mechanism. Next, we use data provided by Barth et al. (2013b)[34] and examine the impact of bank entry requirements and longer supervisor tenure on credit risk.[35] While bank entry requirements are not significant (Table5, column XV), longer supervisor tenure is associated with higher credit risk (Table5, column XVI). This result suggests a need to improve supervision quality, to the extent that supervisor mobility or turnover is an indicator of staff quality. Further research is however welcome to disentangle how the determinants of staff turnover (availability of staff and administrative capacity, experience and training, corruption) interplay to justify this result.

1.6. Robustness checks

In this section, we discuss several tests applied to assess further robustness of our regression results. To test whether the results are biased by larger banking markets[36], we excluded in our regressions Angola, Ghana, Kenya, Nigeria and Tanzania, each at a time. The results reported in Table 1.6 (columns XVII-XXI). The U-shaped relationship between bank competition and credit risk remains valid.

Second, we test whether the results are sensitive to the measure of bank competition and use the Herfindahl-Hirschman index (HHI). It is calculated by summing the squares

[33] We measure information sharing by credit bureau (registry) coverage, which is defined as the number of individuals and firms listed in a credit bureau or registry.

[34] Where yearly surveys are absent, we carried forward the values of the latest available data until the release of a subsequent survey (similar to Birchwood et al., 2017).

[35] "Bank entry requirements" is an index that ranges from 0 to 8 and a higher index value indicates greater stringency. "Longer supervisor tenure" is equal to 1 if the average tenure of current supervisors is greater than 10 years (which corresponds to the 75th percentile of distribution).

[36] We consider as a larger banking sector, any market made up of more than 10 banks in our sample associated with total assets greater than 9 billion USD in 2015 (see Table 1). Using this threshold, we identify five out of the top six banking sectors in SSA.

of the market share of each bank in a country's banking sector.[37] Two specifications are estimated, the first only includes the HHI and the second includes in addition its square. We find similar results as before on the U-shaped relationship between bank competition and credit risk (Table 1.6, columns XXII and XXIII).

Third, we use two alternative measures of bank risk: (i) loan loss provisions as a ratio over total loans (Fungáčová and Weill, 2013; Beck et al., 2013b) and (ii) the Z-score (Laeven and Levine, 2009; Houston et al., 2010; Tabak et al., 2012; Chen et al. 2017a). The Z-score is a measure of overall bank risk and it captures how distant a particular bank is from insolvency. It is calculated as follows:

$$\mathbf{Z-score_{ijt}} = \frac{\overline{\mathbf{ROA_{ijt}}}+\mathbf{Equity_{ijt}}}{\boldsymbol{\sigma}(\mathbf{ROA})_{\mathbf{ijt}}} \quad (1.8)$$

where ROA_{ijt} denotes the return on assets of a bank (with the mean in the numerator), $Equity_{ijt}$ represents the ratio of total equity over total assets, and $\sigma(ROA)_{ijt}$ is the standard deviation of ROA. A higher score suggests a lower probability of bank insolvency. With implementation of both measures (using a 3-year rolling window to estimate the mean and standard deviation), the U-shaped relationship between credit risk and bank competition remains significant.

As outlined previously, competition affects credit risk through two channels: operational efficiency and profitability. We assess the importance of these channels by replacing the dependent variable with a bank inefficiency indicator (non-interest expenses over total assets), and a profit margin measure (net income over total revenue). The results are reported in Table 1.7. We also find a non-linear relationship between bank competition, inefficiency and profitability. More specifically, the findings suggest that an increase in competition initially increases bank profitability by efficiency gains associated with better practices (reduction in administrative expense, lower cost of borrower screening and monitoring). Above a certain threshold, however,

[37] The database on the HHI was developed at the Banque de France using BankScope and Fitch Connect as well as reports from individual banks.

further competition is associated with lower profit margins and higher inefficiencies enticing banks to engage in riskier activities.

1.7. Conclusion

While this study mainly investigates the relationship between competition and credit risk, this paper sheds light on many other factors in Sub-Saharan Africa. Its results are thus both informative and important for policy makers concerned with financial stability in developing countries.

First, in line with recent literature on this topic, we find robust evidence of a U-shaped relationship between bank competition and credit risk. Our results suggest that the efficiency gains of heightened bank competition have to be counterweighted against the potential risks. The channels by which increased competition increases bank instability may include margin erosion, increased risk taking by competing banks and their inability to create adequate buffers to cover for bank loss fluctuations over the business cycle. As competition increases, there is thus need for policies that specifically target the financial stability of deeper and more integrated banking systems.

Second, our study sheds light on the importance of business cycles, economic structure and financial deepening in determining credit risks in Sub-Saharan Africa. More diversified countries experience lower levels of non-performing loans. Both financial deepening and financial inclusion may help to manage credit risk, for instance by lowering the concentration of bank portfolios. Our study also highlights the impact of government deficits and indebtedness in determining credit risk fluctuations. In SSA countries, government interactions with the banking systems are multifaceted – concentration of bank portfolios in government securities, large share of public servants and public enterprises in the client base, frequency of public domestic arrears that may hinder the activity of small firms – and further work is needed to study the components of this feedback loop between the fiscal stance, bank liquidity and solvency.

Finally, our results contribute to the current debate on the importance of the business environment in which banks operate. Our study points to the impact of credit registries in lowering credit risk, suggesting that other structural and institutional characteristics

(quality of accounting, fiscal issues, easy mobilization of collateral, and the reduction of the informal sector) may be instrumental in reducing information asymmetries. Turning to regulatory and prudential frameworks, our study finds that, while much attention has been given to household credit in developed countries, the banks-sovereign nexus appears to play an important role in Sub-Saharan African countries. This suggests that authorities should monitor closely rising public indebtedness and public net liabilities in bank portfolios, particularly when facing exogenous shocks and economic turnarounds, as since 2014-15. The quality of supervision also matters in reducing the share of non-performing ratios, pointing to the need to reinforce staff and administrative capacity of domestic supervisors.

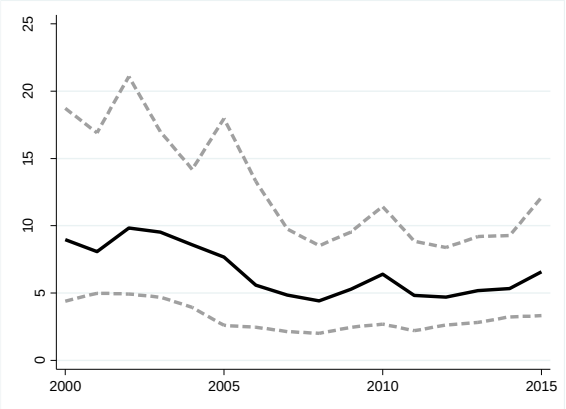
We believe further research is needed to uncover credit risk determinants specific to developing countries, as well as macrofinancial (or prudential) regulations that will not hinder the financial development necessary for their economic development while ensuring the financial stability necessary to make it sustainable.

1.8. Appendix: Figures and Tables

Figure 1.1: Credit risks in Sub-Saharan Africa and the advanced economies, 2000-2015.

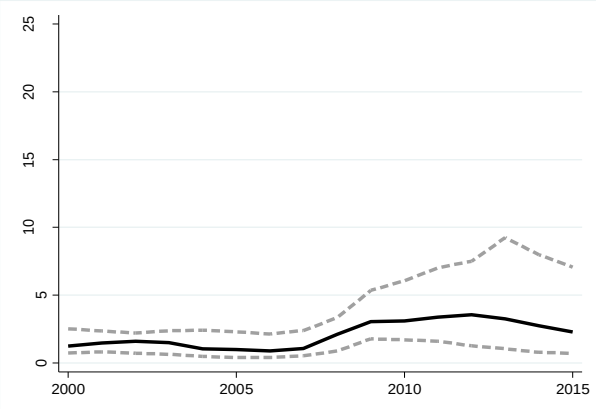
(I) Non-performing loans in Sub-Saharan Africa

Percent of total loans



(II) Non-performing loans in the advanced economies

Percent of total loans



Note: The figure provides information on the non-performing loan ratio defined as impaired loans to total loans. It shows the 25th, 50th (median) and 75th percentiles of the distribution of non-performing loans. The figure reported for the "Advanced Economies" is based on a sample of 105 major banks from the G10 countries plus Austria, Australia, and Spain (Brei and Gambacorta, 2016). All values are unweighted averages across banks and countries.

Sources: Fitch Connect and authors' own calculations.

Figure 1.2: Market power in Sub-Saharan Africa, 2000-2015

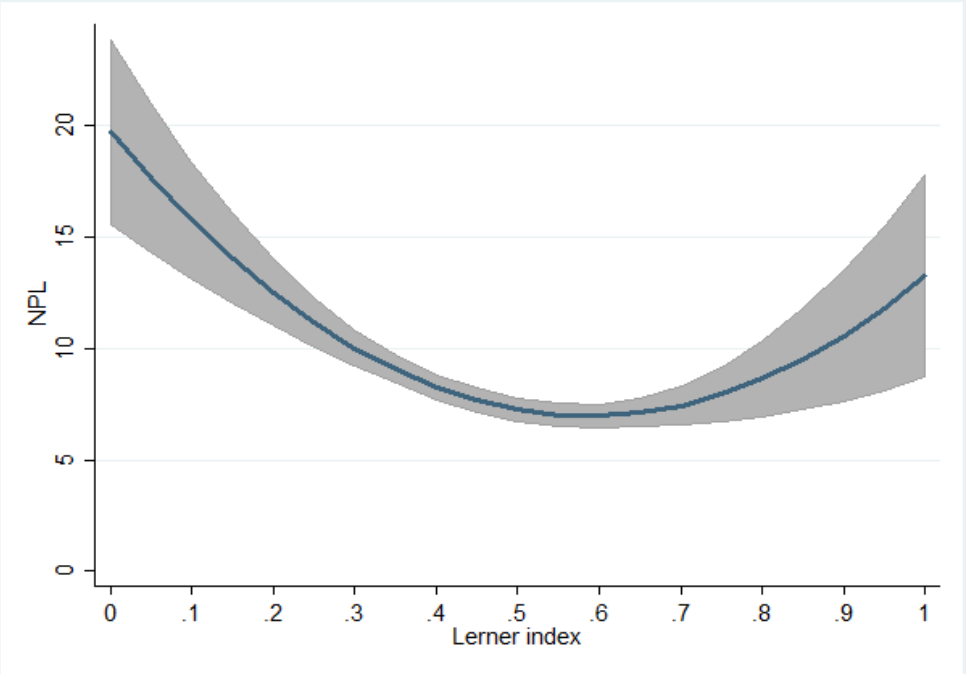
Adjusted Lerner index

Note: The figure provides information on adjusted Lerner index. A lower value indicates more competition. It shows the 25th, 50th (median) and 75th percentiles of the distribution. All values are unweighted averages across banks and countries.

Sources: Fitch Connect and authors' own calculations.

Figure 1.3: Market power and credit risk in Sub-Saharan Africa

Non-performing loans



Note: The figure shows the relationship between the adjusted Lerner index and the non-performing loan ratio based on regression (IV) in Table 1.4. The marginal effects are calculated at average values of the regression variables. The shaded area shows 95% confidence bands.

Sources: Fitch Connect and authors' own calculations.

Table 1.1: Characteristics of the database, 2000-2015

Country	Banks	Foreign banks	NPLs	Adjusted Lerner Index	GDP (2015, USD bn.)	Bank assets (2015, USD bn.)	Total assets (2015, % of GDP)	Real GDP growth	Inflation rate
Angola	13	5	7.74	0.55	103.91	43.83	42.18	7.58	38.00
Benin	3	3	9.55	0.46	8.76	1.41	16.11	4.25	2.84
Botswana	10	7	4.50	0.52	16.01	7.04	43.95	4.25	7.72
Burkina Faso	1	1	6.74	0.55	11.67	1.17	9.98	5.51	2.33
Burundi	1	1	12.2	0.53	2.31	0.20	8.69	2.88	10.16
Cameroon	6	5	9.47	0.54	30.43	5.46	17.95	3.95	2.46
Cape Verde	3	2	8.64	0.33	1.82	1.49	82.09	5.13	1.94
Central Afr. Rep.	1	1	5.92	0.65	1.43	0.16	11.05	1.85	6.71
Chad	2	1	7.55	0.66	13.36	0.63	4.69	7.62	4.23
Congo, Dem. Rep.	4	4	3.96	0.43	29.70	1.56	5.24	4.9	27.07
Cote d'Ivoire	2	2	9.70	0.39	33.96	3.58	10.53	2.62	2.62
Equatorial Guinea	1	1	19.	0.68	16.42	0.69	4.22	9.49	5.12
Ethiopia	3	0	7.55	0.74	48.33	16.37	33.88	9.00	12.9
Gabon	2	2	6.00	0.53	18.55	0.55	2.94	2.44	1.93
Ghana	15	11	11.2	0.55	46.50	9.88	21.25	6.25	16.1
Guinea	2	2	11.0	0.54	5.26	0.81	15.43	2.46	14.83
Kenya	35	13	11.0	0.49	52.20	35.32	67.66	4.46	9.72
Lesotho	2	2	4.59	0.50	2.92	0.34	11.60	3.97	7.10
Madagascar	2	2	7.36	0.62	9.93	0.68	6.87	3.2	9.34
Malawi	6	2	9.85	0.58	8.50	1.20	14.07	4.39	15.73
Mali	3	3	12.6	0.46	12.68	1.96	15.48	4.77	2.40
Mozambique	13	11	5.83	0.47	14.3	6.16	43.06	7.43	8.93
Namibia	3	2	1.74	0.41	14.75	4.71	31.91	4.92	6.73
Niger	2	2	5.38	0.56	7.63	0.44	5.72	4.67	2.15
Nigeria	20	3	10.2	0.37	461.85	136.00	29.45	6.84	11.54
Rwanda	4	4	11.6	0.37	8.00	0.66	8.20	7.66	6.53
Senegal	7	5	7.43	0.45	15.77	5.39	34.17	4.04	1.61
Sierra Leone	4	2	25.0	0.69	3.16	0.29	9.21	6.86	8.31
Swaziland	4	3	2.78	0.59	5.22	1.04	19.87	3.26	7.18
Tanzania	20	14	6.57	0.46	43.73	10.49	23.98	6.6	7.66
Togo	1	0	9.44	0.56	4.04	0.56	13.94	2.86	2.62
Uganda	17	15	4.90	0.47	26.26	5.37	20.46	6.5	7.25
Zambia	9	9	8.91	0.43	26.06	4.55	17.44	6.51	13.7
Total*/Average	**221***	**140***	**8.45**	**0.49**	**33.50**	**9.39**	**21.31**	**5.12**	**8.65**

Note: This table provides information for the sample countries. "Banks" denotes the total number of deposit-taking institutions (domestic and foreign) in a given country. Non-performing loans (NPL), real GDP growth and CPI inflation are expressed as percentages and are unweighted averages over the period 2000-2015.

Sources: Fitch Connect, WDI, IMF-IFS and author's own calculations.

Table 1.2: Description of the variables

Variables	Description	Expected sign	Sources
	Dependent variable		
NPL	Ratio of impaired loans to total loans		Fitch Connect
	Independent variables		
Lerner	Adjusted Lerner Index	+/-	Own estimation
Lerner^2	Adjusted Lerner Index, squared term	+/-	
NIM	Ratio of gross interest and dividend income minus total interest expense to total assets	+	Fitch Connect
Loans	Ratio of gross loans to total assets	+	Fitch Connect
Income diversification	Ratio of total non-interest operating income to total assets	+/-	Fitch Connect
Bank size	Natural logarithm of total assets	+/-	Fitch Connect
GDP growth	Real GDP growth (year-on-year)	-	WDI
Government debt	Government debt as percentage of GDP	+	IMF-WEO
Inflation	Annual inflation rate	+/-	IMF-IFS
Economic concentration	Index of how much a country's economy and trade are concentrated in one or a few products	+	UNCTAD
Rule of Law	Index of agents' perception on the quality of contract enforcement, property rights, the police and the courts.	-	WGI

Table 1.3: Summary statistics for the regression variables

Variable	Unit	Obs.	Mean	Std. Dev.	Min	Max
NPL	Percentage	1655	8.45	9.00	0.07	58.39
Adjusted Lerner Index	Index	1655	0.49	0.15	-0.20	0.82
NIM	Percentage	1655	5.93	3.34	0.62	31.18
Loans	Percentage	1655	52.80	14.61	8.03	87.95
Income diversification	Percentage	1655	3.87	2.18	0.10	15.36
Capitalization	Percentage	1655	12.90	6.64	0.42	71.82
Bank size	Logarithm	1655	12.82	1.39	8.91	16.33
GDP growth	Percentage	1655	5.56	3.19	-6.91	22.59
Government debt	Percentage	1655	38.74	21.34	7.28	150.23
Inflation	Percentage	1655	9.13	9.00	-1.89	108.90
Economic concentration	Index	1655	0.40	0.23	0.17	0.97
Rule of Law	Index	1655	-0.58	0.50	-1.70	0.67

Note: The sample period goes from 2000 to 2015. "Unit" denotes the measurement units of the regression variables. "Obs." denotes the number of observations for the respective variable. The last four columns show the mean, standard deviation, minimum and maximum.

Table 1.4: Results for the baseline model

	(I)	(II)	(III)	(IV)
NPL, t-1	0.690***	0.658***	0.645***	0.644***
	(0.062)	(0.068)	(0.068)	(0.070)
Lerner	**-10.679*** **	**-44.880*** **	**-45.081*** **	**-43.410*** **
	(3.334)	**(14.495)**	**(14.173)**	**(13.687)**
Lerner*Lerner		**38.328*** **	**38.617*** **	**36.949*** **
		(14.404)	**(14.110)**	**(13.685)**
NIM		0.007	0.002	0.028
		(0.093)	(0.098)	(0.111)
Loans		**0.045** **	**0.044** **	**0.052** **
		(0.019)	**(0.020)**	**(0.021)**
Income diversification		0.176	0.158	0.135
		(0.153)	(0.161)	(0.160)
Capitalization		0.027	0.045	0.043
		(0.047)	(0.048)	(0.052)
Bank size		-0.067	0.005	-0.120
		(0.125)	(0.122)	(0.135)
GDP Growth			**-0.092** **	**-0.094** **
			(0.045)	**(0.045)**
Government Debt			**0.028*** **	**0.030*** **
			(0.009)	**(0.009)**
Inflation			0.001	-0.002
			(0.016)	(0.017)
Economic Concentration				**1.740** **
				(0.743)
Rule of Law				-0.080
				(0.380)
Constant	7.596***	11.923**	10.571**	10.490**
	(1.843)	(4.787)	(4.804)	(4.691)
Observations	1655	1655	1655	1655
Banks	221	221	221	221
Hansen test (1)	0.450	0.592	0.519	0.500
AR(2) test (2)	0.593	0.388	0.408	0.394
Inflection point (3)		0.585	0.583	0.587

Note: The sample goes from 2000 to 2015. All estimations are based on the Arellano and Bover (1995) System GMM estimator. Robust standard errors are reported in brackets. (***, **, *) indicate significance at the 1%, 5%, 10% level. Significant coefficients are in bold. (1) Reports p-values for the null hypothesis that the instruments used are not correlated with the residuals. (2) Reports p-values for the null hypothesis that the errors in the first difference regression exhibit no second-order serial correlation. (3) Reports the inflection point (threshold) of the relationship between the Lerner index and non-performing loans.

Table 1.5: Bank type, external shocks and regulation

	(V) Foreign banks	(VI) Foreign, Africa	(VII) Foreign, Developed	(VIII) Public banks	(IX) Large banks	(X)	(XI)	(XII)	(XIII)	(XIV)	(XV)	(XVI)
						External shocks		Financial development and regulatory factors				
NPL, t-1	0.643***	0.642***	0.643***	0.643***	0.640***	0.642***	0.649***	0.644***	0.660***	0.644***	0.618***	0.658***
	(0.070)	(0.071)	(0.070)	(0.0702)	(0.069)	(0.069)	(0.068)	(0.068)	(0.076)	(0.076)	(0.089)	(0.073)
Lerner	**-42.923*** **	**-44.454*** **	**-41.195*** **	**-43.046*** **	**-46.731*** **	**-43.951*** **	**-43.729*** **	**-43.789*** **	**-39.976** **	**-38.397** **	**-47.325*** **	**-35.221** **
	(13.325)	**(13.219)**	**(13.786)**	**(13.577)**	**(14.527)**	**(13.235)**	**(13.726)**	**(14.106)**	**(15.804)**	**(16.704)**	**(15.246)**	**(14.800)**
Lerner*Lerner	**37.155*** **	**40.599*** **	**33.376** **	**36.503*** **	**40.316*** **	**37.659*** **	**37.128*** **	**37.034*** **	**31.878***	**31.464***	**41.268*** **	**30.442** **
	(13.86)	**(13.692)**	**(13.857)**	**(13.629)**	**(15.133)**	**(13.135)**	**(13.947)**	**(14.295)**	**(16.423)**	**(17.194)**	**(15.199)**	**(15.443)**
Lerner*Bank type	1.477	9.416	-9.051	-2.854	-1.031							
	(6.741)	(9.218)	(6.798)	(8.751)	(8.362)							
Lerner*Lerner*Bank type	-2.523	-17.916	17.170	4.946	2.258							
	(12.174)	(16.664)	(12.224)	(14.814)	(14.577)							
Financial crisis						0.078						
						(0.254)						
Commodities shock							**0.713***					
							(0.417)					
Financial development								**-0.062** **				
								(0.025)				
Bank Branches									**-0.121** **			
									(0.054)			
Credit registry coverage										**-0.030** **		
										(0.013)		
Bank entry requirements											0.271	
											(0.362)	
Longer Supervisor Tenure												**1.511** **
												(0.602)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1655	1655	1655	1655	1655	1655	1655	1645	1523	1466	1363	1134
Banks	221	221	221	221	221	221	221	221	221	221	197	170
Hansen (1)	0.432	0.422	0.492	0.488	0.380	0.472	0.452	0.465	0.443	0.345	0.228	0.569
AR2 (2)	0.390	0.343	0.373	0.397	0.387	0.391	0.379	0.397	0.257	0.332	0.941	0.788

Note: The sample goes from 2000 to 2015. All estimations are based on the Arellano and Bover (1995) System GMM estimator. In columns (V)-(IX), the adjusted Lerner index is interacted with a dummy for foreign banks (all, Africa, developed countries), public banks, and bank size. The remaining columns include additional regressors in the baseline specification. (1) Reports p-values for the null hypothesis that the instruments used are not correlated with the residuals. (2) Reports p-values for the null hypothesis that the errors in the first difference regression exhibit no second-order serial correlation. Robust standard errors are reported in brackets. (***, **, *) indicate significance at the 1%, 5%, 10% level. Significant coefficients are in bold.

Table 1.6: Robustness checks (1)

	(XVII)	(XVIII)	(XIX)	(XX)	(XXI)	(XXII)	(XXIII)	(XXIV)	(XXV)
	Exclude Angola	Exclude Ghana	Exclude Kenya	Exclude Nigeria	Exclude Tanzania	HHI index		Reserves	Z-Score
Dependent variable, t-1	0.662***	0.667***	0.548***	0.688***	0.680***	0.715***	0.709***	0.702***	0.193***
	(0.071)	(0.072)	(0.091)	(0.069)	(0.072)	(0.066)	(0.067)	(0.067)	(0.061)
Lerner	**-42.667*** **	**-45.048*** **	**-60.998*** **	**-96.764** **	**-39.313** **			**-33.332*** **	**640.113*** **
	(14.434)	**(13.857)**	**(15.480)**	**(43.423)**	**(15.704)**			**(9.023)**	**(224.129)**
Lerner*Lerner	**35.018** **	**39.128*** **	**51.743*** **	**91.760** **	**32.540** **			**29.452*** **	**-713.386*** **
	(14.890)	**(13.855)**	**(15.662)**	**(45.030)**	**(16.021)**			**(9.628)**	**(263.234)**
HHI						**-0.039** **	**-0.183*** **		
						(0.017)	**(0.052)**		
HHI*HHI							**0.003*** **		
							(0.001)		
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1558	1563	1306	1554	1506	1638	1638	1561	1438
Banks	208	206	186	201	201	221	221	217	221
Hansen (1)	0.509	0.467	0.679	0.751	0.611	0.292	0.287	0.363	0.207
AR2 (2)	0.529	0.851	0.256	0.339	0.304	0.843	0.714	0.879	0.172

Note: The sample goes from 2000 to 2015. All estimations are based on the Arellano and Bover (1995) System GMM estimator. 'Exclude' indicates that regressions are done without banks from the particular country, 'HHI' indicates that the Herfindahl-Hirschman Index is used as a measure for competition, 'Reserves' that reserves for problem loans and 'Z-Score' that the Z-Score is the dependent variable. (1) Reports p-values for the null hypothesis that the instruments used are not correlated with the residuals. (2) Reports p-values for the null hypothesis that the errors in the first difference regression exhibit no second-order serial correlation. Robust standard errors are reported in brackets. (***, **, *) indicate significance at the 1%, 5%, 10% level. Significant coefficients are in bold.

Table 1.7: Robustness checks (2)

	(XXVI)	(XXVII)	(XXVIII)	(XXIX)
	Efficiency indicator		Profitability indicator	
Dependent variable, t-1	0.435***	0.273***	0.279***	0.252***
	(0.120)	(0.069)	(0.066)	(0.057)
Lerner	**-6.374*** **	**-18.932*** **	**51.158*** **	**124.632*** **
	(1.477)	**(4.661)**	**(13.232)**	**(27.27)**
Lerner*Lerner		**17.087*** **		**-100.188*** **
		(5.609)		**(29.481)**
Control variables	Yes	Yes	Yes	Yes
Observations	1655	1655	1654	1654
Banks	221	221	221	221
Hansen (1)	0.253	0.321	0.186	0.566
AR2 (2)	0.271	0.564	0.544	0.682

Note: The sample goes from 2000 to 2015. All estimations are based on the Arellano and Bover (1995) System GMM estimator. Efficiency indicator is measured by non-interest expense as a proportion of total assets. We reach to the same results by using cost-income ratio as an alternative measure of bank efficiency. Profitability is measured by the ratio of net income to total banks' revenue. We also use return on equity and the results remain valid. (1) Reports p-values for the null hypothesis that the instruments used are not correlated with the residuals. (2) Reports p-values for the null hypothesis that the errors in the first difference regression exhibit no second-order serial correlation. Robust standard errors are reported in brackets. (***, **, *) indicate significance at the 1%, 5%, 10% level. Significant coefficients are in bold.

Chapter 2

Informal Sector and Mobile Financial Services in Developing Countries: Does Financial Innovation Matter?[38]

[38] *This chapter was co-authored with L. Jacolin and J. Keneck-Massil, and published as Banque de France working paper No. 721/2019. The paper is currently under revision at The World Economy.*

Abstract

This paper investigates the impact of mobile financial services - MFS (mobile money, and mobile credit and savings) on the informal sector. Using both parametric and non-parametric methods on panel data from 101 emerging and developing countries over the period 2000-15, we find that MFS negatively affect the size of the informal sector. According to estimates derived from propensity score matching, MFS adoption decreases the informal sector size in a range of 2.4 – 4.3 percentage points of GDP. These formalization effects may stem from different possible transmission channels: improvement in credit access, increase in the productivity/profitability of informal firms attenuating subsistence constraints typical of entrepreneurship in the informal sector, as well as possible induced growth of firms already in the formal sector. The robustness of these results is supported by the use of an alternative estimation approach (instrumental variables). These findings lay the groundwork for the scarce literature on the macroeconomic impact of mobile financial services, a major dimension of the growing drive towards economic digitalization.

Keywords: Mobile financial services, Mobile money, Financial innovation, Digitalization, Informal sector, Developing countries

JEL classification: C26, E26, O33, G29, L96

2.1. Introduction

The informal economy (at around 35 % of GDP)[39] is often seen as an obstacle to development in emerging developing countries (EMDCs) insofar as it may introduce significant microeconomic distortions, (competition, sectoral capital allocation, etc.), and macroeconomic losses in efficiency (lower productivity of labor and capital, disincentive to innovate and to scale up, increase in income inequality and poverty). A larger share of the informal sector is also associated with insufficient domestic resource mobilization and public spending to finance access to basic services (health, education), which are essential to reach sustainable development goals, or investment, notably in infrastructure, to facilitate economic diversification and integration in global value chains.

Given the diversity of informal activities, the formalization process associated with economic growth is multifaceted and the efficiency of corrective policies to promote the formal sector a matter of debate (La Porta and Shleifer, 2014). One of the significant dilemma faced by policy makers is that the informal economy has also been shown to generate a significant source of income and economic inclusion to vulnerable segments of the population (women, ethnic minorities, migrants and refugees, poor). Public action is also hindered by poor quality data and studies on this topic have so far been plagued by complex national accounting measurement issues. However, the use of satellite data (night lights method) may provide new insights on the size of the informal sector (Henderson et al., 2012; Medina and Schneider, 2018).

In parallel, mobile financial services (MFS)[40] have been spreading rapidly in developing countries with large informal financial sectors and low formal financial deepening and inclusion. As documented by Guerineau and Jacolin (2014), these countries are

[39] Buehn and Schneider (2012) define the informal sector as all market-based legal production of good and services that escape inclusion in official account, taking aside illicit activities. It is expressed as a share of overall GDP. As discussed in Dell'anno (2016), based on this definition, the terms "*informal, shadow, underground, hidden, unofficial*" are often used synonymously and associated with terms such as economy, sectors, market or GDP or size.

[40] Mobile Financial Services (MFS) refer to the use of a mobile phone to access financial services like credit and savings, in addition to mobile money (GSMA, 2018).

characterized by a strong preference for cash transactions over other means of payment, low access to financial services for large segments of their populations and recourse to informal credit (and self-insurance) to finance consumption and investment project instead of credit by formal banks and insurance. Ironically, this environment may have facilitated the rise of financial innovation in developing countries since the rise of Safaricom's M-Pesa in Kenya in 2007, with significant associated leapfrogging effects. In these countries, MFS represent a rapid and cost-effective option to modernize financial transactions, for instance: ecommerce, direct wage payments to mobile accounts by employers, digitalization of payments among firms, social benefits by public authorities, and tax payments to tax administrations (Aron, 2018).

Another noteworthy development has been the trend towards diversification of financial services offered by a growing array of providers (telecom operators, Fintech startups, banks themselves). From its initial focus on transactions as a means of payment, i.e. mobile money, MFS are increasingly offering credit services, and more recently, insurance services. Financial digitalization is but one form of a towards economic digitalization, a fast-growing and multifaceted economic transformation driven by large network effects that affects both the business models of banks, telecom operators and other financial intermediaries and their relationship with the real sector of the economy.

In our view, assessing the impact of mobile financial services on the informal economy therefore represents a research question of growing and significant interest, one that has received little attention so far. Our research goal is to determine the net effect of MFS adoption on the overall size of the informal sector and analyze some of its transmission channels.

The choice to conduct economic activities in the informal sector is driven by a wide set of economic, financial and institutional motives. The first one may be a desire to avoid tax and social contributions (e.g. Djankov et al., 2010; Goel and Nelson, 2016; Mitra, 2017). Low financial development and in particular poor access to credit may also favor

remaining in the informal sector (e.g. Blackburn et al., 2012; Bose et al., 2012; Berdiev and Saunoris, 2016). The attractiveness of the shadow economy may also be affected by the business cycle and the opportunities it creates in the formal sector (Schneider and Enste, 2000). International constraints, such as openness to political, social and economic globalization (e.g. Pham, 2017; Berdiev and Saunoris, 2018), as well as regulatory and institutional quality (administrative bureaucracy, corruption or quality of governmental or political institutions) may also drive the appetite for informal activities (e.g. 1998; Dabla-Norris et al., 2008; Dreher et al., 2009; Goel and Saunoris, 2014a; Elbahnasawy et al., 2016).

To assess the net impact of mobile financial services on the informal sector, we draw on a panel data from 101 developing countries over the period 2000-15. We find that mobile financial services negatively affect the size of shadow economy. Based on non-parametric approach (propensity score matching), we show that MFS adoption significantly decreases the informal sector size in range of 2.4 – 4.3 percentage points over the period of our study. Formalization effects may stem from different possible transmission channels: improvement in credit access, increase in the productivity/profitability of informal firms attenuating subsistence constraints typical of entrepreneurship in the informal sector, as well as possible induced growth of firms already in the formal sector. The robustness of these results is also supported by the use of an alternative estimation approach (instrumental variables). There is therefore no doubt that mobile money, mobile credit and mobile savings can be considered as powerful tools to accelerate economic formalization.

The remainder of the paper proceeds as follows. Section 2 analyses the transmission channels. Section 3 describes the data. Section 4 details empirical strategy. The empirical results are reported in Section 5, while Section 6 discusses the robustness checks. The final section concludes.

2.2. How do mobile financial services impact the shadow economy?

The literature on the economic impact of mobile financial services is scarce and focuses mostly on microeconomic implications. Jack et al. (2013), as well as Jack and Suri (2014), show that mobile money helps Kenyan households to share risks and smooth shocks. Suri and Jack (2016) find that access to mobile money lifted 2% of Kenyan households out of extreme poverty. Islam et al. (2017) highlight a positive effect of firms' mobile money use on firm investment. This impact is related to reduced transactional costs, increased firms' liquidity, and increased ability to establish credit worthiness by using data generated by mobile financial services use. Beck et al. (2018) have also documented theoretical and empirical impacts of MFS (M-Pesa) on firms' productivity. They point out that entrepreneurs are more willing to use MFS as means of payment to better secure their transactions, and better manage cash flows. The usage of mobile money also increases firms' probability of getting trade credit from their suppliers.[41]

Theoretically, the relationship between MFS adoption and the shadow economy could pass through three channels.

The first transmission channel is a reduction the demand for cash. For La Porta and Shleifer (2014), informal firms are unproductive not only because their productivity is low and informal entrepreneurship is associated mostly with subsistence, but also because they use cash as the only means of payment. Therefore, moving from cash to digital payments (MFS as means of payment) promotes productivity/profitability, by reducing operational costs and making commercial transactions more secure, fluid and cheaper, as documented by Klapper (2017), and Beck et al. (2018). These efficiency gains increase the opportunity costs of staying in the small-scale and less productive informal sector.

[41] Other studies have also looked at the impact of mobile money on resilience to climate shocks (Riley, 2018), antipoverty programs (Aker et al., 2016), agricultural outcomes (Aker and Ksoll, 2016), remittances (Munyegera and Matsumoto, 2016) or gender equality (Sekabira and Qaim, 2017).

Second, MFS may also affect the informal sector by improving access to credit, since informal MSMEs (which account for about 80 % of total MSMEs) and self-entrepreneurs usually report access to finance as the biggest obstacle they encounter (GPFI, 2018). Many digital financial services providers increasingly diversify their activities and combine mobile money and, credit, savings and insurance services to provide a full client relationship, similar to that of traditional banks. In addition, bundling these services with a wide array of non-bank services allows digital financial services providers to create an economic ecosystem, a powerful tool of client base and product use growth. Because it reaches out to previously unbanked populations in the informal sector, MFS encourage entrepreneurship and contribute to the empowerment of individuals or communities.

In so far as they generate large datasets on users (habits, credit history, ect.), MFS also facilitate credit access by reducing information asymmetries and improving transparency. [42] As is underlined in Klapper (2017), data analytics of digital transactions can help financial institutions create a qualifying credit score for MSMEs or self-employed entrepreneurs to start or expand their business in the formal sector.

Third, MFS may indirectly impact the shadow economy through formal sector growth, as the previous transmission mechanisms may also be applied to formal firms and they may be in a position to access MFS first, especially credit services. In particular, the improvement in productivity/profitability of formal firms induced by the use of MFS could be associated with an increase in hiring, thereby reducing the informal sector.

Finally, MFS can help decrease informal activities indirectly through the growth of formal sector, by boosting productivity/profitability, and hence reducing the opportunity benefits of informality. Access to mobile credit/savings can also strengthen the credibility of constrained MSMEs and self-entrepreneurs, helping them overcome the entry cost into the formal sector. In sum, the formalization effect of MFS services

[42] See Aron (2018) for more details.

could therefore reflect both a transfer of informal firms to the formal sector and the formal sector own growth.

2.3. Data description

The purpose of our study is to examine the relationship between the development of MFS and the size of the informal economy in emerging and developing countries.

2.3.1. The informal sector

The definition and estimation of the size of the informal sector remains a source of debate within the economic literature. Several studies have defined and estimated the size of the informal sector, either excluding illicit activities, such as Medina and Schneider (2018), Buehn and Schneider (2012), Elgin and Öztunali (2012) or including it (Alm and Embaye, 2013). In this paper, we adopt the former approach both for data availability reasons and a focus on domestic resources allocation, illicit activities being by nature neither authorized nor taxable.

The estimates of the size of the informal economy as a percentage of GDP are collected from Medina and Schneider (2018). These estimates are derived from a Multiple Indicators, Multiple Causes (MIMIC) approach. A particular type of structural equation model (SEM), the MIMIC model uses associations between different observable causes and impacts of an unobservable variable (the shadow economy), to estimate it. Unlike previous estimates that use GDP per capita and growth of GDP per capita as cause and indicator variables, Medina and Schneider (2018) use the "*night lights*" approach by Henderson et al. (2012) to capture economy activity, which relies on satellite data. They consequently provide a satisfactory response to the criticisms linked to the endogeneity problem of GDP associated with previous studies based on national accounting.

Based on these data, our initial sample covered 158 countries. We first excluded advanced economies (as defined by the IMF) given the low proportion the informal activities in these countries (on average less than 15% of GDP) and countries in conflict

(Libya, Syria and Yemen). After eliminating countries with no data on control variables, our final sample consists of 101 countries over the period 2000-15, as reported in Table 2.A1 (in appendix). The informal sector is on average equal to 34.2 % of GDP, with significant disparities between regions as shown in the Figure 2.A1 (in appendix).

2.3.2. Mobile financial services (MFS)

Mobile Financial Services (MFS) refer to the use of a mobile phone to access financial services like credit and savings, in addition to mobile money (GSMA, 2018). These services can be accessed independently from access to internet.

A mobile money service denotes transferring money and making payments using mobile phone (GSMA, 2018). According to Aron (2017), page 7: "*the common characteristics of various definitions of mobile money are: it is electronic money issued on receipt of funds in an amount equal to the available monetary value; it is electronically recorded on a mobile device; the electronic value is redeemable for cash, and the electronic value may be accepted as a means of payment by parties other than the issuer (for example, for person-to-person transfers (P2P), retail payments and payment for services; government-to-person (G2P) transfers (and receipts); donor-to-person cash transfers; and business transfers (and receipts); and the electronic value is backed up by storage of equivalent funds in one or more banks depending on central banking or other regulations.*"

Launched in the Philippines in 2001, mobile money became widely known after its successful introduction in Kenya in 2007 (M-Pesa). According to Jack and Suri (2016), mobile money is used by at least one individual in 96% of Kenyan households and M-PESA, leading to a dramatic rise of financial inclusion of both households and MSMEs. By the end of 2015, 251 mobile money services were offered in 93, with Sub-Saharan Africa being the world's most dynamic market[43]. MFS represent 426.5 million registered

[43] 127 services, against 36 in East Asia and Pacific, 9 in Europe and Central Asia, 31 in Latin America and the Caribbean, 16 in Middle East and North Africa, 40 in South Asia (Mobile money metrics, GSMA).

accounts, associated with over one billion transactions per year and an average of 33 million transactions per day.

Mobile financial services are available in 72 of the 101 countries contained in our sample (see Table 2.A1 in Appendix).[44] In our empirical approach, we measure mobile financial services by a dummy variable which takes the value one from the year the service is launched and zero otherwise. Data are collected from the GSMA's Mobile money deployment tracker database.

2.4. Econometric framework

We assume that the relationship between the informal sector size and the adoption of MFS is determined by the following linear equation:

$$\boldsymbol{Informal_{i,t} = \delta MFS_{i,t} + X'\beta + \mu_i + \epsilon_{i,t}} \quad (2.1)$$

where $Informal_{i,t}$ denotes the size of informal sector (in percentage of GDP) of country i in year t. $MFS_{i,t}$ is the dummy variable taking the value one from the year the service is launched in country i, and zero otherwise. X' is a vector of exogenous variables. μ_i and $\epsilon_{i,t}$ are respectively an unobservable time invariant country specific effect and error term. The description and sources of the variables and summary statistics are reported in Tables A2 and A3.

2.4.1. Control variables

We include in our model the growth of GDP per capita in order to capture the possible impact of economic development on informal sector size. This variable also captures the business cycle (Medina and Schneider, 2018) and the long-term decrease of the informal sector induced by economic development (see Figure A1). We expect a negative relationship between economic activity and the informal sector. Schneider (2005, 2010) shows, for instance, that individuals and firms have a greater incentive to

[44] 21 countries are not covered by our study due to the unavailability of data on the informal sector or the control variables used for our empirical strategy.

migrate from the informal to formal sector at the top of the business cycle in order to seize business and job opportunities. We therefore expect a negative relationship between economic development and the informal sector.

Since tax evasion represents a major motive to operate in the informal sector, we include a variable capturing government size, measured by the amount of government spending. We find this measure to be an important decision variable decision for firms in developing countries, given the importance of the public sector both as a client and a major employer of the formal sector. Government spending may also provide a more trustworthy and forward-looking picture for firms of governments financing needs, hence their anticipated tax burden, than past current tax burden ratios. A broad government with more resources may favour formal firms to ensure transparency and taxability. It could also have a crowding-out effect on private initiative and encourage informal activities (Berdiev and Saunoris, 2018). Its overall impact on the informal sector is therefore unclear.

Total investment is measured by total investment (or gross capital formation) as a proportion of GDP. Larger investment relative to GDP can be interpreted as sign of a dynamic economic. We therefore expect a negative relationship between total investment and the size of informal sector.

We use the new financial development index provided by Svirydzenka (2016) as a measure of financial development. This index has the advantage of taking into account all dimensions of financial development, namely: depth, accessibility (financial inclusion) and efficiency. Some studies show that an improvement in the development of financial sector is associated with a smaller informal sector size (Blackburn et al., 2012; Bose et al., 2012; Capasso and Jappelli, 2013), thanks to enhanced disclosure of information.

Like Moller and Wacker (2017), we measure infrastructure by the ratio of fixed telephone lines per 100 people.[45] Infrastructure is considered as an important driver of economic growth and development (Calderon and Serven, 2014). Improved infrastructure can contribute to the reduction of the informal sector by increasing firms' productivity and manufacturing output (Fedderke and Bogetic, 2009; Rud, 2012).

We also include in our model growth in the agricultural activities. Torgler and Schneider (2009), as well as Hassan and Schneider (2016) document that farmers are more likely to evade taxes than other professions and therefore to operate informally.

The informal sector may also be impacted by globalization negatively, as it increases exposure of local firms to best international practices, as shown by Berdiev and Saunoris (2018). The social globalization index captures international interpersonal contacts, cultural proximity and information flows (through television, internet use and the presence of foreign population). Elgin (2013) shows that informal sector is lower in countries that experience high internet usage (also see Dreher, 2006; Goel et al., 2012; Cariolle et al., 2019). The political globalization index captures the diffusion of sound government policies. We expect a negative relationship between both control variables and the shadow economy.

Finally, we control for both institutional framework and trade environment. Following Dreher et al. (2009), as well as Buehn and Schneider (2012b), we include in our model an indicator apprehending corruption level, namely government integrity index.[46] Trade environment is measured by the trade freedom index[47] which assesses tariff and non-tariff barriers and how those impact imports and exports of goods and services (Elbahnasawy et al., 2016).

[45] Fixed telephone lines are poorly correlated with MFS adoption.

[46] It ranges from 0 (very corrupt government) to 10 (very little corruption).

[47] It ranges from 0 (low trade freedom) to 100 (higher trade freedom).

We first estimate Equation 1 using a fixed-effects model[48] in order to limit bias due to unobserved heterogeneity (i.e. unobserved effects that influence the underground economy). The results are discussed in the Section 5. In addition, we relax the linearity assumption of the relationship between the shadow economy and MFS adoption using a non-parametric approach based on propensity score matching (PSM).

2.4.2. The propensity score matching (PSM)

In this section, our main objective is to evaluate the impact of MFS adoption on the informal sector size (treated group), compared to countries that did not adopt MFS (control group).

Let $Informal_{1i}$ be the potential size of the informal sector in country i if MFS is adopted, and $Informal_{0i}$ the potential size of the informal sector in country i without MFS. Let MFS_i be the treatment variable, taking the value one from the year the service is adopted in country i, and zero otherwise. In addition, MFS adoption is conditional to a set of observed covariates X. Thus, for each country, we observe (MFS_i, $Informal_i$, X), where $Informal_i$ is the realized outcome:

$$\boldsymbol{Informal_i = Informal_{0i}\ if\ MFS_i = 0\ and\ Informal_i = Inforrmal_{1i}\ if\ MFS_i = 1} \quad (2.2)$$

Since it is not possible to observe the outcome of the treatment for both countries at the same time, we need to build a counterfactual by asking, for a country i with a MFS, what would have been the informal sector size in the absence of MFS? Hence, the effect of MFS for a country i is given by:

$$\boldsymbol{\theta_i = Informal_{1i} - Informal_{0i}} \quad (2.3)$$

[48] Hausman's test indicates a preference for the fixed-effects model (or within estimator) over the random-effects model.

Then, the average treatment effect on the treated (ATT) defined as the mean of the difference in outcome (informal sector size) between the two groups (treated and control groups), is computed as follows:

$$\boldsymbol{ATT = E[Informal_{1i}|MFS_i = 1] - E[Informal_{0i}|\ MFS_i = 1]} \quad (2.4)$$

The ATT is based on two assumptions namely, the unconfoundedness assumption or conditional independence assumption (CIA) and the common support assumption (CSA). The CIA implies that the selection into the treatment group is only conditional to a set of observed covariates. In other words, after controlling-for these covariates, the treatment is independent of the potential outcome. Rosenbaum and Rubin (1983) define the propensity score - PS (or probability to adopt MFS) under the CIA as:

$$\boldsymbol{p(X) = pr(MFS = 1|X)} \quad (2.5)$$

where X is the vector of pre-treatment characteristics.

The CSA requires sufficient overlap in the characteristics of treated and control countries such that, for each country, the probability of the MFS adoption is comparable to the probability of non-adoption. The CSA is reflected by equation (6):

$$\boldsymbol{0 < pr(MFS = 1|X) < 1} \quad (2.6)$$

When the two assumptions are met, the PSM estimator for ATT can be considered as unbiased.

2.5. Empirical results

This section presents the results of the impact of MFS adoption on the underground economy based on fixed-effects and PSM estimates.

2.5.1. Fixed effects estimates

We estimate three separate models for the shadow economy. The first includes all control variables, excepted institutional framework and trade environment, the second

adds an institutional framework variable, and the third incorporates all control variables.

Table 2 1: Fixed-effects estimates

	(1) FE	(2) FE	(3) FE
Mobile financial services	**-1.027****	**-0.967****	**-0.936****
	(0.396)	**(0.387)**	**(0.375)**
GDP per capita	-0.133***	-0.135***	-0.136***
	(0.026)	(0.025)	(0.026)
Government spending	-0.036**	-0.037**	-0.034**
	(0.014)	(0.014)	(0.014)
Total investment	-0.071**	-0.075***	-0.071***
	(0.028)	(0.027)	(0.026)
Financial development index	-15.70***	-15.74***	-14.91***
	(3.691)	(3.519)	(3.426)
Infrastructure	-0.079	-0.072	-0.091
	(0.073)	(0.077)	(0.070)
Agriculture	-0.012	-0.011	-0.013
	(0.008)	(0.008)	(0.008)
Social globalization index	-0.391***	-0.371***	-0.329***
	(0.059)	(0.056)	(0.058)
Political globalization index	-0.033	-0.041	-0.032
	(0.040)	(0.037)	(0.037)
Government integrity		-0.079**	-0.080**
		(0.034)	(0.033)
Trade freedom			-0.046*
			(0.024)
Constant	66.67***	68.82***	68.87***
	(3.595)	(4.013)	(3.915)
Observations	1269	1269	1269
Countries	101	101	101
R^2 (within)	0.496	0.510	0.518
F-test	24.37***	23.50***	22.37***

Note: The sample goes from 2000 to 2015. The dependent variable is shadow economy (% of GDP). Robust standard errors are reported in brackets. (***, **, *) indicate significance at the 1 %, 5 % and 10 % level.

The regression results are reported in Table 1. The coefficient of MFS adoption is negative and significant at the 5 % level (columns 1 to 3). This confirms our hypothesis of a negative relationship between informality and MFS adoption.

2.5.2. Propensity score matching results

We estimate the propensity score (PS) using a logit model with MFS adoption as the dependent variable). To estimate the PS, we rely on the literature (GSMA, 2016b; Mothobi and Grzybowski, 2017; Della Peruta, 2018; Aron, 2018) to identify the set of variables that may likely to influence both MFS adoption and informality. These include: mobile phone market share (the ratio of mobile phones subscription in country *i* to that of his region), income level (measured by the logarithm of household consumption per capita), financial development (domestic credit to private sector), investment freedom, rule of law, inflation, social globalization index, labor force participation rate, urban population growth, and education level (mean years of schooling).

Table 2.2: Logit estimate of the propensity score

Dependent variable	Mobile financial services (dummy variable)
Mobile phone market share	0.055***
	(0.012)
Households consumption	-0.876***
	(0.154)
Financial development	0.026***
	(0.005)
Investment Freedom	0.018***
	(0.005)
Rule of Law	-1.217***
	(0.177)
Inflation	-0.007
	(0.013)
Social globalization index	0.049***
	(0.014)
Labor force	0.029***
	(0.007)
Urban population growth	0.149***
	(0.044)
Level of education	-0.031
	(0.044)
Observations	1104
Pseudo R^2	0.155
Model χ^2	149.45***
Log likelihood ratio	-591.25

Note: The sample goes from 2000 to 2015. The dependent variable is MFS adoption. Robust standard errors are reported in brackets. (***, **, *) indicate significance at the 1 %, 5 %, 10 %. Unreported constant included. All independent variables are one-year lagged, excepted investment freedom and rule of law.

Table 2.2 reports the estimates of the propensity score model. Our results show that the main drivers of MFS adoption are the mobile phone market share, income level, financial development, investment freedom, rule of law, social globalization, labor force, and urban population growth. The positive correlation between the probability of the adoption of MFS and regional market share confirms that the emergence of MFS is fundamentally linked to the mobile phone market's size (GSMA, 2016a). MFS are more available in low- and middle-income countries as they are considered as low-cost solutions, and hence more appealing to low-income populations (GSMA, 2016b) than to high income populations with high consumption levels and high access to a variety of means of payments. Financial deepening, investment freedom, and the quality of institutional framework (proxied by rule of law) also provide important incentives for MFS adoption. This confirms earlier results that restrictive regulatory environments and investment barriers are negatively correlated with MFS adoption (Pénicaud, 2013; Evans and Pirchio, 2014). Labor force participation and the urbanization rate both have a positive effect on the deployment of MFS since their transactions are mostly from urban to rural areas, and fulfil a need for distant payments (Buku and Meredith, 2013; Della Peruta, 2018). Macroeconomic stability (proxied by the inflation rate) is not significant, as some countries (Argentina, Democratic Republic of the Congo, or Malawi) with an average inflation rate of 10 %, have nonetheless decided to adopt MFS. The education level is also not significant, suggesting that the use of MFS is simple enough to be accessible to the less educated populations, already familiar with the use of mobile phone applications.

Based on the propensity score estimates, we can match treated and untreated countries using four different matching algorithms for robustness purposes. First, under the N-nearest-neighbour matching, each treated *i* is matched with untreated *j* with close PS. Following Minea and Tapsoba (2014), and Balima et al. (2017), we consider the nearest (N = 1), the two-nearest (N = 2), and the three-nearest (N = 3). The second method is the radius or caliper matching (Dehejia and Wahba, 2002), which matches each treated *i* with untreated *j* that falls within radius *r*. We use the PS to define

a medium (r = 0.1), a small (r = 0.05) and a wide (r = 0.2) radius.[49] Third, we use the kernel matching developed by Heckman et al. (1998), which matches each treat *i* with all untreated, with weights inversely proportional to the gap between the treated and control observations. We employ the Eparnecknikov function in this paper. The fourth algorithm is the local linear matching, which is similar to the kernel matching but includes a linear term in the weighting function.[50]

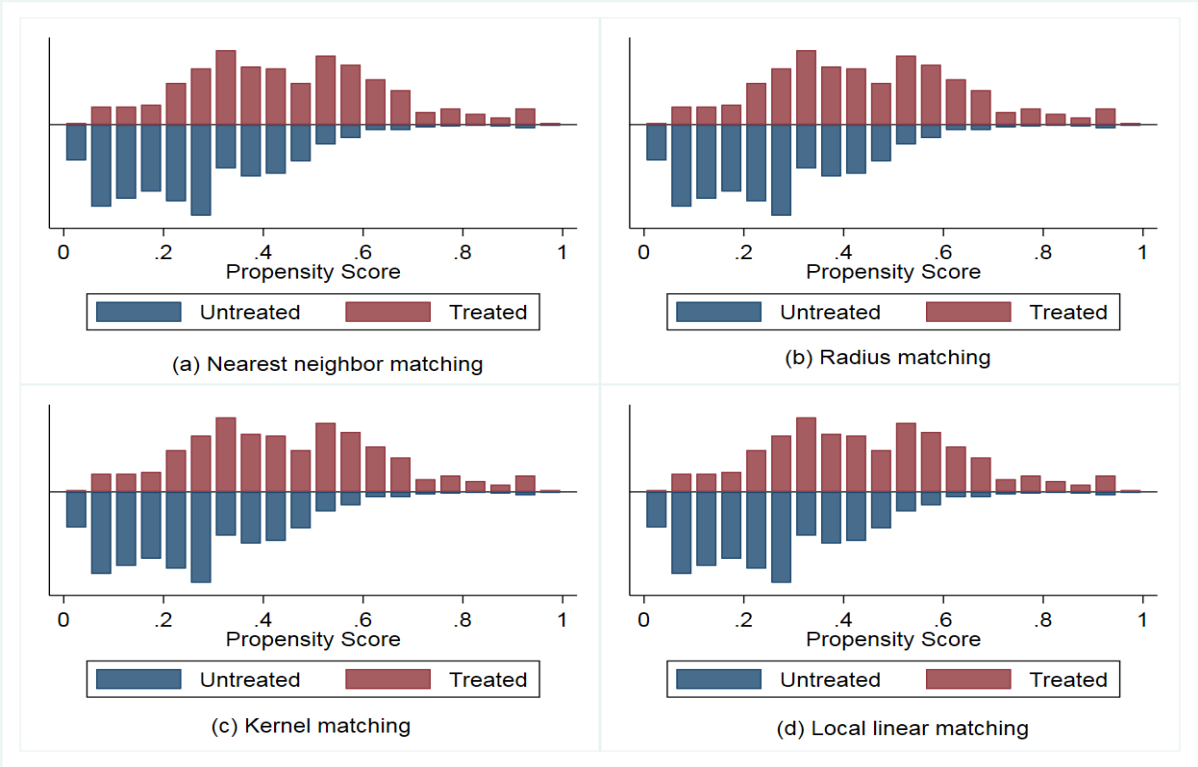
First, the quality of matching appears satisfactory according to standard assessment tools. Figure 2.1 presents the distribution of the estimated of the PS for the two groups and the region of common support. A visual inspection of the density distributions (Caliendo and Kopeinig, 2008) indicates that the common support assumption is satisfied: all the treated observations and the untreated observations were within the region of common support. In other words, there is sufficient overlap in the distribution of the PS for MFS adopters and non-adopters. Table 2.3 presents result from covariate balancing tests, which reveals that the standardized mean difference for overall covariates used in the estimation process of PSM reduces from 28.0 % before matching to a range of 3.6 – 5.7 % after matching. The total bias also decreases by 79.6 – 87 % depending on the matching methods. These values are greater than the 20 %, critical value suggested by Rosenbaum and Rubin (1985).

The second diagnostic tool used is the pseudo-R^2 (defined as the difference between the pseudo-R^2 for the matched and for the unmatched samples) from the logit estimation of the conditional probabilities of the adoption of MFS. The results show that the pseudo-R^2 is very close to zero after matching for all matching algorithms, suggesting that there are no systematic differences in the distribution of covariates between the MFS adopters and non-adopters after matching. The p-values of likelihood ratio test highlight the joint significance of all covariates in the logit model

[49] Following Austin (2011), we define medium radius as 0.2 of the standard deviation of the logit of the propensity score. The wide radius and small radius are set equal to two and a half the medium radius, respectively (Lin, 2010).
[50] The default bandwidth (0.06) is used for the kernel and local linear regression matching.

after matching, but not before matching. In sum, the low pseudo-R^2, low mean standardized bias, high total bias reduction, and insignificant p-values of the likelihood ratio test after matching indicate that the specification of the propensity score estimation process has successfully balanced the distribution of covariates between MFS adopters and non-adopters.

Figure 2.1: Distribution of the estimated propensity score and the region of common support



The PSM yields significant insights on how the adoption of MFS affects the underground economy. The four matching algorithms show that the adoption of MFS has a negative and significant (at the 1 % level) impact on the share of informal sector activities in range of 2.4 – 4.3 percentage points, depending on the matching algorithm (see Table 2.4). Our results show that improvement in firms' productivity/profitability and access to credit stemming from MFS use (Section 2) represent significant incentives for MSMEs or self-employed entrepreneurs to enter the formal sector and translate into tangible formalization effects. Our findings may also reflect the growth of the formal sector. These results are all the more remarkable as the diffusion of this financial innovation is both in terms of geographic coverage, product diversification (credit,

savings and insurance) and client base. Possible cross effects with other forms of economic digitalization may also unfold and amplify these effects, suggesting that further formalization effects may be on the way.

In order to ensure the robustness of our matching estimations, we also need to check for possible hidden bias due to unobserved variables that may influence MFS adoption. As suggested by Rosenbaum (2002), we use of a sensitivity analysis called bounding approach (Rosenbaum bounds – rbounds) to address this issue. The critical thresholds of gamma (Γ), beyond which the causal inference of significant MFS adoption impact may be questionable, are reported in Table 2.4.[51] The critical values of gamma (Γ) range from 1.65-1.75 to 2.15-2.25. These cutting points are largely in line with the literature (Rosenbaum, 2002; DiPrete and Gangl, 2004)[52], suggesting that the estimated average treatment effects of MFS adoption on the informal sector are robust, even in the presence of unobserved heterogeneity.

[51] For instance, the critical value of 1.90-2.00 (radius matching) suggests that if countries that have the same X-vector differ in their odds by a factor of 90-100 %, the negative and significant impact of MFS adoption on the shadow economy may be questionable.

[52] Tipping critical levels usually range between 1.1 and 2.2.

Table 2.3: Matching quality indicators before and after matching

Matching algorithm		Pseudo R^2		LR χ^2		$p > \chi^2$		Mean standardized bias		Total % bias reduction
		Before matching	After matching	Before matching	After matching	Before matching	After matching	Before matching	After matching	
Nearest neighbors matching	N = 1	0.154	0.009	214.92	9.35	0.000	0.499	28.0	4.3	84.64
	N = 2	0.154	0.009	214.92	8.87	0.000	0.535	28.0	4.9	82.50
	N = 3	0.154	0.009	214.92	8.63	0.000	0.567	28.0	5.2	81.43
Radius matching	r = 0.045	0.154	0.007	214.92	7.33	0.000	0.694	28.0	4.3	84.64
	r = 0.09	0.154	0.006	214.92	5.97	0.000	0.802	28.0	3.6	87.14
	r = 0.18	0.154	0.011	214.92	10.70	0.000	0.381	28.0	5.7	79.64
Kernel matching	Bw = 0.06	0.154	0.007	214.92	7.03	0.000	0.722	28.0	4.1	85.36
Local linear matching	Bw = 0.06	0.154	0.009	214.92	9.35	0.000	0.499	28.0	4.3	84.64

Source: Author's calculations.

Table 2.4: PSM estimates of the impact of MFS adoption on the informal sector and sensitivity analysis

	Nearest neighbor matching			Radius matching			Kernel matching	Local linear matching
	N = 1	N = 2	N = 3	r = 0.045	r = 0.09	r = 0.18	Bw = 0.06	Bw = 0.06
Mobile financial service (ATT)	**-4.278*** **	**-4.152*** **	**-4.078*** **	**-3.391*** **	**-2.946*** **	**-2.378*** **	**-3.336*** **	**-3,133*** **
	(1.154)	**(1.097)**	**(1.051)**	**(0.838)**	**(0.772)**	**(0.680)**	**(0.835)**	**(0.859)**
Critical level of hidden bias (Γ)	1.70-1.75	1.95-2.05	2.15-2.25	2.05-2.15	1.90-2.00	1.65-1.75	2.00-2.10	2.00-2.10
Number of observations	1104	1104	1104	1104	1104	1104	1104	1104
Bootstrap replications	500	500	500	500	500	500	500	500

Note: Bootstrapped standard errors are reported in brackets. (***, **, *) indicate significance at the 1%, 5%, 10% level.

2.6. Robustness checks

The relationship between the size of informal sector and MFS adoption may be endogenous given possible omitted variables bias, measurement errors or reverse causality. Since the shadow economy is associated with a strong preference for cash because it is untraceable (Williams and Schneider, 2016), the prevalence of a large informal sector represents a largely untapped market for financial services and hence strong incentives to develop financial innovations like MFS. The early and rapid growth of MFS in emerging and developing countries points out to such reverse causality effects. Moreover, since the PSM method leads to unbiased estimates only when the selection into the treatment is based the observed, we confirm our results by an alternative estimation approach using instrumental variables estimator (2SLS) to control for unobservable factors.

The main challenge is to find a suitable instrument to isolate the causal effect of the MFS adoption on informal activities. Our first instrument is the mobile phone subscription ratio (per 100 people), as the deployment of MFS is fundamentally linked to the mobile phone market's dynamism (GSMA, 2016a). We use urban population (as a % of total population) as a second instrument in so far as MFS transactions are mostly from urban to rural areas (Della Peruta, 2018).

We also estimate three separate models for the shadow economy as before. The results are reported in Table 2.5. We assess the validity and the relevance of our instruments using three diagnostic tests. First, we use the under-identification test by Kleibergen-Paap (2006) to check whether the equation is identified (i.e., that the instruments are correlated with the endogenous variable). Second, we employ the weak-identification test by Kleibergen-Paap (2006) to examine whether the instruments are only weakly correlated with the endogenous regressor. Finally, we use the over-identification test by Hansen (1982) in order to check whether the orthogonality conditions are valid. The results of these tests, which are reported at the bottom of Table 2.4, show that the instruments used are valid and relevant.

The empirical results of the instrumental variables point in the same direction as previously: the MFS adoption lead to lower informal activities (Table 2.5, columns 1 to 3). All coefficients are significant at the 1 % level.

In addition, we test whether our results are sensitive to the measure of MFS using the number of MFS providers as an alternative indicator. The number of MFS providers refers to the number of institutions (mobile phone operators and/or financial institutions) offering digital financial services year-by-year. The correlation rate between this variable and mobile money indicator is 65 % and significant at the 1% level. The results are reported in Table 2.5 (columns 4 to 6). Our results remain valid. More specifically, in response to a 10 % increase in the standard deviation of MFS providers, the standard deviation of shadow economy decreases in range of 2,7 – 3,6 % (Table 2.5, columns 4 to 6).

Finally, our findings also highlight other drivers of shadow economy, including economic development, tax burden proxied by government spending, total investment, financial development, infrastructure, social globalization, government integrity, and trade freedom all favour the development of the formal sector over the informal one.

Table 2.5: Instrumental variable regressions

	(1) 2SLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS
Mobile financial services	**-5.226*** **	**-5.844*** **	**-4.628*** **			
	(1.270)	**(1.332)**	**(1.334)**			
MFS (providers)				**-1.954*** **	**-2.132*** **	**-1.634*** **
				(0.482)	**(0.494)**	**(0.484)**
GDP per capita	-0.130*	-0.120*	-0.118*	-0.121*	-0.112*	-0.111*
	(0.066)	(0.066)	(0.065)	(0.068)	(0.067)	(0.066)
Government spending	0.086***	0.088***	0.088***	0.089***	0.091***	0.090***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Total investment	-0.230***	-0.229***	-0.232***	-0.242***	-0.242***	-0.242***
	(0.025)	(0.026)	(0.025)	(0.026)	(0.027)	(0.026)
Financial development index	-8.295***	-6.463**	-7.166**	-10.200***	-8.944***	-9.172***
	(2.925)	(2.890)	(2.809)	(2.986)	(2.961)	(2.868)
Infrastructure	-0.258***	-0.242***	-0.257***	-0.272***	-0.260***	-0.274***
	(0.039)	(0.039)	(0.040)	(0.040)	(0.041)	(0.041)
Agriculture	-0.006	-0.008	-0.011	-0.011	-0.013	-0.015
	(0.029)	(0.029)	(0.029)	(0.030)	(0.030)	(0.029)
Social globalization index	-0.166***	-0.116***	-0.101***	-0.149***	-0.109***	-0.091**
	(0.031)	(0.037)	(0.037)	(0.031)	(0.037)	(0.038)
Political globalization index	-0.011	-0.012	-0.010	0.012	0.0132	0.010
	(0.019)	(0.020)	(0.020)	(0.023)	(0.024)	(0.023)
Government integrity		-0.083***	-0.071**		-0.065**	-0.056*
		(0.031)	(0.030)		(0.030)	(0.029)
Trade freedom			-0.057***			-0.067***
			(0.022)			(0.022)
Constant	51.17***	50.37***	52.69***	48.45***	47.58***	50.94***
	(2.668)	(2.666)	(2.603)	(2.796)	(2.810)	(2.716)
Observations	1269	1269	1269	1269	1269	1269
Countries	101	101	101	101	101	101
R^2 (centered)	0.349	0.344	0.364	0.289	0.274	0.323
Under id test: KP LM statistic	245.8	235.7	217.9	186.3	179.1	157.4
Weak id test: KP LM statistic	186.6	176.2	167.1	110.9	106.4	90.65
Over id test: Hansen j statistic	0.298	0.470	0.166	0.951	1.254	0.532
Hansen j-test (p-value)	0.585	0.493	0.684	0.330	0.263	0.466

Note: The sample goes from 2000 to 2015. The dependent variable is shadow economy (% of GDP). MFS dummy variable and MFS providers are treated as endogenous variables, and they are instrumented via mobile phone subscription and urban population. Regional fixed effects are included in each specification. Robust standard errors are reported in brackets. (***, **, *) indicate statistical significance at the 1 %, 5 %, and 10 % level.

2.7. Conclusion

This paper investigates whether and to what extent financial innovation such as mobile financial services may affect the size of the informal sector, which represent a large share of economic activity in developing countries. This research question has received little attention so far but, in our view, may have important macroeconomic repercussions as it may be a driver of financial development and growth, as well as a tool to increase mobilization of domestic resources.

Using a panel data from 101 emerging and countries over the period 2000-15, we find that MFS negatively affect the size of the informal sector. Based on non-parametric approach (propensity score matching), we show that MFS adoption significantly decreases the informal sector size in range of 2.4 – 4.3 percentage points. Formalization effects may stem from different possible transmission channels: improvement in credit access, increase in the productivity/profitability of informal firms attenuating subsistence constraints typical of entrepreneurship in the informal sector, as well as possible induced growth of firms already in the formal sector. The robustness of these results is also supported by the use of an alternative estimation approach (instrumental variables). Without doubt, mobile money, mobile credit and mobile savings can be considered as powerful tools to accelerate economic formalization. Our study also confirms that economic and financial development, infrastructure, trade freedom, as well as the quality of governance, also have a positive impact on the attractiveness of the formal sector over the informal sector.

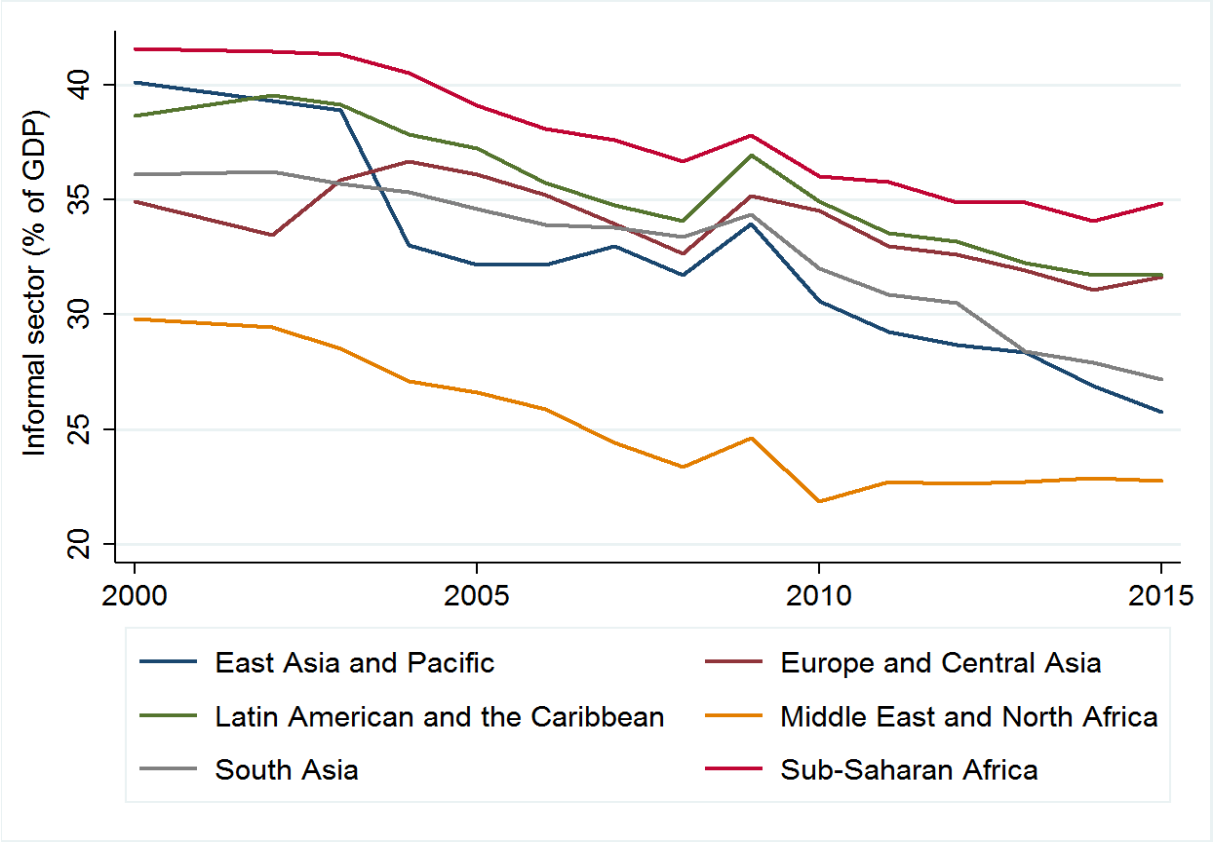
These findings lay the groundwork for the literature on the MFS' macroeconomic implications, which has received little attention so far. As financial digitalization intensifies, we expect associated macroeconomic effects to increase, calling for more research on its overall impact on inclusive economic development and domestic resource mobilization. The ongoing diversification of MFS, combined with the digitalization of other economic transactions (tax, wages, etc.) may also entail additional cumulative cross-effects along the road.

They may also provide substantial inputs to the current debate on institutional quality and regulation of mobile financial services. First, MFS contribute to strengthen transparency of economic activity and financial transactions: digitization makes domestic corruption more difficult. Second, like any financial innovation, MFS have created new types of fraud (fake currency deposits, phishing, SIM swaps, etc.). This shows that regulatory environments are important enablers of MFS growth.

Further research is needed to determine how these new financial institutions affect financial stability. The jury may still be out on whether MFS are complements or competitors to banking systems and micro finance and whether their impact on financial development and international integration is stabilizing or not. But the significance of this issue certainly grows as exponentially as MFS services themselves, calling for more regulatory vigilance and monitoring to make these services a net contributor to sustainable development.

2.8. Appendix: Figure and Tables

Figure 2.A1: Informal sector in emerging and developing countries, 2000-2015



This Figure provides information on the evolution of the informal sector across regions and over time.

Sources: Medina and Schneider (2018) and authors' own calculations.

Table 2.A1: List of countries

Sub-Saharan Africa	Latin America & the Caribbean	Europe & Central Asia	Middle East & North Africa	East Asia & Pacific	South Asia
Benin (2010)	Argentina (2013)	Albania	Algeria	Cambodia (2009)	Bangladesh (2006)
Botswana (2011)	Bahamas	Armenia (2012)	Bahrain	Fiji (2010)	Bhutan
Burkina Faso (2012)	Belize	Azerbaijan	Egypt (2013)	Indonesia (2007)	India (2007)
Burundi (2010)	Bolivia (2013)	Bosnia and Herzegovina	Iran (2011)	Malaysia (2007)	Nepal (2009)
Cameroon (2010)	Brazil (2013)	Bulgaria	Jordan	Mongolia (2010)	Pakistan (2009)
Cape Verde	Chile	Croatia	Kuwait	Philippines (2001)	Sri Lanka (2012)
Central African Republic	Colombia (2011)	Georgia (2013)	Morocco (2010)	Thailand (2004)	
Chad (2012)	Costa Rica	Hungary	Oman	Vietnam (2010)	
Congo, Dem. Rep. (2012)	Dominican Republic (2014)	Kazakhstan	Saudi Arabia		
Congo, Rep. (2011)	Ecuador	Kyrgyz Republic (2014)	Tunisia (2010)		
Cote d'Ivoire (2008)	El Salvador (2011)	Moldova	United Arab Emirates		
Ethiopia (2013)	Guatemala (2011)	Poland			
Gabon (2012)	Guyana (2013)	Romania (2014)			
Gambia	Honduras (2011)	Russia (2002)			
Ghana (2009)	Jamaica	Tajikistan			
Guinea (2012)	Mexico (2012)	Turkey (2012)			
Guinea-Bissau (2010)	Nicaragua (2011)	Ukraine			
Kenya (2007)	Paraguay (2010)				
Lesotho (2012)	Peru (2015)				
Madagascar (2010)	Suriname				
Malawi (2012)	Uruguay				
Mali (2010)	Venezuela				
Mauritania (2013)					
Mauritius					
Mozambique (2011)					
Namibia (2010)					
Niger (2010)					
Nigeria (2011)					
Rwanda (2009)					
Senegal (2008)					
Sierra Leone (2010)					
South Africa (2009)					
Swaziland (2011)					
Tanzania (2008)					
Togo (2013)					
Uganda (2009)					
Zambia (2009)					

Note: This table provides information for the sample countries. The launch year of the first mobile money service is reported in brackets.

Source: Mobile money deployment tracker, GSMA.

Table 2.A2: Description of the variables

Variables	Description	Sources
Informal	Informal sector (% of GDP)	Medina and Schneider (2018)
Mobile financial services (MFS)	Dummy variable that takes the value one in the year the service is launched and zero otherwise	Authors' calculations & Mobile money deployment tracker (GSMA)
MFS providers	Number of operators	
Mobile phone subscription	Mobile phone subscription per 100 people	WDI-World Bank
Mobile phone market share	Mobile phone market share at the regional level	Authors' calculations & WDI-World Bank
Growth GDP per capita	Percentage change in GDP per capita (year-on-year)	WDI-World Bank
Households consumption	Households consumption per capita	WDI-World Bank
Government spending	Level of government spending	Heritage Foundation
Total Investment	Gross capital formation (% of GDP)	WEO-IMF
Financial Development	Financial development index	Svirydzenka (2016)
	Domestic credit to private (% of GDP)	WDI-World Bank
Inflation	Average consumer prices (percent change)	WEO-IMF
Infrastructure	Fixed telephone lines per 100 people	WDI-World Bank
Agriculture	Agriculture added value (annual growth)	
Social Globalization	Interpersonal contact, cultural proximity and information flows	Dreher (2006) & Gygli et al. (2018)
Political Globalization	Diffusion of sound government policies	
Labor force	Labor force participation rate (% of adult population)	
Urban population growth	Percentage change in urban population (year-on-year)	WDI-World Bank
Urban population	Urban population (% of total population)	
Education level	Mean years of schooling (people aged 25 years and above)	UNDP
Government integrity	Level of corruption	
Investment Freedom	Absence of investment restrictions	Heritage Foundation
Trade Freedom	Absence of trade restrictions	
Rule of law	Index of agents' confidence in and abide on the rules of society	WGI-World Bank

Table 2.A3: summary statistics

Variable	Unit	Obs.	Mean	Std. Dev.	Min	Max
Informal sector	Percentage	1269	34,05	10,14	12,02	69,01
Mobile financial services	Dummy variable	1269	0,31	0,46	0,00	1,00
MFS providers	Number of providers	1269	0,74	1,71	0,00	18,00
Mobile phone subscription	Percentage	1269	66,78	45,95	0,00	200,93
Mobile phone market share	Percentage	1269	6,39	11,71	0,00	86,38
Growth GDP per capita	Percentage	1269	2,66	4,01	-36,83	33,03
Households consumption	Logarithm	1178	7,51	1,06	5,22	10,58
Government spending	Index	1269	73,43	16,76	0,00	97,60
Total investment	Percentage	1269	24,39	8,45	4,86	73,04
Financial development index	Index	1269	0,24	0,15	0,00	0,71
Domestic credit	Percentage	1249	34,24	23,51	0,56	126,73
Inflation	Percentage	1267	6,69	9,10	-3,47	221,49
Infrastructure	Percentage	1269	11,35	10,73	0,00	43,39
Agriculture	Percentage	1269	2,86	7,95	-45,35	55,62
Social globalization	Index	1269	52,27	14,75	10,87	81,38
Political globalization	Index	1269	69,29	15,42	15,93	95,31
Labor force participation	Percentage	1269	63,42	10,87	39,15	89,05
Urban population growth	Percentage	1269	2,55	1,87	-2,70	14,68
Urban population	Percentage	1269	52,20	20,89	8,25	98,34
Education	Percentage	1264	7,08	2,79	1,20	12,70
Government integrity	Index	1269	32,90	12,87	0,00	90,00
Rule of law	Index	1269	-0,39	0,61	-1,92	1,45
Trade freedom	Index	1269	68,92	12,86	0,00	89,20
Investment freedom	Index	1269	49,82	17,51	0,00	90,00

Note: The sample period goes from 2000 to 2015. "Unit" denotes the measurement units of the regression variables. "Obs." denotes the number of observations for the respective variable. The last four columns show the mean, standard deviation, minimum and maximum.

Chapter 3

Shadow Economy and Educational Systems in Africa[53]

[53] *This chapter was co-authored with J. Keneck-Massil. The paper is published in Economics Bulletin as Keneck-Massil, J. and Noah, A., (2019) "Shadow economy and educational systems in Africa", Economics Bulletin, Vol. 39, Issue 2, pp. 1467-1478.*

Abstract

Using data from a sample of 30 countries over the period 2000-15, we find evidence that shadow economy is higher in countries where educational system is focused on general programs. This finding highlights the mismatch between the needs of the private sector in skilled workers and what the educational system offers in some countries. In addition, we show that vocational education negatively affects the size of the shadow economy, suggesting that it enhances students' opportunities of finding gainful employment in formal sector. We also find that shadow economy in Africa is related to financial development, public investment as well as demographic dividend. In terms of public implications, our findings call for the need for a balanced educational system between general and vocational education programmes in order to reduce the size of the shadow economy in Africa.

Keywords: Education, Informal sector, General education, Vocational education

JEL classification: A20, E26, O55

3.1. Introduction

According to a UN estimate, a quarter of the world's population will be African by 2050 (United Nations, 2015). This demographic growth already presents a real social and economic challenge for many countries and, therefore, calls for the implementation of several structural transformations. These reforms are all the more essential, since informal economy[54] is particularly high throughout Africa. The extent of informality represents an unweighted average of 38% on a continent-wide scale over the period 2000-15, as compared to 32% in emerging and developing countries outside Africa. A wide spread shadow economy is a major constraint to the social and economic outcomes, especially in Sub-Saharan African (SSA) countries, where it is particularly extensive and where the challenges for development are stronger than ever before with respect to the population projection in 2050 mentioned above. The informal sector has been regarded as a constraint to development mainly because it reduces the ability of governments to collect revenues which are indispensable in providing public goods and services. It also aggravates the already inefficient use of scarce financial resources, distorts investment and increases income inequality (Kodila-Tedika and Mutascu, 2014; Elbahnasawy et al., 2016).

The large size of informal economy in Africa can be interpreted as reflecting a weakness in private sector. It can also be analysed under the prism of a mismatch between the needs of the private sector in skilled workers and what the educational system offers in some countries. If this is the case, then it follows that is more relevant to assess the relationship between educational system and shadow economy.

The purpose of this study consists in establishing an empirical relationship between shadow economy and educational system. In particular, we investigate the impact of the general education versus vocational education on the size of shadow economy in

[54] Buehn and Schneider (2012a) define the informal sector as all market-based legal production of good and services that escape inclusion in official account. As discussed in Dell'anno (2016), based on this definition, the informal, shadow, hidden, unofficial are often used synonymously with terms such as economy, market or GDP.

30 African over the period 2000-15. Our findings indicate that shadow economy has been higher in countries where educational system is focused on general programs. In addition, we find that vocational education negatively affects the size of the shadow economy, suggesting that vocational education enhances students' opportunities of finding gainful employment in the formal sector. We also find that shadow economy in Africa is related to financial development, public investment as well as demographic dividend, which is a reflection of growth potential generated by the youth bulge. In terms of public implications, our findings draw attention to the need for a more balanced educational system between general and vocational education in order to reduce the size of the shadow economy in Africa.

The remainder of the paper proceeds as follows. Section 2 provides a review of related literature. Section 3 describes data and empirical approach. The results are reported in Section 4, and Section 6 discusses the robustness checks. The final section concludes.

3.2. Literature review

The literature identifies several factors explaining informality. Their relative weights vary according to the features of each country. Referring to several studies, tax and social security contribution burdens are one of the main factors of the underground economy (e.g. Schneider and Enste, 2000; Djankov et al., 2010; Schneider et al., 2010; Goel and Nelson, 2016; Mitra, 2017). For instance, Schneider et al. (2010) point out that the incentive to work in the informal sector depends on the difference between the cost of labour in the official sector and the after-tax income from work. The wider the gap is, the more economic agents will prefer to shift to the informal sector and avoid the formal one. Some studies also single out the institutional framework (bureaucracy, rule of law, corruption, political environment and legal system) as a key factor of the shadow economy (e.g. Dabla-Norris et al., 2008; Dreher et al., 2009; Buehn and Schneider, 2012b; Buehn et al., 2013; Goel and Saunoris, 2014a,b; Elbahnasawy et al., 2016). Dreher et al. (2009) investigated the relationship between unofficial economy and institutional framework. More precisely, they have shown that an improvement in the institutional

quality reduces the shadow economy and impacts the corruption market.[55] In addition, Globalization[56] is also considered as a mitigating factor of the volume of the informal sector. In this respect, Schneider and Enste (2000) argue that policies aimed to promote greater economic integration, such as eliminating trade restrictions may generate incentives for economic agents to migrate from the informal to the formal sector. More recently, Berdiev and Saunoris (2018) found out that globalization has a significant influence in reducing shadow economy. In particular, they demonstrated that political globalization (such as the dissemination of sound government policies, policies to fight corruption, etc.) has a much greater weight than economic and social aspects of globalization.[57] Moreover, economic conditions play a crucial role in giving incentives to economic agents to work, or disincentives not to, in the underground economy. For instance, in periods of economic boom individuals and firms can easily migrate from the informal to the formal sector to seize the opportunities offered by the formal sector. In periods of recession, many economic agents try to compensate their income losses from the formal sector through informal activities (Schneider, 2005). La porta and Shleifer (2014) also highlight that the more a country develops the smaller of the informal sector size. Other studies have also shown that an improvement in the development of the financial sector is associated with a smaller informal sector (e.g. Blackburn et al., 2012; Bose et al., 2012; Capasso and Jappelli, 2013 and, Berdiev and Saunoris, 2016).

The studies focusing on the relationship between shadow economy and the human capital are scarce. Buehn and Farzanegan (2013) examined the effect of education on the informal sector for more than 80 countries from 1999 to 2007. The authors found that higher levels of participation in education tend to lower informality activities only in an environment characterized by institutional framework of high quality. On this part, Berrittella (2015) looked at the impact of public education spending on shadow

[55] See also Choi and Thum (2005), Dreher and Schneider (2010), Cooray et al. (2017).
[56] Globalization is a generic term used to describe social, economic (trade and financial), cultural, environmental and political globalization aspects.
[57] See also Elgin (2013) and Pham (2017).

economy using a cross-country analysis. The results show that public policies which increase expenditure on education reduce the size of the shadow economy. To the best of our knowledge, there are no studies on the relationship between informality and education in Africa. This paper aims to contribute to this issue by analysing the impact of secondary education - especially educational systems, on shadow economy in Africa.

3.3. Methodology

3.3.1. Data

The purpose of our study is to examine the relationship between education and informal economy in Africa over the period 2000-15. The study covers 30 African countries.[58] To this end, we use three educational variables: secondary education, vocational education and general education. Data on education are drawn from the UNESCO-education database. Secondary education refers to the number of individuals enrolled in secondary education programs, regardless of age, divided by the population of the age group that officially corresponds to the same level. General education is measured as a percentage of students in secondary education enrolled in general programmes. This is an educational system designed to develop learners' general knowledge, without necessarily preparing them for a particular job or profession. Vocational education is measured as a percentage of students in secondary education enrolled in vocational programmes, which refers to an education designed for learners to acquire the knowledge, abilities and competencies specific to a particular profession or class of occupations or trade. Based on Glewwe and Kremer (2006) as well as Buehn and Farzanegan (2013), we prefer to focus our analysis on secondary education because it is more appropriate than tertiary education in developing countries. In particular, the population covered by secondary education is larger than that covered by tertiary education.[59] These two variables can therefore be interpreted

[58] Our initial sample covers 47 countries. 17 countries were excluded from our sample mainly due to the poor quality of education data

[59] There are also data challenges for tertiary education.

as a decomposition of secondary education. Table 3.A1 (in appendices) provides information for the sample countries. The average secondary school enrolment represents 45% over the period 2000-2015. The best-performing countries in this field are South Africa with an average enrolment rate of 91%, Mauritius (88%) and Cape Verde (86%). The worst performing are Mozambique (20%), Chad (19%) and Niger (12%). The data also show that education systems in Africa are mainly oriented towards general education. The average share of general programmes in the secondary education is 93% as opposed to 7% for vocational programmes.

The estimation of the size of the informal sector remains a source of controversies within the academic literature. This is mainly due to the difficulty in providing a clear definition of the informal sector as well as the lack of a proper approach to measure it. However, several studies have attempted to estimate its size, including Medina and Schneider (2018), Buehn and Schneider (2012b), Elgin and Öztunali (2012) and Alm and Embaye (2013). In this paper, we adopt the approach suggested by Medina and Schneider (2018), and Buehn and Schneider (2012b), which define the informal sector as an all market-based legal production of good and services that escapes inclusion in the official account. This definition is also adopted by Elgin and Öztunali (2012) but differs from one by Alm and Embaye (2013) who include illegal production in their definition of the informal sector. The estimates of the size of the informal economy as a percentage of GDP are collected from Medina and Schneider (2018). These estimates are derived from a Multiple Indicators, Multiple Causes (MIMIC) approach. The MIMIC model, which is a particular type of strucutural equation model (SEM), consists in using associations between different observable causes and impacts of an observed variable (shadow economy in the present case), to estimate the variable itself. Based on these estimates, within our sample of 30 African countries, covering the period 2000-15, the average size of the informal economy as a percentage of the GDP is 35%, with slight disparities between regions (39% in West Africa, 35% in East Africa, 34% in Central Africa, 33% in Southern Africa and 31% in North Africa).

3.3.2. Empirical approach

In order to examine the impact of education (and education systems) on the shadow economy, we estimate the following model:

$$\boldsymbol{shadow_{it}} = \boldsymbol{\alpha_0} + \boldsymbol{\alpha_1 Educ_{it}} + \boldsymbol{\beta X_{it}} + \boldsymbol{\alpha_i} + \boldsymbol{\alpha_t} + \boldsymbol{\varepsilon_{it}} \quad (3.1)$$

where the subscripts denote the country i and the time period t. α_i denotes country fixed effects and α_t time fixed effects. The dependent variable ($shadow_{it}$) is the shadow economy expressed as a percentage of GDP. $Educ_{it}$ denotes our three interest variables, namely secondary education, vocational education and general education. X_{it} is a vector of control variables including financial development, public investment, GDP per capita, institutional framework, social globalization index, demographic dividend, total tax rate.[60] Summary statistics are reported in Table 3.1.

Table 3.1: Summary statistics for the regression variables

Variable	Unit	Obs.	Mean	Std. Dev.	min	max
Shadow economy	Percentage	357	34	6.67	19.2	55.5
Secondary education	Percentage	357	44.75	26.17	6.11	102.75
Vocational education	Percentage	357	7.28	7.38	0.00	45.23
General education	Percentage	357	92.72	7.38	54.77	100.00
Financial development	Percentage	357	24.74	21.96	1.97	106.26
Public investment	Percentage	357	22.59	7.88	3.95	59.72
GDP per capita	Logarithm	357	7.04	1.02	5.39	9.16
Institution	Index	357	0.61	0.29	0.05	1.00
Social globalization	index	357	40.58	14.01	15.86	73.30
Demographic dividend	Percentage	357	55.96	6.20	47.24	70.78
Total tax rate	Percentage	245	47.56	18.15	13.6	94.7

Notes: The sample period runs from 2000 to 2015. "Unit" denotes the measurement units of the regression variable. "Obs." denotes the number of observations for the respective variable. The last four columns show the mean, standard deviation, minimum and maximum.

[60] Data come from three databases including World Bank database (WDI), Polity4 and KOF Swiss Economic Institute.

As mentioned above, the choice to operate in the informal sector is driven by a wide of economic, financial and institutional motives. Low financial development (credit to private sector) and in particular poor access to credit may favour remaining in the informal sector (Blackburn et al., 2012; Bose et al., 2012). The attractiveness of the shadow economy may also influence by economic prosperity (GDP per capita) and the opportunities it creates in the formal sector (Schneider and Enste, 2000; La Porta and Shleifer, 2014; Goel and Nelson, 2016). Openness to social globalization (Pham, 2017; Berdiev and Saunoris, 2018), as well as institutional framework (Dabla-Norris et al., 2008; Dreher et al., 2009; Goel and Saunoris, 2014a) may also drive the appetite for formal activities over informal one. Moreover, tax burden (total tax rate in percentage of profit) is also considered as one of the main motives for firms move to the underground sector (Goel and Nelson, 2016).

First, we estimate this model using the Ordinary Least Squares (OLS). However, this approach raises an important issue – that of endogeneity. This endogeneity problem may arise because education depends upon some macroeconomic factors, which if not included in the model, would induce a correlation between education and the error term. In addition, a wide informal sector can also be interpreted as a reflection of a failing education system. This is a case of reverse causality. To deal with such an issue, we use a Two-Stage Least Squares (2SLS) estimation strategy. The lagged values (1 to 3 year) of education indicators are used as instruments (Buehn and Farzanegan. 2013).

3.4. Empirical results

As mentioned above, we first estimated our model using OLS. The regression results are reported in Table 3.2. These results show that secondary education enrollment in Africa positively affects the size of the informal sector (column 1 in Table 3.2). We then proceed to assessment effect of the educational system (column 2 and 3 in Table 3.2). The results highlight the opposite effect of education system on the size of informal economy. In particular, vocational education is associated with a lower size of informal

sector, while general education is coupled with higher informal activities. The significant control variables have the signs expected in the literature.

In views of the limitations of the OLS estimation strategy (omitted variable bias, reverse causality and measurement error), we prefer to lean on the results from the instrumental variables estimation approach (2SLS). Table 3.3 presents the results obtained by using 2SLS estimation. We proceed through the same steps as before and reached to the similar findings.

Secondary education in Africa is significantly (at 1% level) associated with a larger size of informal activities. The 2SLS method also confirms the opposite effect of secondary education on shadow economy depending on the educational system preferred by the country. Vocational (general) oriented education system negatively (positively) affects the size of the informal sector. The positive effect of secondary education on the informal sector therefore could be explained by the pre-eminence of general education over vocational education. This finding highlights the mismatch between the needs of the private sector in skilled workers and what the educational system offers in some countries. African economies would do well to balance their education systems through the promotion of vocational education, which, as our results show (columns 9 and 10, Table 3.3), helps reduce the size of the informal sector.

All our significant control variables have the signs expected in literature. Financial development negatively impacts the spread of informal activities. This result confirms the role played by financial institutions in the process of business formalization. Informal activities are, by definition, associated with the lack of transparency. However, in order to qualify for a loan, firms or individuals must necessarily disclose information about their assets or income (Bose et al, 2012; Capasso and Jappelli, 2013).

Table 3.2: Results for the baseline model

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS					
Secondary education	0.057**	0.103***				
	(0.025)	(0.032)				
Vocational program			-0.080**	-0.105**		
			(0.034)	(0.044)		
General program					0.080**	0.105**
					(0.034)	(0.044)
Financial development	-0.071***	-0.078***	-0.063***	-0.078***	-0.063***	-0.078***
	(0.017)	(0.024)	(0.018)	(0.024)	(0.018)	(0.024)
Public investment	-0.072***	-0.133***	-0.097***	-0.175***	-0.097***	-0.175***
	(0.027)	(0.033)	(0.028)	(0.035)	(0.028)	(0.035)
GDP per capita	-2.435***	-3.619***	-1.517***	-2.104***	-1.517***	-2.104***
	(0.595)	(0.647)	(0.484)	(0.539)	(0.484)	(0.539)
Institutions	-1.640	-3.028**	-1.175	-1.495	-1.175	-1.495
	(0.996)	(1.240)	(0.933)	(1.119)	(0.933)	(1.119)
Social globalization	0.007	0.118**	-0.029	0.077	-0.029	0.077
	(0.042)	(0.059)	(0.043)	(0.061)	(0.043)	(0.061)
Demographic dividend	-0.342***	-0.443***	-0.200**	-0.197*	-0.200**	-0.197*
	(0.103)	(0.133)	(0.086)	(0.106)	(0.086)	(0.106)
Total tax rate		0.019***		0.024***		0.024***
		(0.005)		(0.007)		(0.007)
Constant	76.00***	81.97***	65.86***	63.69***	57.85***	53.15***
	(5.948)	(7.298)	(3.947)	(4.534)	(5.320)	(6.689)
Time fixed effects	YES	YES	YES	YES	YES	YES
Obs.	357	245	357	245	357	245
Number of Countries	30	30	30	30	30	30
R^2	0.529	0.545	0.529	0.537	0.529	0.537
Adj. R^2	0.498	0.509	0.497	0.500	0.497	0.500

Notes: The sample goes from 2000 to 2015. Robust standard errors are reported in brackets. (***, **, *) indicate statistical significance at the 1 %, 5 % and 10 % level.

Both public investment and institutional framework[61] also play a role in reducing the informal sector in Africa. Both variables are significant at 1% level. In particular, the results indicate that improvement in the quality of political institutions is accompanied by a decrease in the size of the informal sector. Corruption market is weak in this context. Policy makers also seem more willing to implement reforms or regulations in favour of private sector development. Tax rate is significant and positively impacts

[61] We use Polity2 index as an indicator of institutional framework. This index measures the quality of political institutions and runs from -10 (full dictatorship) to 10 (full democracy). This index is used in a re-scaled form from 0 to 1.

informality at 1 % level. This suggests higher taxes promote the spread of the shadow economy.

Finally, we examine the effect of demographic dividend on shadow economy. We measure demographic dividend by the proportion of adults aged 15 to 64 as a percentage of the total of population. It corresponds on average to 56%, ranging from 47 to 71% over the period 2000-15. This variable allows us to capture the growth potential generated by changing the age structure of a country. This growth potential is due to the strong representativeness of the young population. It can also be interpreted as the availability of workforce. According to our results, demographic dividend negatively impacts informal economy in Africa. Young and dynamic, the African population, in addition to being an available labour force, represents an opportunity to be seized in view of the economic potential that characterizes it.

Table 3.3: Instrumental variables

	(7)	(8)	(9)	(10)	(11)	(12)
	2SLS					
Secondary education	0.082***	0.147***				
	(0.027)	(0.031)				
Vocational program			-0.111**	-0.137**		
			(0.056)	(0.070)		
General program					0.111**	0.137**
					(0.056)	(0.070)
Financial development	-0.040**	-0.045**	-0.038**	-0.048**	-0.038**	-0.048**
	(0.016)	(0.020)	(0.017)	(0.020)	(0.017)	(0.020)
Public investment	-0.074***	-0.102***	-0.094***	-0.133***	-0.094***	-0.133***
	(0.026)	(0.028)	(0.026)	(0.032)	(0.026)	(0.032)
GDP per capita	-3.002***	-4.082***	-1.902***	-2.518***	-1.902***	-2.518***
	(0.705)	(0.685)	(0.550)	(0.558)	(0.550)	(0.558)
Institution	-3.860***	-5.729***	-3.877***	-4.623***	-3.877***	-4.623***
	(1.057)	(1.203)	(0.878)	(1.030)	(0.878)	(1.030)
Social globalization	0.010	0.100*	0.014	0.104*	0.014	0.104*
	(0.043)	(0.055)	(0.042)	(0.058)	(0.042)	(0.058)
Demographic dividend	-0.458***	-0.594***	-0.291***	-0.247**	-0.291***	-0.247**
	(0.089)	(0.102)	(0.085)	(0.101)	(0.085)	(0.101)
Total tax rate		0.017***		0.018**		0.018**
		(0.007)		(0.009)		(0.009)
Constant	86.41***	92.39***	72.81***	69.18***	61.66***	55.49***
	(5.862)	(6.006)	(3.504)	(3.565)	(7.026)	(8.421)
Time fixed effects	YES	YES	YES	YES	YES	YES
Obs.	266	190	246	181	246	181
Number of countries	30	30	30	30	30	30
(Centered) R^2	0.616	0.655	0.650	0.653	0.650	0.653
Over id. test: Hansen J test	0.764	3.088	0.336	1.411	0.336	1.411
Hansen J test (p-value)	0.683	0.214	0.845	0.494	0.845	0.494
Under id. test (p-value)	0.000	0.000	0.000	0.000	0.000	0.000

Notes: The sample goes from 2000 to 2015. Robust standard errors are reported in brackets. (***, **, *) indicate statistical significance at the 1 %, 5 % and 10 % level. The Hansen test evaluates the joint validity of instruments used. The under-identification test by Kleibergen and Paap (2006) indicates whether the equation is identified (i.e., that the instruments are correlated with the endogenous variable).

3.5. Robustness checks

In this section, we discuss the tests applied to assess further robustness of our regression results. To test whether the results are sensitive to the choice of control variables, we use alternative control variable including financial constraint indicator and government size. We use lending rate as a measure of financial access in order to

capture the effect of firm's external financing constraint.[62] This is another aspect of financial development. A well-developed financial sector is usually associated with low external financing constraints (Beck and Demirguc-Kunt, 2006). We therefore expect a positive relationship between shadow economy and financial access. Government size index[63] captures changes in government spending and taxation. It used in the literature as a tax burden indicator (Schneider et al., 2010). In addition, it measures the crowding out effect of government decision-making on individual choices and economic freedom.

The results of robustness test are reported in Table 3.4. Our results remain valid in each specification used (columns 13 to 18, Table 3.4). The financial constraint indicator and government size positively affect shadow economy, confirming the above-mentioned adverse effects.

We also test whether our results are sensitive to the measure of the informal sector. For this purpose, we use the shadow economy estimates stem from the currency demand approach of Alm and Embaye (2013). In addition, since GDP is potentially correlated with the informal sector measure and school attainment, we run a set of regressions without GDP as a control variable. The results are reported in Table 3.A2 (in appendices). We reach to the same findings as before.

[62] Data are collected from a World Bank database (WDI).

[63] Data come from Fraser Institute.

Table 3.4: Robustness checks (1)

	(13)	(14)	(15)	(16)	(17)	(18)
	2SLS					
Secondary education	0.056**	0.086***				
	(0.025)	(0.023)				
Vocational program			-0.089*	-0.064*		
			(0.053)	(0.034)		
General program					0.089*	0.064*
					(0.053)	(0.034)
Financial development	-0.058***		-0.052***		-0.052***	
	(0.016)		(0.020)		(0.020)	
Public investment	-0.045	0.013	-0.100***	-0.004	-0.100***	-0.004
	(0.029)	(0.032)	(0.036)	(0.033)	(0.036)	(0.033)
GDP per capita	-1.760**	-1.275***	-0.405	0.005	-0.405	0.005
	(0.792)	(0.394)	(0.665)	(0.348)	(0.665)	(0.348)
Institution	-1.060	-6.632***	-1.167	-5.743***	-1.167	-5.743***
	(1.630)	(1.017)	(1.619)	(0.976)	(1.619)	(0.976)
Social globalization	-0.122**	-0.090**	-0.174***	-0.060	-0.174***	-0.060
	(0.053)	(0.045)	(0.061)	(0.051)	(0.061)	(0.051)
Demographic dividend	-0.289**	-0.676***	-0.130	-0.562***	-0.130	-0.562***
	(0.124)	(0.074)	(0.142)	(0.087)	(0.142)	(0.087)
Government size	0.807***		0.877***		0.877***	
	(0.212)		(0.232)		(0.232)	
Financial constraint		0.084***		0.097***		0.097***
		(0.016)		(0.019)		(0.019)
Constant	62.00***	80.54***	46.38***	67.93***	37.52***	61.53***
	(6.823)	(4.115)	(5.643)	(3.993)	(7.731)	(5.936)
Time Fixed Effects	Yes	Yes	No	Yes	No	Yes
Regional Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
Obs.	273	218	221	202	221	202
Number of countries	30	30	30	30	30	30
(Centered) R^2	0.681	0.780	0.672	0.784	0.672	0.784
Over id. test: Hansen J-test	0.237	0.098	1.695	1.164	1.695	1.164
Hansen J-test (p-value)	0.626	0.754	0.429	0.281	0.429	0.281
Under id. test (p-value)	0.000	0.000	0.000	0.000	0.000	0.000

Notes: The sample goes from 2000 to 2015. Robust standard errors are reported in brackets. (***, **, *) indicate significance at the 1%, 5% and 10% level. The Hansen test evaluates the joint validity of instruments used. The under-identification test by Kleibergen and Paap (2006) indicates whether is identified (i.e., that the instruments are correlated with the endogenous variable).

3.6. Conclusion and policy implications

This paper has empirically examined the impacts of secondary education – disaggregated into vocational and general education, on the size of the informal sector in African countries. This question is more relevant in view of the demographic challenges facing African economies in the future. Furthermore, studies focusing on the relationship between education and shadow economy are scarce.

Using data from a sample of 30 countries over the period 2000-15, we find evidence that shadow economy has been higher in countries where the educational system is focused on general educational programs. This finding highlights the mismatch between the needs of the private sector in skilled workers and what educational systems offer in some countries. In addition, we find that vocational education negatively affects the size of shadow economy, suggesting that vocational education enhances students' opportunities of finding gainful and qualified employment in formal sector. We also find that shadow economy in Africa is also related to financial development, public investment as well as demographic dividend.

In terms of public implications, our findings point to the need for a balanced educational system between general and vocational education in order to reduce the size of the shadow economy in Africa. An increase in public investment as well as public awareness would be required in view of apprehensions usually expressed about the vocational education. Considering the challenges ahead (e.g. strong demographic growth, digitalization of the economy, climate shocks, etc.), African countries should rethink their educational systems. Educational systems should be focused on professions of the future and not on those of the past. Furthermore, educational systems should be able to offer appropriate vocational training opportunities that match the demand for skilled employment in the formal sector. A well-educated population will always know how to turn challenges into opportunities. It will also be able to cope with the rapid changes in the world.

3.7. Appendix: Tables

Table 3.A1: List of countries

Country	Shadow economy (% of GDP)	Secondary education	General education	Vocational education
Algeria	27.82	79.20	90.97	9.03
Angola	41.13	19.87	67.37	32.63
Benin	51.05	38.59	93.81	6.19
Botswana	30.23	79.51	93.93	6.07
Burkina Faso	35.48	19.68	94.06	5.94
Burundi	37.96	22.00	93.78	6.22
Cameroon	30.95	40.05	80.17	19.83
Cape Verde	29.87	86.37	97.24	2.76
Chad	36.63	18.72	98.47	1.53
Congo. Dem. Rep.	44.85	42.10	80.99	19.01
Egypt	34.05	78.93	75.17	24.83
Eritrea	40.91	30.80	99.15	0.85
Ghana	41.32	46.46	97.67	2.33
Guinea	38.51	22.82	98.68	1.32
Kenya	34.01	47.56	99.28	0.72
Lesotho	28.55	49.79	96.87	3.13
Madagascar	42.94	31.59	97.05	2.95
Malawi	37.62	31.55	100.00	0.00
Mali	35.73	32.70	88.23	11.77
Mauritania	28.64	21.85	97.92	2.08
Mauritius	21.14	88.43	88.98	11.02
Morocco	32.47	53.20	93.99	6.01
Mozambique	33.89	19.64	92.28	7.72
Niger	38.94	11.82	96.05	3.95
Rwanda	33.71	24.98	82.60	17.40
Senegal	39.02	31.76	96.44	3.56
South Africa	24.11	91.44	94.47	5.53
Swaziland	38.41	52.89	99.71	0.29
Togo	37.24	42.25	93.86	6.14
Tunisia	32.92	85.51	91.46	8.54
Average	**35.00**	**44.75**	**92.72**	**7.28**

Notes: This table provides information for the sample countries. Data are expressed as average over the period 2000-15.

Sources: Medina and Schneider (2018), UNESCO-education database and authors' calculations.

Table 3.A2: Robustness checks (2)

	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)
	2SLS			2SLS					
	Medina and Schneider (2018) database			Alm and Embaye (2013) database					
Secondary education	0.038*			0.158**			0.147**		
	(0.021)			(0.077)			(0.073)		
Vocational education		-0.090***			-0.237**				-0.242**
		(0.034)			(0.115)				(0.094)
General education			0.090***			0.237**		0.242**	
			(0.034)			(0.115)		(0.094)	
Control variables	YES	YES	YES	YES	YES	YES	YES	YES	YES
Without GDP	YES	YES	YES	YES	YES	YES	NO	NO	NO
Obs.	300	285	285	80	73	73	80	73	73
Number of countries.	30	30	30	16	16	16	16	16	16
(Centered) R^2	0.680	0.660	0.660	0.477	0.531	0.531	0.217	0.418	0.418
Over id test: Hansen J-test	0.009	0.339	0.339	0.604	0.597	0.597	0.118	0.414	0.414
Hansen J-test (p-value)	0.922	0.560	0.560	0.437	0.440	0.440	0.731	0.520	0.520
Under id test (p-value)	0.000	0.000	0.000	0.000	0.005	0.005	0.000	0.002	0.002

Notes: The sample goes from 2000 to 2015 for the Medina and Schneider (2018) database, and from 2000 to 2006 for the Alm and Embaye (2013) databases. Robust standard errors are reported in brackets. Unreported constant included. Time and regional fixed effects are included. (***, **, *) indicate significance at the 1%, 5% and 10% level. The Hansen test evaluates the joint validity of instruments used. The under-identification test by Kleibergen and Paap (2006) indicates whether the equation is identified (i.e., that the instruments are correlated with the endogenous variable).

Chapter 4

What Causes Natural Disasters? The Role of Weather, Policies and Climate Change[64]

[64] *This chapter is a preliminary version of an ongoing research project with S. Acevedo.*

Abstract

We use monthly data in 181 countries over the period 1990-2014 to investigate the main factors that determine the incidence of different types of natural disasters. Our results confirm the significant role played by weather patterns in the occurrence of natural disasters, and the intensification of disasters in a warming world. We also find that the incidence of disasters is related to the economic development process, the macroeconomic environment, as well as institutions. In particular, better living standards, access to credit and a good institutional framework reduce the occurrence of natural disasters caused by droughts, epidemics, floods and landslides. In contrast, urbanization, land degradation, and armed conflicts increase the probability of most disaster types. By identifying the main determinants of natural disasters, our paper will help countries implement public policies to build resilience to natural disasters and climate change.

Keywords: Natural disasters, Climate change, Public policies, Resilience

JEL classification: O50, Q54, Q56, Q58

4.1. Introduction

Between 1990 and 2014, the world experienced more than 9 000 natural disasters, killing 1.8 million people and disrupting the lives of over 5 billion more.[65] The economic cost to developed and developing countries is large; $2.8 trillion (2010 constant US$) in damages were caused by disasters over this period. The upsurge in extreme weather events has given rise to a sizeable academic literature mainly looking at the economic implications of natural disasters (Skidmore and Toya, 2002; Noy, 2009. Dell et al., 2012; Loayza et al., 2012; Strobl, 2012; Cavallo et al., 2013; Fomby et al., 2013; Felbermayr and Gröschl, 2014; Mohan et al., 2018; Acevedo et al., 2018; among others).[66] The economic impact of natural disasters is not clear enough. While the vast majority of papers find that natural disasters negatively affect economic growth and several productive elements, some suggest a positive impact (Skidmore and Toya, 2002; Loayza et al., 2012). [67] For Loayza et al. (2012); the natural disasters' effect may differ across sectors (also see Mohan et al., 2018).

Surprisingly, little attention has been paid to addressing the determinants of natural disasters. In other words, what causes a natural hazard to become a natural disaster? Before proceeding further, it is useful to make a distinction between natural hazard and natural disaster. Earthquakes or heavy rains are not considered natural disasters themselves, but natural hazards. For example, if an earthquake hits a deserted island, it will not be considered a natural disaster but a natural hazard due to the absence of people and material assets. If, on the other hand, the same earthquake occurs in an inhabited area and verifies at least one of the four criteria mentioned above, the event will be considered a natural disaster. As the figure (4.1) illustrates, there are three

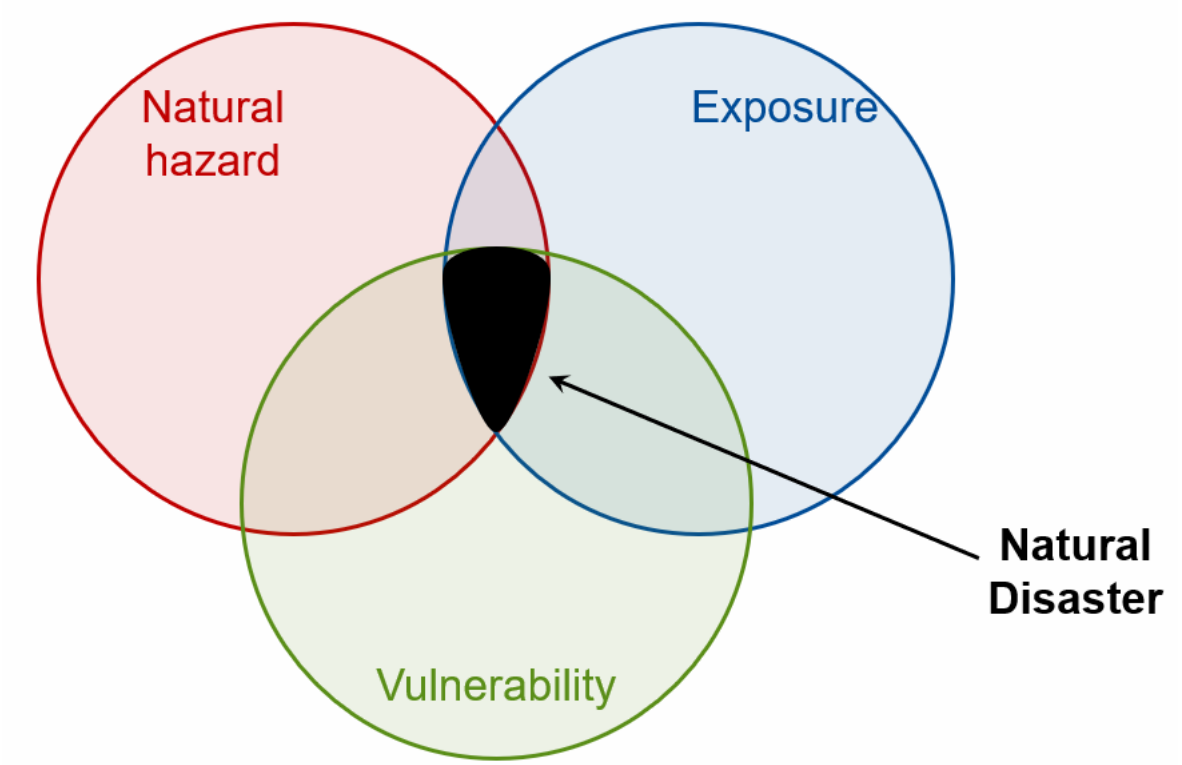
[65] EM-DAT (Guha-Sapir et al., 2015) defines a natural disaster as an event in which at least one of the following criteria is met: i) 10 or more people reported killed, ii) 100 or more people reported affected, or iii) a declaration of a state of emergency, or a call for international assistance is made.

[66] Also see Klomp (2014, 2018), Keerthiratne and Tol (2017), Brei et al. (2019), Albuquerque and Rajhi (2019) for the impact of natural disasters on financial sector; Carter et al. (2007), Rentschler (2013), Keerthiratne and Tol (2018), Warr and Aung (2019) on poverty and inequality; or Lis and Nickel (2010), Ouattara and Strobl (2013), Klomp (2017) for fiscal implications of natural disasters.

[67] For more details, see the meta-analyses of Klomp and Valckx (2014), and Lazzaroni and Bergeijk (2014).

ingredients for natural disasters to strike (Peduzzi et al., 2009): natural hazard, exposure and vulnerability.

Figure 4.1: Three key ingredients for natural disasters to strike



Source: Authors.

With global warming, the occurrence and intensity of natural disasters are likely to increase (IPCC, 2018),[68] leading to more damages, fatalities, and macroeconomic instability. Resilience to disasters has consequently become a prominent issue that concerns policymakers in every country. Yet, in order to effectively build resilience, what is needed is an in-depth knowledge of the factors that cause natural disasters.

The objective of this paper is therefore to investigate the main factors that determine the incidence of different types of natural disasters. Which economic and structural factors increase or reduce exposure and/or vulnerability to natural hazards, in addition to weather conditions? Thomas and López (2015) were the first to address this issue. The authors find that population density and people's vulnerability (measured by low

[68] The Intergovernmental Panel on Climate Change (IPCC).

GDP per capita) are positively associated to the frequency some natural disasters (floods, storms, heat waves). They also show that the incidence of natural disasters is related to weather patterns.

In the present paper, we provide new evidence on the role of weather, policies and climate change on the frequency of natural disasters. Using data from 181 countries over the period 1990-2014, we show that the incidence of natural disasters is related to weather conditions, economic development, macroeconomic environment, living standards, as well as institutions. In particular, better living standards, access to credit and good institutions reduce the frequency of natural disasters induced by droughts, epidemics, floods and landslides. However, urbanization, land degradation, and armed conflicts increase the occurrence of most disaster types. We also find that flood-induced disasters will decrease in some countries, while the likelihood of epidemics and tropical cyclones will increase with climate change.

Unlike previous studies, our analysis is more granular; we use monthly data, and examine key determinants for different disaster types. One drawback of Thomas and López (2015)'s paper is that they used an aggregated approach by focusing only on the annual frequency of some disasters classified into two groups: hydrometeorological (floods, storms, heat waves) and climatological (droughts, wildfires) disasters.[69] Such approach implies that the effect of a factor does not differ when disasters belong to the same group. However, this is not the case since, for instance, weather conditions differently affect the probability of floods and heat waves. Disaggregated analysis is therefore more relevant to identify and interpret the complex role of weather conditions, economic and structural factors, as well as climate change, on the likelihood of different disaster types.

[69] Natural disasters are usually classified into five main groups, i.e. biological (epidemic, insect infestation, animal accident), climatological (drought, wildfire), hydrological (flood, landslide, wave action), geophysical (earthquake, mass movement, volcanic activity) and meteorological (extreme temperature, fog, storm) disasters.

The paper proceeds as follows. Section 2 describe data and the empirical approach. Section 3 discusses the results. Finally, Section 4 concludes summarizing the main findings and policy implications.

4.2. Data and methodology

4.2.1. Data

Our dataset covers 181 countries over the period 1990-2014. Countries and groups are listed in Annex Table 4.A1. The monthly data on natural disasters come from the International Disaster Database (EM-DAT) provided by the Centre for Research on the Epidemiology of Disasters (CRED). The EM-DAT database's coverage is global and contains data on the occurrence of natural disasters from 1900 to present.[70] The data are compiled from various sources, including UN agencies, NGOs, insurance companies, research institutes and press agencies (Guha-Sapir et al., 2015).

CRED defines a natural disaster as an event triggered by natural hazards, often sudden and unforeseen, that causes great damage, destruction and human suffering. For a disaster to be documented in the EM-DAT database at least one of the following criteria must be fulfilled: i) ten or more people reported killed; ii) hundred or more reported affected; iii) declaration of a state of emergency; or iv) call for international assistance.

Our study only focuses on nine types of natural disasters, namely drought, earthquake, epidemic, flood, landslide, wildfire, heat wave, tropical cyclone and other storms (primarily winter storms). Infrequent natural disasters such as insect infestation, animal accident or mass movement were excluded from the analysis, as well as volcanic activity and cold waves.[71]

[70] We only use data after 1990 because there is some evidence that disaster might be underreported in the earlier period. EM-DAT only started to systematically record disasters in 1998; Acevedo (2016) discusses the likely underreported of disasters caused tropical cyclones in the Caribbean.

[71] As we will see later, cold waves will no longer be relevant in the future in the context of rising temperatures. There are also any significant results for volcanic activity. More details and tables are available upon request.

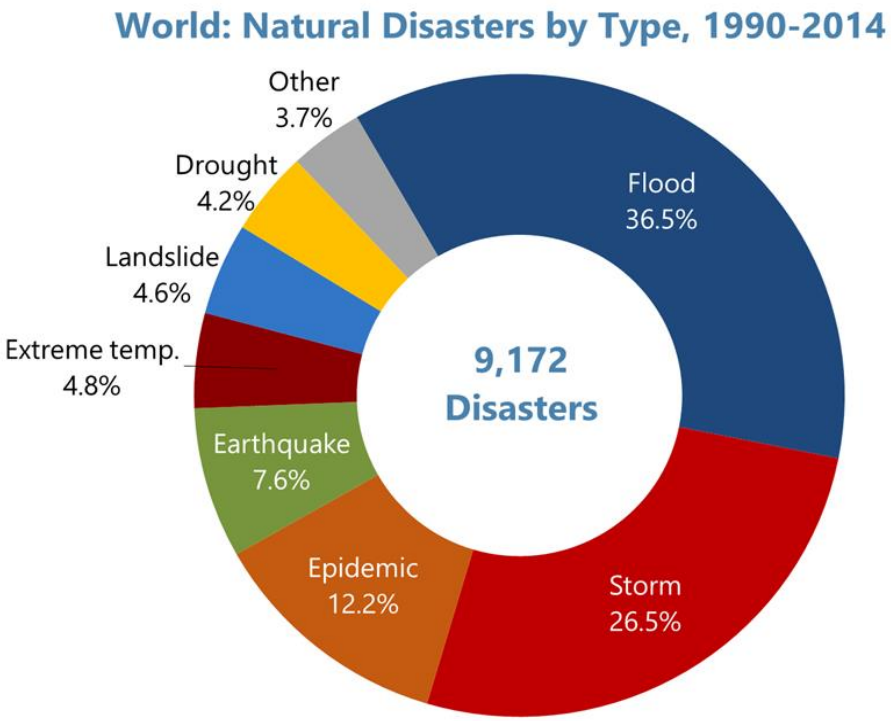
Data on precipitation and temperature are collected from the University of Anglia's Climate Research Unit (CRU Timeseries, 1901-2015). The temperature and precipitation series are constructed by aggregating grid cell data at 0.5×0.5 degree resolution (approximately 56 kilometers × 56 kilometers at the equator) to the level of individual countries or subnational regions at annual and monthly frequency. Summary statistics of temperature and precipitation by type of disaster are described in Table 4.A2.

The main other data sources used are the IMF World Economy Outlook database and World Bank World Development Indicators database. All data sources used, and summary statistics are reported in Annex Table 4.A3.

4.2.2. A brief history of natural disasters

The world experienced on average 367 natural disasters per year since 1990 (Figure 4.2). Most of them are caused by floods (36.5 %), storms (26.5 %) and epidemics (12.2 %).

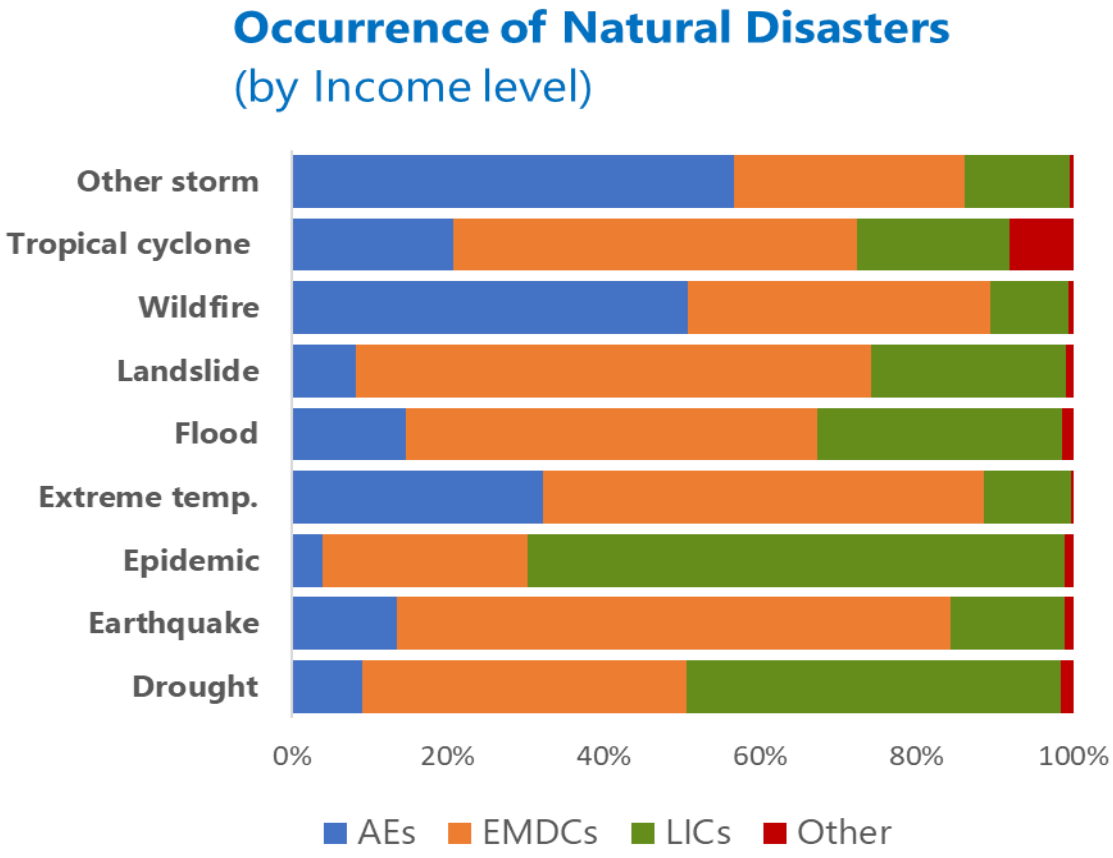
Figure 4.2



Source: EM-DAT, and authors' calculations.

Considering income level, most disasters took place in emerging and developing countries - EMDCs (47 %), and low-income countries - LICs (30 %), compared to 21 % in advanced economies (Figure 4.3). At regional level, disasters have hit the hardest East Asia and Pacific (26 %), and Sub-Saharan Africa (19 %). East Asian and Pacific countries are more exposed to disasters triggered by tropical cyclones, floods and landslides. As compared to the rest of the world, Sub-Saharan African countries have experienced more disasters induced by droughts and epidemics.

Figure 4.3:



Source: EM-DAT, and authors' calculations.

4.2.3. Methodology approach

The probability that a natural disaster takes place in country *i* in a given month *t* is estimated using a conditional fixed-effects model developed by Chamberlain (1980). The baseline model can be given as:

$$\boldsymbol{Pr[disaster_{it} = 1] = \alpha_i + \gamma_1 C_{it} + \gamma_2 GDP_{it-12} + \gamma_3 Pop_{it-12} + \varepsilon_{it}} \quad (4.1)$$

where our dependent variable takes the value one if a natural disaster occurs in country i during month t and zero otherwise. C_{it} is a vector of weather conditions variables, i.e. precipitation, temperature (linear and quadratic terms), and the weather anomalies over the preceding twelve months. The weather anomalies capture the cumulative deviation of temperature and precipitation with respect to its monthly average over the previous ten years. The weather variables allow us to take into account the natural hazard dimension of disasters. The specification also controls for the level of real GDP per capita ($\mathrm{GDP}_{\mathrm{it}-12}$) and population ($\mathrm{Pop}_{\mathrm{it}-12}$). Both variables capture the exposure and vulnerability of economies, respectively. The parameter α_i is a country-specific intercept to control for time-invariant unobserved characteristics like size and geographical factors. There is some evidence that the nearer a country is to the equator, the higher the probability of disaster occurrence is, due to their climate. In addition, landlocked countries are less subject to meteorological disasters, while earthquakes occur only in areas where tectonic plates collide (Kahn, 2005; Lis and Nickel, 2010; Kellenberg and Mobarak, 2011). The variables are lagged to address possible simultaneity and endogeneity issues. The final parameter ε_{it} represents the error term.

The baseline model will then be augmented individually by other exposure and vulnerability-related factors to disasters. The augmented model is thus specified as follows:

$$\boldsymbol{Pr}[\boldsymbol{disaster}_{\boldsymbol{it}} = \mathbf{1}] = \boldsymbol{\alpha}_{\boldsymbol{i}} + \boldsymbol{\gamma}_{\mathbf{1}}\boldsymbol{C}_{\boldsymbol{it}} + \boldsymbol{\gamma}_{\mathbf{2}}\boldsymbol{GDP}_{\boldsymbol{it}-\mathbf{12}} + \boldsymbol{\gamma}_{\mathbf{3}}\boldsymbol{Pop}_{\boldsymbol{it}-\mathbf{12}} + \boldsymbol{\beta}_{\boldsymbol{k}}\boldsymbol{X}_{\boldsymbol{it}-\mathbf{12}} + \boldsymbol{\varepsilon}_{\boldsymbol{it}} \quad (4.2)$$

where the vector X_{it-12} include other lagged explanatory variables to capture the role of economic and structural factors on the likelihood of natural disasters. These variables are related to domestic macroeconomic environment, urbanization, financial development, land degradation, living standards and institutional framework.

4.3. Determinants of natural disasters

4.3.1. Extreme weather and natural disasters

The baseline results are portrayed by Table 4.2. As the table shows, weather conditions have a very strong influence on the likelihood of various types of disaster. In particular, more precipitation increases the occurrence of disasters caused by floods, landslides, tropical cyclones, and other storms, but decreases the frequency of disasters induced by droughts, wildfires, and heat waves. The effects of temperature are also as expected, with higher temperatures leading to more disasters triggered by droughts, flood, wildfires, heat waves, and tropical cyclones, but reducing the probability of other storms. The results also indicate that weather conditions have non-linear effects on the probability of most disasters.

Moreover, the estimations suggest that the weather anomalies over the preceding 12 months also play an important role in the frequency of most types of disasters, except those induced by tropical cyclones. The formation of tropical cyclones is strongly influenced by short-term weather patterns. Epidemics, however, are not sensitive to short-term weather conditions, but respond to temperature deviations in the year before the event is triggered. For instance, changes in temperatures induced by El Niño Southern Oscillation (ENSO) event significantly increase malaria and cholera epidemics (Kovats et al., 2003). In particular, weather anomalies are lengthening the transmission seasons of mosquito-borne diseases such as malaria.[72] Overall, our results are similar to those of Acevedo et al. (2018).

Two proxies of vulnerability (real GDP per capita) and exposure (total population per country) are also included in the baseline model. GDP per capita allows us to capture in particular the extent to which economic development could help to better manage or mitigate the risks from disasters. As the results show, the probability of disasters caused by epidemics, floods, wildfires, heat waves, tropical cyclones, and other storms

[72] Also see Paz (2009) on the relationship between the cholera outbreaks in Africa and temperature variability.

is lower in rich economies than in poor countries. As a country develops, the more resources it has to improve access to water and sanitation, or implement vaccination programs to reduce risks from epidemics. The opportunities related to the economic development process, specifically in terms of jobs creation, can also reduce people's vulnerability to disasters. As documented by Kahn (2005), as well as Toya and Skidmore (2007), economic development can accordingly be considered as implicit insurance against the frequency of disasters. However, population growth increases exposure to several disasters (epidemics, floods and tropical cyclones). In particular, the spread of urban slums, as well as crowded living conditions resulting from demographic growth, accelerate the propagation of epidemics.

Table 4.1: Baseline model results, 1990-2014

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	**Drought**	**Earthquake**	**Epidemic**	**Flood**	**Landslide**	**Wildfire**	**Heat wave**	**Tropical cyclone**	**Other storms**
Precipitation	-0.002**	-0.003***	0.000	0.022***	0.018***	-0.023***	-0.008***	0.012***	0.011***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.003)	(0.001)	(0.001)
$Precipitation^2$	0.000***	0.000***	0.000	-0.000***	-0.000***	0.000***	0.000**	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Temperature	0.023***	0.023*	0.011	0.052***	-0.010	0.112***	0.281**	0.165***	-0.061***
	(0.009)	(0.012)	(0.009)	(0.007)	(0.014)	(0.015)	(0.143)	(0.030)	(0.007)
$Temperature^2$	-0.000	-0.001**	0.000	-0.001***	-0.000	0.001**	0.005	-0.002*	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.004)	(0.001)	(0.000)
Prec. Deviations (12 months)	-0.005***	0.000	-0.000	0.000***	0.001**	-0.001***	-0.003***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Temp. Deviations (12 months)	0.039***	0.008	0.023***	-0.010**	-0.016	0.023*	0.021	0.001	0.031***
	(0.005)	(0.010)	(0.005)	(0.004)	(0.014)	(0.013)	(0.016)	(0.009)	(0.007)
Log GDP per capita $_{t-12}$	0.008	0.031	-0.181***	-0.093***	-0.065	-0.122*	-0.292*	-0.136*	-0.204***
	(0.015)	(0.033)	(0.024)	(0.020)	(0.047)	(0.068)	(0.153)	(0.082)	(0.058)
Log Population $_{t-12}$	0.027	-0.122	1.766***	2.403***	0.445	0.475	1.014	1.369***	-0.354
	(0.166)	(0.462)	(0.145)	(0.166)	(0.502)	(0.638)	(0.984)	(0.366)	(0.378)
Observations	29,976	24,708	35,772	43,632	19,620	18,732	12,924	20,652	33,684
Number of countries	101	83	120	147	66	63	44	69	114
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variables are dummy variables that indicate when a disaster of each type takes place "1", and "0" otherwise. Robust standard errors are reported in brackets. (***, **, *) indicate statistical significance at the 1%, 5%, and 10% levels. Countries for which there is no disaster over the period were dropped from the estimates: there is no variation in the outcome; conditionnal fixed effects specification eliminates any variable that is time-invariant. This is the reason behind the difference with the number of countries in the initial sample, as well as the data availability issues for some variables.

The marginal effects, necessary to interpret change in the predicted probability of disaster when the regressors fluctuate, also yield some interesting insights (see Figure 4.A1).[73] We have decided to compare Sub-Saharan African countries to the rest of the world as it is one of the most vulnerable regions to extremes events. Therefore, under similar weather conditions, SSA is particularly vulnerable to droughts but the risk for floods is similar to the rest of the world. In addition, marginal effects charts also confirm that economic development reduces vulnerability to disasters, while population growth increases exposure. For instance, with the same demographic trend, the probability of epidemics is higher in SSA countries than in non-SSA countries.

4.3.2. The role of economic and structural factors

We now turn our attention to other economic and structural factors that may influence vulnerability and/or exposure to disasters. These include urbanization, macroeconomic environment, financial development, land degradation, living standards, and institutional framework (see Tables 4.3 and 4.4).

Urbanization

The urbanization rate is defined as the share of urban to total population. The impact of urban population on the probability of disaster is positive and significant for earthquakes, landslides and heat waves (Table 4.3). These findings suggest that the increasing concentration of population, as well as certain socioeconomic factors inherent in urban areas, considerably rise their vulnerability to natural hazards. Indeed, urbanization process is perceived as an essential factor in the risk of some disasters (Gencer, 2013; Milan and Creutzig, 2015). Accelerated and unplanned urbanization generally manifests itself in non-compliance with building standards and the use of inadequate building materials. This further increase vulnerability to natural disasters such as earthquake (Hossain et al., 2017). People migration from rural to urban areas can also lead to the expansion of unregulated settlements in landslide-prone areas.

[73] On this point, panel logit is preferred as it allows for the estimation of predicted and marginal effects accounting for the country fixed-effects.

Table 4.2: The Augmented models (1), 1990-2014

VARIABLES	(1) Drought	(2) Earthquake	(3) Epidemic	(4) Flood	(5) Landslide	(6) Wildfire	(7) Heat wave	(8) Tropical cyclone	(9) Other storms
Urban population $_{t-12}$	0.006	0.034***	0.000	0.005	0.028*	-0.005	0.087**	0.004	0.015
	(0.009)	(0.012)	(0.008)	(0.008)	(0.016)	(0.028)	(0.034)	(0.012)	(0.012)
Observations	29,976	24,708	35,772	43,632	19,620	18,732	12,924	20,652	33,684
Number of countries	101	83	120	147	66	63	44	69	114
Capital investment $_{t-12}$	-0.060***	-0.006	-0.011***	-0.008*	-0.015	-0.001	0.023	0.019**	0.004
	(0.005)	(0.010)	(0.004)	(0.004)	(0.013)	(0.015)	(0.021)	(0.009)	(0.009)
Observations	27,516	22,644	32,388	39,648	18,000	18,288	12,804	18,588	31,656
Number of countries	95	78	113	141	62	62	44	64	110
Public consumption $_{t-12}$	-0.040***	0.032	-0.051***	-0.017***	-0.015	0.038	0.035	-0.018	0.016
	(0.008)	(0.020)	(0.007)	(0.006)	(0.028)	(0.030)	(0.024)	(0.023)	(0.013)
Observations	27,816	22,680	34,272	40,620	18,756	18,324	12,876	18,024	32,904
Number of countries	95	79	117	141	64	62	44	63	113
Domestic credit $_{t-12}$	-0.015***	-0.001	-0.005**	-0.003**	-0.018***	0.007**	-0.006	-0.003	-0.003
	(0.002)	(0.003)	(0.002)	(0.001)	(0.005)	(0.003)	(0.005)	(0.003)	(0.002)
Observations	27,924	22,764	32,964	40,836	18,444	17,844	12,456	19,788	31,872
Number of countries	98	80	116	145	65	62	44	69	113
Financial institutions $_{t-12}$	-1.292***	-0.053	-1.487***	-0.046	-2.789***	0.408	-1.243	-1.754**	-0.742
	(0.391)	(0.682)	(0.458)	(0.308)	(0.973)	(0.771)	(1.170)	(0.779)	(0.519)
Observations	29,676	24,408	35,172	43,032	19,620	18,732	12,924	20,352	33,684
Number of countries	100	82	118	145	66	63	44	68	114
Forest area $_{t-12}$	-0.124***	0.019	-0.029***	-0.034***	-0.053*	0.041	0.022	0.011	-0.025
	(0.011)	(0.024)	(0.011)	(0.011)	(0.030)	(0.035)	(0.096)	(0.017)	(0.027)
Observations	28,308	22,992	33,588	41,100	18,600	17,724	11,676	19,296	31,164
Number of countries	99	80	117	144	65	62	42	67	110
Agricultural land $_{t-12}$	0.062***	0.019	0.029***	0.013*	0.059**	0.009	0.044	0.034**	0.022
	(0.008)	(0.018)	(0.008)	(0.007)	(0.028)	(0.026)	(0.037)	(0.016)	(0.015)
Observations	29,760	24,192	35,256	42,840	19,476	18,648	12,564	20,256	32,832
Number of countries	101	82	119	146	66	63	44	68	113
Baseline model	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table reports the results of the baseline model, augmented by each variable. The dependent variables are dummy variables that indicate when a disaster of each type takes place "1", and "0" otherwise. Robust standard errors are reported in brackets. (***, **, *) indicate statistical significance at the 1%, 5%, and 10% levels. Countries for which there is no disaster over the period were dropped from the estimates: there is no variation in the outcome; conditionnal fixed effects specification eliminates any variable that is time-invariant. This is the reason behind the difference with the number of countries in the initial sample, as well as the data availability issues

Domestic macroeconomic environment

Capital investment (gross capital formation) and government consumption, all relative to GDP, were used to assess the effect of macroeconomic environment on the likelihood of disasters. Our results (shown in Table 4.3) highlight that capital investment and public consumption both reduce the probability of disasters triggered by droughts, epidemics and floods. For capital investment, this means that investing in irrigation

systems or heath systems (such as the building of hospitals) help reduce the probability of drought and epidemics, respectively. With respect to public consumption, the results do not suggest that government spending should be increased without some fiscal rules. This simply reflects the fact that governments with more resources are better able to anticipate or cope with vulnerability to disasters.

Financial sector

Domestic credit to private sector as a share of GDP, and financial institutions index[74] Svirydzenka (2016) were used as indicators of financial sector. Our results (Table 4.3) indicate that better access to credit and high financial institutions index negatively affect the frequency of several disasters (droughts, epidemic, flood, landslides and tropical cyclones), except for wildfire-induced disasters.[75] Access to credit is generally considered a key driver of private sector growth (Beck et al., 2005). Better access to credit help firms to invest and develop new technologies for coping with extremes weather events. Moreover, access to finance also enables households to better smooth their consumption. All positive externalities associated with financial sector development therefore contribute to reducing the probability of some disasters.

Land degradation

We look at the effect of land degradation on the likelihood of disasters using two variables related to agriculture and forestry[76]: agricultural land and forest area, all relative to land area. Our results suggest that natural disasters caused by drought, epidemics, floods, landslides, and tropical cyclones become likelier as land degradation continues (see Table 4.3 and Figure 4.A2). Deforestation and the increase in agricultural land damage ecosystems and hence exacerbate the risk of some natural disasters.

[74] Financial institutions include banks, insurance companies, pension funds, and mutual funds. Financial institutions index is defined as a combination of three dimensions: depth, access and efficiency.

[75] One possible explanation for the positive impact of domestic credit on the probability of wildfires may be that natural disasters caused by wildfires mostly took place in advanced economies with developed financial sectors.

[76] According to IPCC (2019), agriculture, forestry and other types of land use represent around 23 % of human greenhouse gas emissions.

Forest areas are crucial in the functioning of both water and carbon cycles. In particular, forest soil helps prevent droughts, floods, and landslides by easing water infiltration.

Living standards

We now investigate the impact of living standards such as education (education index[77] and tertiary education), physicians per capita and socioeconomic conditions index.[78] The effect of education on the probability of disaster is negative and significant for droughts, epidemics, wildfires, tropical cyclones (Table 4.4). Education is the most powerful tool to decrease people's vulnerability. Education helps improve health, reduce poverty and inequality, and promote access to information and resources (Jensen and Miller, 2017). Hence, the more educated a population is, the better it is able to anticipate and adapt to negative shocks. Education level significantly affects risk perception. For instance, Benjamin et al. (2013) point out that improved education in rural areas enables poor farmers (more vulnerable to droughts) to better cope with extremes weather events. Investing in health systems is equally important to prevent disasters caused by epidemics, as can be seen in Table 4.4. Our results also indicate that an improvement in living conditions leads to a reduction in the probability of several disasters (from droughts to landslides, and other storms). Poor people are more exposed and vulnerable to disasters than the rest of the society. The precarious livelihood of these people often leads them to settle in disasters-prone areas (Auffthammer and Kahn, 2018). On balance boosting human capital and better living conditions matter for reducing the incidence of several disasters.

[77] Education index (UNDP) refers to mean years of schooling (people aged 25 years and above).

[78] Socioeconomic conditions index (ICRG) is the sum of three subcomponents: unemployment, consumer confidence and poverty. High value indicates better socioeconomic conditions.

Institutional framework

Finally, three indicators allow us to examine the effect of institutional environment: corruption index, bureaucracy quality index, and armed conflicts.[79] We find that low corruption leads to a reduced frequency of several disasters (Table 4). These results stem from a lower misappropriation of public funds related to low level of corruption. Moreover, there is some evidence that extremes weather events induce conflicts (Burke et al., 2009; Hsiang et al., 2013). Based on that, we now investigate whether the relation is also moving in the opposite direction. Our results show that armed conflicts increase the probability of disasters (from droughts to landslides, and other storms). This results from population movements, degradation in living conditions or misuse of common resources (e.g. water) caused by armed conflicts, which then increase population exposure and vulnerability to natural disasters.

[79] Corruption and bureaucracy quality indices come from ICRG. High values indicate low corruption level and high bureaucracy quality, respectively. "Armed conflicts" is a dummy variable take the value one in situations of armed conflict, and zero otherwise. The variable is constructed from the Armed conflict database (IISS).

Table 4.3: The Augmented models (2), 1990-2014

VARIABLES	(1) Drought	(2) Earthquake	(3) Epidemic	(4) Flood	(5) Landslide	(6) Wildfire	(7) Heat wave	(8) Tropical cyclone	(9) Other storms
Education index $_{t-12}$	-3.371***	1.220	-1.927**	0.449	-0.431	-3.571**	0.690	-1.783	1.965**
	(0.791)	(1.214)	(0.789)	(0.553)	(1.632)	(1.735)	(1.999)	(1.331)	(0.860)
Observations	26,760	22,212	31,812	38,616	17,364	16,812	11,436	17,616	29,952
Number of countries	99	81	117	144	61	60	41	66	108
Tertiary education $_{t-12}$	-0.003	-0.006	-0.019***	0.001	-0.014	-0.004	-0.005	-0.018***	-0.006
	(0.004)	(0.006)	(0.005)	(0.003)	(0.009)	(0.006)	(0.008)	(0.007)	(0.004)
Observations	18,924	14,040	21,252	28,428	10,296	11,196	9,012	11,280	22,680
Number of countries	88	65	100	135	49	48	35	56	95
Physicians per capita $_{t-12}$	-0.423***	-0.128	-0.662***	-0.142	-0.490*	0.271	-0.085	0.016	-0.362***
	(0.140)	(0.167)	(0.145)	(0.089)	(0.264)	(0.201)	(0.274)	(0.178)	(0.126)
Observations	27,852	22,536	32,892	40,176	18,456	17,400	12,072	18,000	31,404
Number of countries	99	79	117	144	66	61	42	66	112
Socio. conditions $_{t-12}$	-0.221***	-0.091**	-0.087***	-0.057***	-0.143***	0.074	0.150**	-0.040	-0.057*
	(0.023)	(0.036)	(0.023)	(0.019)	(0.046)	(0.048)	(0.073)	(0.039)	(0.030)
Observations	23,268	19,116	27,804	34,224	17,388	16,308	12,132	15,252	27,336
Number of countries	80	65	94	118	59	55	42	51	95
Low corruption $_{t-12}$	-0.004	-0.111**	-0.409***	-0.179***	-0.079	-0.202**	-0.237*	0.074	-0.083*
	(0.041)	(0.057)	(0.038)	(0.033)	(0.080)	(0.091)	(0.138)	(0.060)	(0.050)
Observations	23,268	19,116	27,804	34,224	17,388	16,308	12,132	15,252	27,336
Number of countries	80	65	94	118	59	55	42	51	95
Bureaucracy quality $_{t-12}$	-0.199***	0.034	-0.111**	-0.121**	0.191	0.247	0.012	0.000	-0.233**
	(0.057)	(0.103)	(0.048)	(0.050)	(0.127)	(0.164)	(0.383)	(0.092)	(0.093)
Observations	23,268	19,116	27,804	34,224	17,388	16,308	12,132	15,252	27,336
Number of countries	80	65	94	118	59	55	42	51	95
Armed conflicts $_{t-12}$	0.163*	0.370***	0.266***	0.281***	0.279*	0.368	0.278	0.059	0.251*
	(0.083)	(0.134)	(0.074)	(0.069)	(0.162)	(0.228)	(0.328)	(0.143)	(0.129)
Observations	29,976	24,708	35,772	43,632	19,620	18,732	12,924	20,652	33,684
Number of countries	101	83	120	147	66	63	44	69	114
Baseline model	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table reports the results of the baseline model, augmented by each variable. The dependent variables are dummy variables that indicate when a disaster of each type takes place "1", and "0" otherwise. Robust standard errors are reported in brackets. (***, **, *) indicate statistical significance at the 1%, 5%, and 10% levels. Countries for which there is no disaster over the period were dropped from the estimates: there is no variation in the outcome; conditionnal fixed effects specification eliminates any variable that is time-invariant. This is the reason behind the difference with the number of countries in the initial sample, as well as the data availability issues for some

4.3.3. Climate change and the probability of natural disasters

We then turn our attention to the role of climate change. The Intergovernmental Panel on Climate Change constructed four scenarios of greenhouse gas concentrations, also known as Representative Concentration Pathways (RCP). We focus on two: i) RCP 4.5: intermediate scenario, assumes increased attention to environment, with emissions peaking around 2050 and declining thereafter; ii) RCP 8.5: unmitigated scenario

characterized by increasing emissions throughout the 21st century. Under RCP 8.5 scenario, temperatures are projected to rise significantly by 2050 relative to 2010-14, as can be seen in Figure 4.A3. Global warming will also lead to changes in precipitations patterns by 2050 (Figure 4.A4).

To assess the impact of climate change on the probability of disasters, we estimate the probability of each disaster using a panel conditional fixed-effects (as in Equation 4.1) in which precipitation and temperature are the main regressors. We then combine the estimated elasticities and the projected monthly precipitation and temperature in 2050 under the RCP 8.5 scenario to forecast the likelihood of natural disasters.[80] On balance, the results indicate that most disaster types will be more common by 2050. Especially, flood-induced disasters will decrease in some countries (Figure 4.A5), while the likelihood of disasters caused by epidemics or tropical cyclones will become more frequent (Figure 4.A6).

4.3.4. Robustness checks

This paper also considers alternative specifications to explore robustness of the baseline and augmented models. First, we augment the baseline model no longer with a single variable but also with several variables. Table 4.A5 in appendix summarize the results of this specification.

Second, we use the monthly occurrences of disaster by type as an alternative dependent variable. As our new dependent variable is a non-negative count variable, a model for count data should be applied. There are in fact two paths: either use a negative binomial or Poisson estimators. The Poisson fixed-effects estimator is preferred to the negative binomial since, as point out by Allison and Waterman (2002), and Greene (2005), the conditional negative binomial model for panel data developed

[80] The results under the RCP 4.5 scenario are available upon request.

by Hausman et al. (1984), is not a true fixed-effects method because it does not control for all stable covariates.[81]

One of the key features of the Poisson regression model is that the conditional mean should be equal to the conditional variance (also known as equidispersion assumption). Empirically, however, this assumption is rarely met. Count data usually exhibit over-dispersion, i.e, the conditional variance is larger than the conditional mean (Hilbe, 2014). The monthly occurrences of 6 out of our 9 natural disaster's type are over-dispersed, and 3 are under-dispersed. Consequently, overdispersion may induce standards errors of the estimates to be underestimated. This means that a non-significant variable could appear a significant predictor. To deal with both under and over-dispersion issues, we estimated fixed-effects Poisson models with robust standard errors, as recommended by Allison and Waterman (2002), and Hilbe (2014).[82] The corresponding results are shown in Table 4.A6.

Overall, our results are, for many variables, similar (in terms of sign and significance) to those in the baseline and augmented models.

[81] To the best of our knowledge, there are currently no statistics software addressing this issue. As consequence, the negative binomial estimator offers no particular advantage for panel data.

[82] This procedure is both flexible and robust as suggested by Wooldridge (1999).

4.4. Conclusions and policy recommendations

This paper investigates the main factors that determine the incidence of different types of natural disasters using monthly data in 181 countries over the period 1990-2014. Our results confirm the significant role played by weather patterns in the occurrence of natural disasters, and the intensification of disasters in a warming world. We also find that the incidence of disasters is related to the economic development process, the macroeconomic environment, as well as institutions. In particular, better living standards, access to credit and a good institutional framework reduce the occurrence of natural disasters caused by droughts, epidemics, floods and landslides. In contrast, urbanization, land degradation, and armed conflicts increase the probability of most disaster types. By identifying the main determinants of natural disasters, our paper will help countries implement public policies to build resilience to natural disasters and climate change.

From these results, we can also generate a toolkit of policies for policymakers. In that way, building resilience to natural disasters requires to promote inclusive and sustainable economic and social development. Accelerating financial development, while enhancing access to financial services for poor and low-income people is also crucial to reduce the risk from disasters. Another useful tool is to promote climate-smart agriculture practices in order to combat land degradation and achieve sustainable agriculture. Climate-smart agriculture rests on three pillars: i) food security and farmers' well-being, ii) adaption to climate change, and iii) environment-friendly (climate change mitigation or reduction in greenhouse gas emissions). In addition, as population and urbanization rise, strengthening zoning laws and building codes to limit vulnerability to natural disasters. Other useful policies consist of improving institutions (bureaucracy quality and fighting corruption) and people's living conditions by investing in human capital, through health and education.

4.5. Appendix: Tables and Figures

Table 4.A1: List of countries

Advanced economies	Emerging Market Economies			Low-Income Developing Countries	
Australia	Albania	Iraq	Trinidad and Tobago	Afghanistan	Nicaragua
Austria	Algeria	Jamaica	Tunisia	Bangladesh	Niger
Belgium	Angola	Jordan	Turkey	Benin	Nigeria
Canada	Argentina	Kazakhstan	Turkmenistan	Bhutan	Papua New Guinea
Cyprus	Armenia	Kuwait	Tuvalu	Bolivia	Rwanda
Czech Republic	Azerbaijan	Lebanon	Ukraine	Burkina Faso	Senegal
Denmark	Bahamas, The	Libya	United Arab Emirates	Burundi	Sierra Leone
Estonia	Bahrain	Macedonia, FYR	Uruguay	Cambodia	Solomon Islands
Finland	Barbados	Malaysia	Vanuatu	Cameroon	Sudan
France	Belarus	Maldives	Venezuela	Central African Republic	São Tomé and Príncipe
Germany	Belize	Mauritius		Chad	Tajikistan
Greece	Bosnia and Herzegovina	Mexico		Comoros	Tanzania
Hong Kong SAR	Botswana	Morocco		Congo, Democratic Republic of the	Togo
Iceland	Brazil	Namibia		Côte d'Ivoire	Uganda
Ireland	Brunei Darussalam	Oman		Djibouti	Uzbekistan
Israel	Bulgaria	Pakistan		Eritrea	Vietnam
Italy	Cabo Verde	Palau		Ethiopia	Yemen
Japan	Chile	Panama		Gambia, The	Zambia
Korea	China	Paraguay		Ghana	Zimbabwe
Latvia	Colombia	Peru		Guinea	
Lithuania	Costa Rica	Philippines		Guinea-Bissau	
Luxembourg	Croatia	Poland		Haiti	
Macao SAR	Dominica	Qatar		Honduras	
Malta	Dominican Republic	Romania		Kenya	
Netherlands	Ecuador	Russia		Kiribati	
New Zealand	Egypt	Samoa		Kyrgyz Republic	
Norway	El Salvador	Saudi Arabia		Lao P.D.R.	
Portugal	Equatorial Guinea	Seychelles		Lesotho	
Puerto Rico	Fiji	South Africa		Liberia	
San Marino	Gabon	Sri Lanka		Madagascar	
Singapore	Georgia	St. Kitts and Nevis		Malawi	
Slovak Republic	Grenada	St. Lucia		Mali	
Slovenia	Guatemala	St. Vincent and the Grenadines		Mauritania	
Spain	Guyana	Suriname		Moldova	
Sweden	Hungary	Swaziland		Mongolia	
Switzerland	India	Syria		Mozambique	
United Kingdom	Indonesia	Thailand		Myanmar	
United States	Iran	Tonga		Nepal	

Source: IMF countries classification.

Table 4.A2: Summary statistics of temperature and precipitation by type of disasters, 1990-2014

	Temperature (°C)									Precipitation (mm)								
	Mean	St. Dev.	Median	Min.	Max.	Percentile				Mean	St. Dev.	Median	Min.	Max.	Percentile			
						1	10	90	99						1	10	90	99
Total																		
Non-SSA	17,9	10,4	21,4	-27,6	39,2	-11,1	2,4	28,0	33,9	102,7	106,6	65,7	0,0	1150,8	0,0	5,5	255,2	456,0
SSA	24,5	4,0	25,1	4,4	36,6	11,5	19,5	28,9	32,8	94,2	100,1	64,3	0,0	899,2	0,0	1,2	225,2	445,3
Drought																		
Non-SSA	19,9	9,2	23,1	-22,0	34,5	-7,5	6,8	28,1	32,8	86,5	92,5	54,7	0,1	541,7	0,4	6,4	226,9	416,1
SSA	22,8	4,3	23,3	5,1	34,2	7,7	18,0	27,2	32,6	67,8	66,9	49,7	0,0	386,5	0,0	1,1	161,3	272,2
Earthquake																		
Non-SSA	16,5	10,0	19,1	-20,6	33,0	-7,7	1,8	26,5	30,4	105,2	119,1	61,8	0,0	1118,8	0,8	9,3	270,8	476,2
SSA	22,6	4,0	23,6	11,8	27,5	11,8	18,1	26,3	27,5	112,0	94,7	84,8	13,5	372,3	13,5	24,1	214,8	372,3
Epidemic																		
Non-SSA	21,5	9,0	25,0	-25,4	34,9	-9,1	8,6	28,2	31,9	122,1	118,0	81,4	0,0	907,1	0,4	6,5	281,8	515,9
SSA	25,2	3,1	25,2	14,5	33,9	17,7	21,3	29,3	33,0	95,5	95,2	70,8	0,0	579,5	0,0	1,1	223,5	399,7
Flood																		
Non-SSA	20,1	8,5	23,7	-23,0	34,6	-6,8	7,4	27,6	30,2	158,2	125,9	119,6	0,2	1118,8	3,5	29,1	329,5	550,6
SSA	25,0	3,3	25,1	11,0	34,9	13,9	21,5	29,2	32,9	148,8	96,3	138,8	0,0	810,6	0,4	38,8	261,2	468,6
Landslide																		
Non-SSA	18,3	10,2	22,3	-25,4	30,0	-21,3	2,9	26,6	28,6	166,2	117,8	144,6	2,7	569,6	5,2	28,1	322,4	519,2
SSA	23,9	2,5	24,1	18,6	27,0	18,6	19,3	26,9	27,0	155,6	101,4	134,4	2,7	505,2	2,7	50,6	256,9	505,2
Wildfire																		
Non-SSA	18,2	8,3	20,8	-12,4	33,0	-4,8	5,9	26,8	29,3	61,7	53,3	54,1	0,0	288,6	1,1	9,2	110,6	256,3
SSA	20,4	5,2	22,2	11,0	28,7	11,0	13,9	25,3	28,7	23,8	27,7	12,5	0,0	104,7	0,0	1,2	65,9	104,7
Heat wave																		
Non-SSA	23,0	4,9	22,6	9,6	34,1	10,8	16,5	29,6	32,3	70,4	66,2	52,6	0,0	427,2	0,0	8,5	149,0	344,0
SSA	27,9	0,0	27,9	27,9	27,9	27,9	27,9	27,9	27,9	135,9	0,0	135,9	135,9	135,9	135,9	135,9	135,9	135,9
Tropical cyclone																		
Non-SSA	23,7	5,2	25,5	-10,1	31,0	4,0	17,0	27,7	29,5	209,7	137,0	198,0	5,3	1150,8	11,7	58,6	376,9	570,1
SSA	26,2	2,8	25,9	20,4	36,6	20,4	23,3	30,4	36,6	220,6	116,8	221,0	19,0	540,7	19,0	63,4	372,3	540,7
Other storms																		
Non-SSA	11,3	11,3	10,1	-24,2	34,0	-20,4	-1,9	26,8	29,6	97,4	92,4	67,9	1,7	1118,8	4,1	25,7	211,5	473,4
SSA	23,7	4,9	24,7	11,0	32,9	11,0	15,6	28,5	32,9	104,7	84,6	92,6	7,2	500,2	7,2	19,0	193,6	500,2

Source: Climatic Research Unit, EM-DAT, and authors' calculations.

Table 4.A3: Summary statistics, 1990-2014

	Source	Unit	Mean	St. Dev.	Median	Min.	Max.	Percentile			
								1	10	90	99
Real GDP per capita			8,4	2,2	8,4	-0,2	31,9	3,1	6,0	10,6	14,5
Non-SSA	WEO-WDI	Logarithm	8,8	2,0	8,8	-0,2	22,6	2,6	6,6	10,7	14,5
SSA			7,1	2,2	6,6	4,0	31,9	4,8	5,6	8,8	16,0
Population			-5,2	2,2	-4,9	-12,3	0,3	-11,2	-8,2	-2,8	-0,1
Non-SSA	WDI	Logarithm	-4,9	2,0	-4,9	-10,1	0,3	-9,6	-7,8	-2,6	0,2
SSA			-5,2	1,6	-4,7	-9,6	-1,7	-9,4	-7,4	-3,2	-2,0
Urban population			55,6	24,7	55,5	5,4	100,0	10,4	21,8	89,5	100,0
Non-SSA	WDI	Percentage	59,1	23,0	61,8	8,5	100,0	13,0	25,5	88,5	100,0
SSA			34,7	15,3	34,7	5,4	86,9	7,6	15,6	54,8	82,2
Capital investment			23,3	8,2	22,5	-2,4	67,9	4,0	14,3	33,3	47,6
Non-SSA	WDI	Percentage	24,3	7,5	23,2	-0,7	67,9	9,3	16,6	33,8	47,4
SSA			20,3	9,3	19,9	-2,4	60,2	0,0	9,5	31,3	48,4
Government consumption			16,7	8,4	15,3	0,8	55,1	3,0	8,2	26,2	55,1
Non-SSA	WEO-WDI	Percentage	17,1	8,2	16,3	1,4	55,1	3,3	8,5	25,3	55,1
SSA			15,3	8,8	12,7	0,8	55,1	2,3	7,4	28,0	43,8
Domestic credit			43,7	39,8	30,1	2,0	175,3	2,0	7,0	101,5	175,3
Non-SSA	WDI	Percentage	52,0	40,9	40,7	2,0	175,3	2,6	11,0	111,2	175,3
SSA			18,6	21,9	13,0	2,0	160,1	2,0	4,2	34,0	138,2
Financial institutions	Svirydzenka (2016)	Index	0,4	0,2	0,3	0,0	1,0	0,0	0,1	0,7	0,9
Non-SSA			0,4	0,2	0,4	0,0	1,0	0,0	0,2	0,8	0,9
SSA			0,2	0,1	0,2	0,0	0,7	0,0	0,1	0,3	0,6
Forest area			32,4	24,4	31,4	0,0	98,9	0,0	1,3	66,9	91,0
Non-SSA	WDI	Percentage	31,8	24,5	31,0	0,0	98,9	0,0	1,1	66,7	91,4
SSA			34,3	23,4	32,4	0,9	88,5	1,0	6,4	68,0	88,4
Agriculture land			37,8	22,2	38,5	0,4	85,5	0,9	7,8	70,2	80,8
Non-SSA	WDI	Percentage	37,1	21,9	37,7	0,4	85,5	1,2	7,4	67,3	81,2
SSA			46,3	20,5	46,8	3,1	82,7	8,0	17,9	73,3	80,7
Education index			0,6	0,2	0,6	0,1	0,9	0,1	0,3	0,8	0,9
Non-SSA	UNDP	Index	0,6	0,2	0,6	0,1	0,9	0,2	0,4	0,8	0,9
SSA			0,4	0,1	0,4	0,1	0,7	0,1	0,2	0,5	0,7
Tertiary education			29,6	23,9	24,1	0,0	89,0	0,5	2,7	66,2	89,0
Non-SSA	WDI	Percentage	35,6	23,0	31,4	0,0	89,0	1,3	8,7	69,8	89,0
SSA			5,2	5,7	3,4	0,3	40,0	0,4	0,7	10,6	32,2
Physicians per capita	WDI	Real number	1,5	1,4	1,1	0,0	7,5	0,0	0,1	3,6	5,8
Non-SSA			1,8	1,3	1,6	0,0	6,4	0,0	0,2	3,7	4,8
SSA			0,2	0,3	0,1	0,0	1,9	0,0	0,0	0,5	1,3
Socioeconomic conditions			5,6	2,3	5,5	0,0	11,0	0,5	2,5	9,0	10,5
Non-SSA	ICRG	Index	6,2	2,3	6,0	0,0	11,0	0,5	3,4	9,3	10,7
SSA			3,8	1,6	3,9	0,5	8,0	1,0	2,0	6,0	7,0
Low corruption			2,9	1,3	2,7	0,0	6,0	0,5	1,5	5,0	6,0
Non-SSA	ICRG	Index	3,1	1,3	3,0	0,0	6,0	1,0	1,5	5,0	6,0
SSA			2,3	1,0	2,0	0,0	5,0	0,0	1,0	4,0	5,0
Bureaucracy quality			2,2	1,1	2,0	0,0	4,0	0,0	1,0	4,0	4,0
Non-SSA	ICRG	Index	2,4	1,1	2,0	0,0	4,0	0,0	1,0	4,0	4,0
SSA			1,3	0,9	1,0	0,0	4,0	0,0	0,0	2,5	3,5
Armed conflict	Armed Conflict Database (IISS)	Dummy variable	0,1	0,3	0,0	0,0	1,0	0,0	0,0	1,0	1,0
Non-SSA			0,1	0,3	0,0	0,0	1,0	0,0	0,0	1,0	1,0
SSA			0,2	0,4	0,0	0,0	1,0	0,0	0,0	1,0	1,0

Table 4.A4: Robustness checks (1)

VARIABLES	(1) Drought	(2) Earthquake	(3) Epidemic	(4) Flood	(5) Landslide	(6) Wildfire	(7) Heat wave	(8) Tropical cyclone	(9) Other storms
Precipitation	-0.001	-0.004***	-0.001	0.023***	0.017***	-0.022***	-0.007**	0.011***	0.012***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.003)	(0.001)	(0.001)
Precipitation^2	0.000**	0.000***	0.000**	-0.000***	-0.000***	0.000***	0.000*	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Temperature	0.024**	0.030**	0.007	0.048***	0.000	0.110***	0.277*	0.202***	-0.061***
	(0.010)	(0.015)	(0.010)	(0.008)	(0.018)	(0.015)	(0.149)	(0.035)	(0.008)
Temperature^2	-0.000	-0.001***	0.001*	-0.001***	-0.001	0.001**	0.005	-0.003***	0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.004)	(0.001)	(0.000)
Prec. Deviations (12 months)	-0.006***	0.000	-0.001***	0.000***	0.001**	-0.001**	-0.003***	0.000	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Temp. Deviations (12 months)	0.032***	0.008	0.017**	-0.014***	-0.027	0.019	0.024	0.009	0.013*
	(0.007)	(0.012)	(0.007)	(0.005)	(0.017)	(0.014)	(0.017)	(0.010)	(0.007)
Log GDP per capita $_{t-12}$	0.051	-0.048	-0.214***	-0.019	0.006	-0.048	-0.895**	-0.372**	-0.063
	(0.050)	(0.072)	(0.044)	(0.036)	(0.071)	(0.104)	(0.403)	(0.186)	(0.072)
Log Population $_{t-12}$	-1.347***	-2.564**	1.502***	2.173***	-0.598	-0.179	-0.210	-0.481	-0.251
	(0.441)	(1.024)	(0.399)	(0.386)	(1.038)	(1.247)	(1.663)	(0.922)	(0.687)
Urban population $_{t-12}$	0.075***	0.056***	-0.008	0.001	0.023	-0.062*	0.116***	0.031	0.012
	(0.014)	(0.016)	(0.012)	(0.010)	(0.021)	(0.035)	(0.043)	(0.019)	(0.015)
Capital investment $_{t-12}$	-0.050***	-0.009	-0.021***	-0.005	0.030*	0.003	0.061**	0.039***	-0.006
	(0.008)	(0.014)	(0.006)	(0.006)	(0.018)	(0.019)	(0.029)	(0.012)	(0.011)
Public consumption $_{t-12}$	0.017	-0.009	-0.021*	-0.009	0.005	0.113***	0.070*	0.034	0.006
	(0.015)	(0.033)	(0.012)	(0.010)	(0.039)	(0.038)	(0.037)	(0.033)	(0.021)
Domestic credit $_{t-12}$	-0.008**	-0.000	0.002	-0.002	-0.025***	0.005	-0.012	-0.002	-0.002
	(0.003)	(0.005)	(0.003)	(0.002)	(0.007)	(0.004)	(0.008)	(0.004)	(0.003)
Forest area $_{t-12}$	-0.202***	0.058	-0.010	-0.041***	0.056	-0.048	0.011	0.014	-0.037
	(0.022)	(0.042)	(0.017)	(0.016)	(0.047)	(0.046)	(0.145)	(0.026)	(0.035)
Agricultural land $_{t-12}$	0.058***	0.034	0.010	0.036***	0.057	0.006	0.091*	0.003	0.020
	(0.016)	(0.029)	(0.014)	(0.011)	(0.041)	(0.039)	(0.054)	(0.025)	(0.019)
Socio. conditions $_{t-12}$	-0.110***	-0.114**	0.031	-0.012	-0.116**	0.090	0.174**	-0.026	-0.051
	(0.032)	(0.045)	(0.029)	(0.023)	(0.055)	(0.058)	(0.089)	(0.047)	(0.036)
Physicians per capita $_{t-12}$	-0.250	-0.055	-0.743***	-0.132	-0.358	0.008	0.138	0.217	-0.119
	(0.191)	(0.222)	(0.173)	(0.109)	(0.354)	(0.253)	(0.341)	(0.215)	(0.157)
Low corruption $_{t-12}$	0.073	-0.052	-0.359***	-0.178***	-0.107	-0.355***	-0.230	0.083	-0.150**
	(0.055)	(0.073)	(0.046)	(0.038)	(0.094)	(0.107)	(0.169)	(0.070)	(0.059)
Armed conflicts $_{t-12}$	0.208*	0.131	0.221**	0.189**	0.261	0.563**	-0.149	-0.058	0.246*
	(0.116)	(0.171)	(0.098)	(0.085)	(0.210)	(0.249)	(0.383)	(0.165)	(0.144)
Observations	19,104	14,892	22,152	27,144	13,884	13,284	10,176	12,084	22,980
Number of countries	75	56	87	110	54	50	39	47	90
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

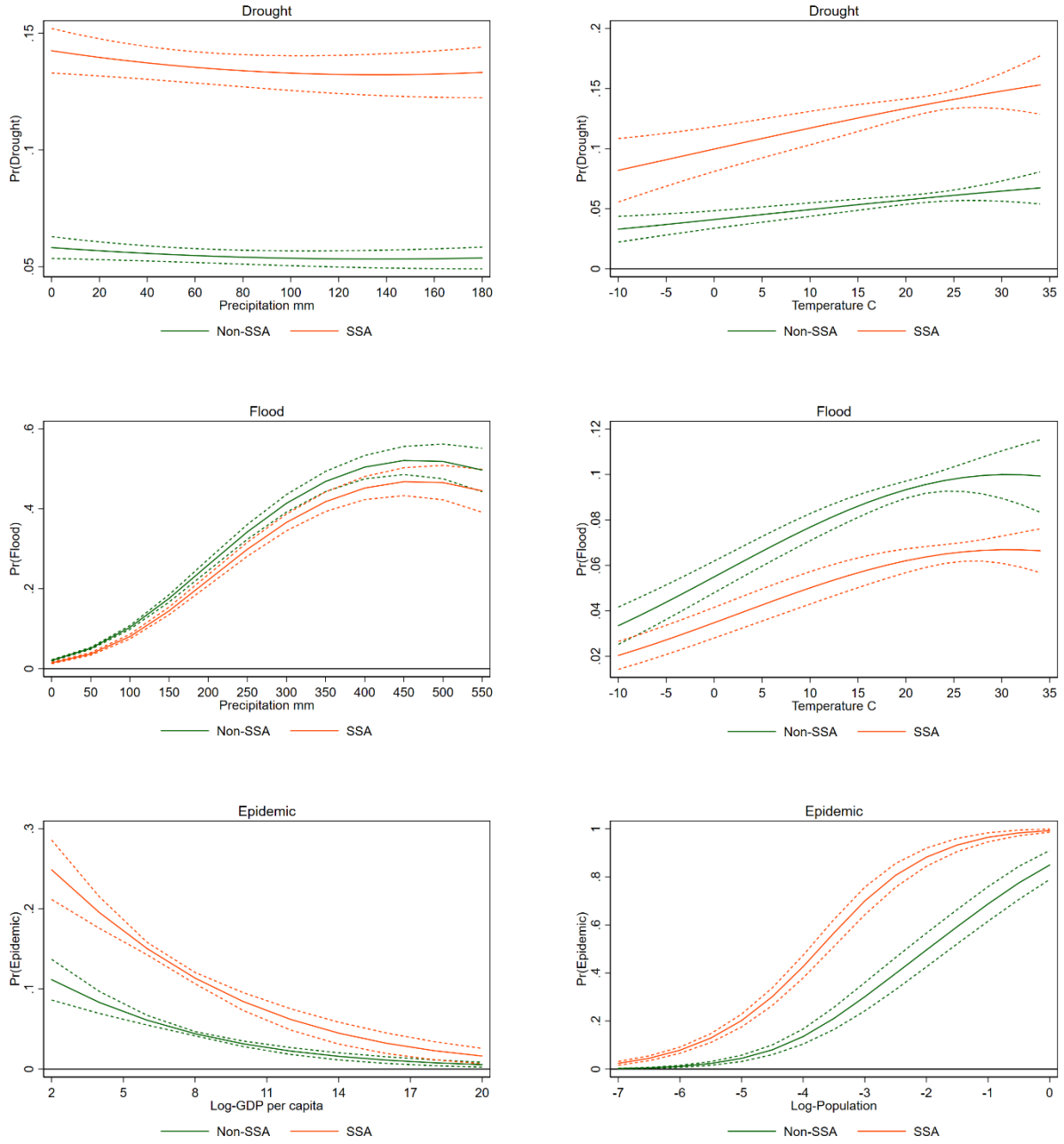
Note: The dependent variables are dummy variables that indicate when a disaster of each type takes place "1", and "0" otherwise. Robust standard errors are reported in brackets. (***, **, *) indicate statistical significance at the 1%, 5%, and 10% levels. Countries for which there is no disaster over the period were dropped from the estimates: there is no variation in the outcome; conditionnal fixed effects specification eliminates any variable that is time-invariant. This is the reason behind the difference with the number of countries in the initial sample, as well as the data availability issues for some variables.

Table 4.A5: Poisson fixed-effects estimates

VARIABLES	(1) Drought	(2) Earthquake	(3) Epidemic	(4) Flood	(5) Landslide	(6) Wildfire	(7) Heat wave	(8) Tropical cyclone	(9) Other storms
Precipitation	-0.001**	-0.003***	-0.001	0.018***	0.016***	-0.019***	-0.006*	0.011***	0.011**
	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.005)	(0.003)	(0.003)	(0.004)
Precipitation^2	0.000***	0.000***	0.000**	-0.000***	-0.000***	0.000**	0.000**	-0.000	-0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Temperature	0.019	0.018**	0.006	0.043**	0.002	0.102***	0.324***	0.202***	-0.041***
	(0.012)	(0.008)	(0.011)	(0.017)	(0.033)	(0.013)	(0.125)	(0.040)	(0.011)
Temperature^2	-0.000	-0.001***	0.001	-0.001	-0.001	0.001	0.003	-0.003***	0.000
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.004)	(0.001)	(0.001)
Prec. Deviations (12 month:	-0.005***	0.000	-0.001*	0.000*	0.001*	-0.001*	-0.003***	0.000	0.001**
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
Temp. Deviations (12 mont	0.025	0.005	0.008	-0.006	-0.023	0.027*	0.023	0.007	0.012**
	(0.015)	(0.011)	(0.014)	(0.006)	(0.016)	(0.016)	(0.017)	(0.009)	(0.005)
Log GDP per capita $_{t-12}$	0.043	-0.054	-0.176***	-0.015	0.006	-0.061	-0.819*	-0.300*	-0.055
	(0.151)	(0.102)	(0.062)	(0.054)	(0.052)	(0.131)	(0.485)	(0.169)	(0.062)
Log Population $_{t-12}$	-0.687	-1.963**	1.375	1.696***	-0.983	-0.102	-0.353	-0.323	-0.278
	(1.079)	(0.973)	(0.919)	(0.364)	(0.836)	(1.930)	(1.225)	(0.820)	(0.753)
Urban population $_{t-12}$	0.053*	0.046***	-0.008	0.011	0.027*	-0.058	0.106	0.036***	0.018
	(0.030)	(0.011)	(0.029)	(0.012)	(0.016)	(0.037)	(0.064)	(0.014)	(0.016)
Capital investment $_{t-12}$	-0.041**	-0.009	-0.021	0.001	0.031	0.001	0.058*	0.030*	-0.004
	(0.019)	(0.016)	(0.014)	(0.006)	(0.020)	(0.031)	(0.032)	(0.016)	(0.011)
Public consumption $_{t-12}$	0.012	0.003	-0.016	-0.008	0.011	0.113*	0.063**	0.028	0.004
	(0.037)	(0.040)	(0.029)	(0.010)	(0.053)	(0.066)	(0.027)	(0.030)	(0.014)
Domestic credit $_{t-12}$	-0.007	-0.002	0.002	-0.002	-0.025***	0.005	-0.009	0.000	-0.002
	(0.008)	(0.004)	(0.009)	(0.002)	(0.005)	(0.008)	(0.007)	(0.003)	(0.003)
Forest area $_{t-12}$	-0.154***	0.054	-0.008	-0.018	0.051	-0.051	-0.001	-0.009	-0.036
	(0.054)	(0.034)	(0.042)	(0.015)	(0.042)	(0.045)	(0.109)	(0.026)	(0.037)
Agricultural land $_{t-12}$	0.044	0.032	0.014	0.031*	0.062	0.001	0.086	0.002	0.012
	(0.051)	(0.031)	(0.033)	(0.017)	(0.039)	(0.038)	(0.053)	(0.022)	(0.022)
Socio. conditions $_{t-12}$	-0.085	-0.093**	0.030	-0.011	-0.124**	0.079	0.147	-0.033	-0.028
	(0.081)	(0.042)	(0.069)	(0.024)	(0.049)	(0.077)	(0.091)	(0.040)	(0.038)
Physicians per capita $_{t-12}$	-0.136	-0.059	-0.714	-0.186	-0.223	-0.019	0.182	0.121	-0.111
	(0.411)	(0.174)	(0.497)	(0.122)	(0.352)	(0.309)	(0.308)	(0.204)	(0.185)
Low corruption $_{t-12}$	0.110	-0.062	-0.272***	-0.159***	-0.135	-0.356***	-0.169	0.049	-0.115**
	(0.141)	(0.059)	(0.102)	(0.045)	(0.105)	(0.125)	(0.202)	(0.063)	(0.057)
Armed conflicts $_{t-12}$	0.144	0.136	0.151	0.041	0.259	0.445	-0.155	-0.067	0.248
	(0.259)	(0.119)	(0.187)	(0.119)	(0.227)	(0.452)	(0.288)	(0.153)	(0.183)
Observations	19,104	14,892	22,152	27,144	13,884	13,284	10,176	12,084	22,980
Number of ifscode	75	56	87	110	54	50	39	47	90
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

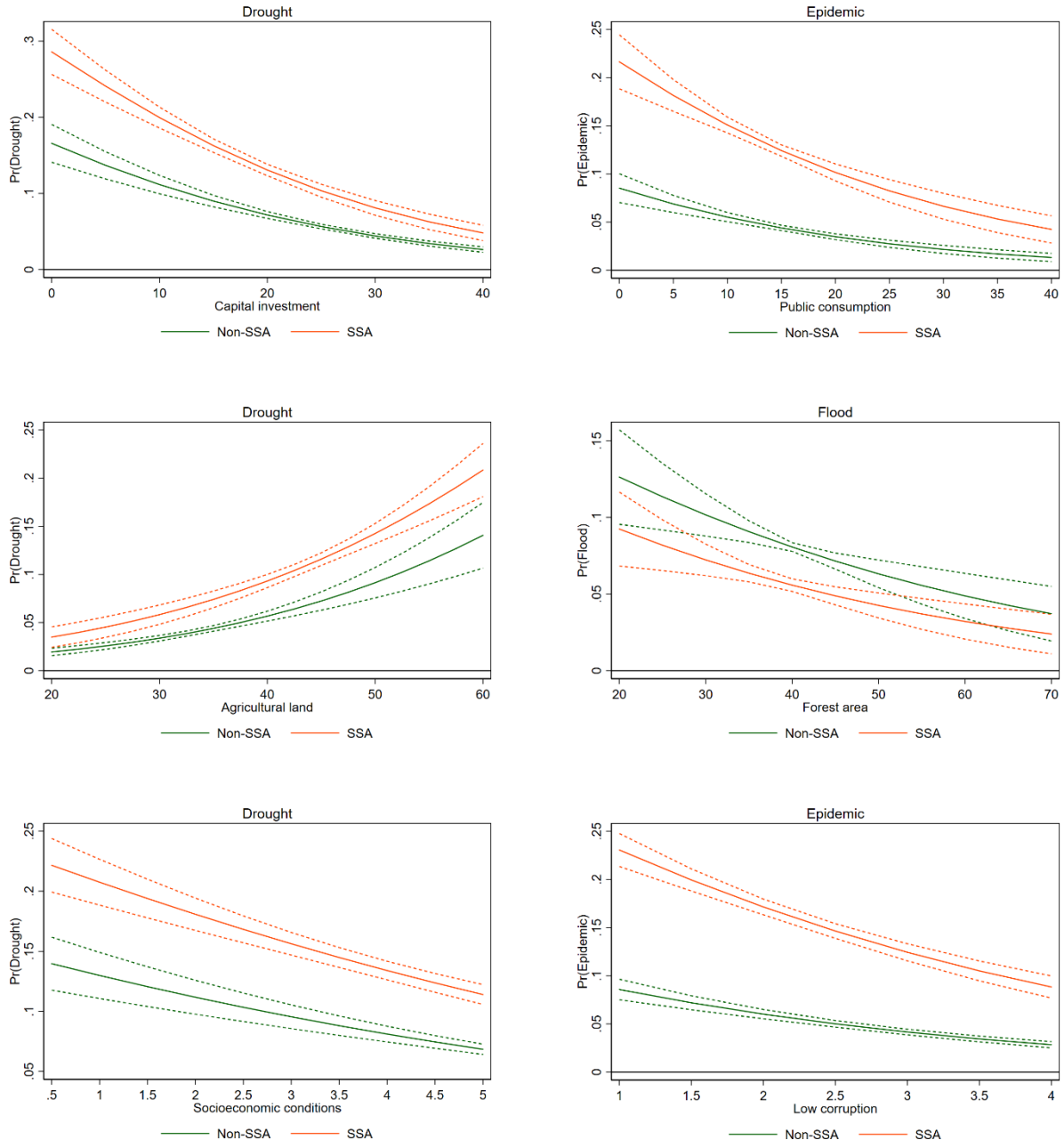
Note: The dependent variables are non-negative count variables measuring the occurrences of each type of disaster. Robust standard errors are reported in brackets. (***, **, *) indicate statistical significance at the 1%, 5%, and 10% levels. Like conditional fixed effects, the Poisson fixed effects specification also eliminates any country with no disaster over the period.

Figure 4.A1: *Predicted Probabilities of Droughts, Epidemics, and Floods*



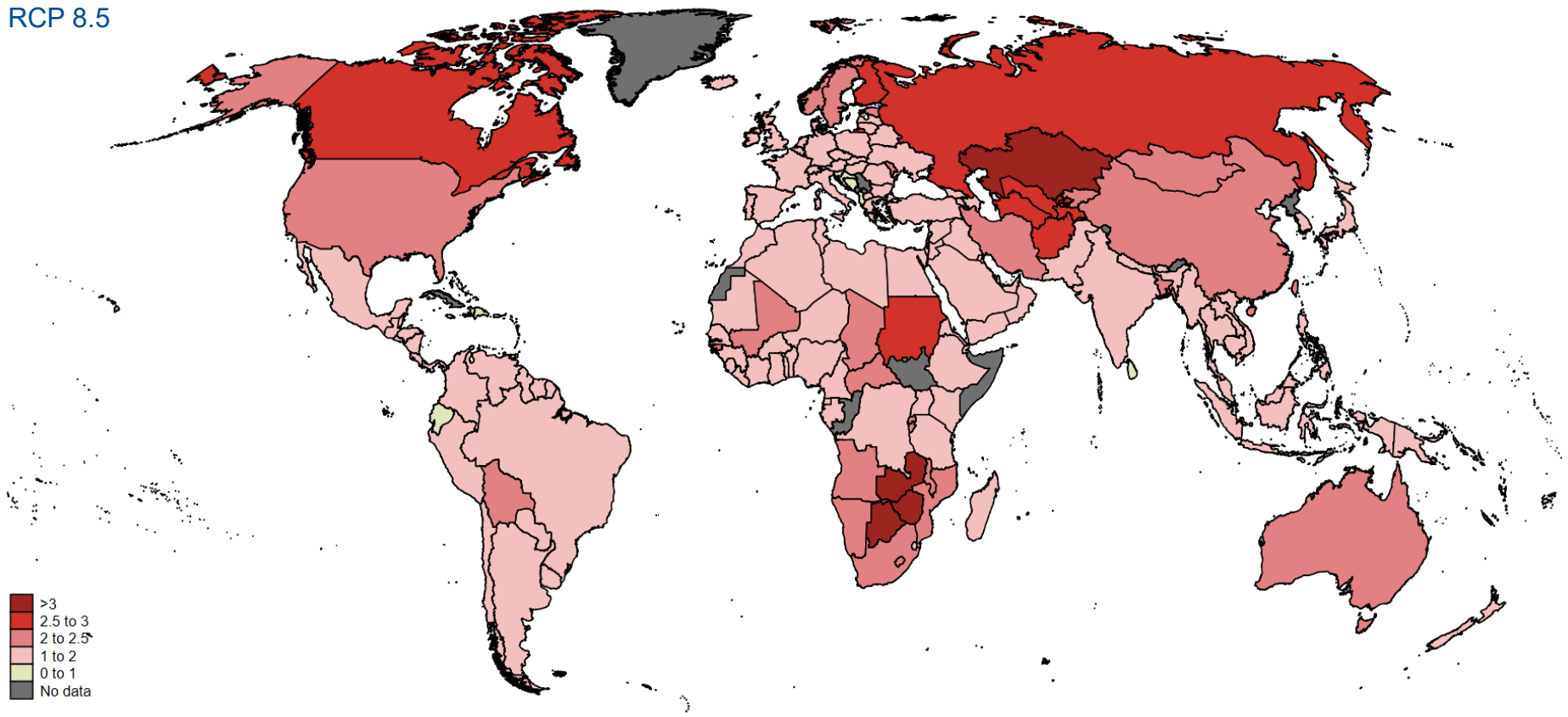
Notes: Dashed lines indicate the 95 percent confidence intervals.

Figure 4.A2: Predicted Probabilities of Drought, Epidemic, and Floods



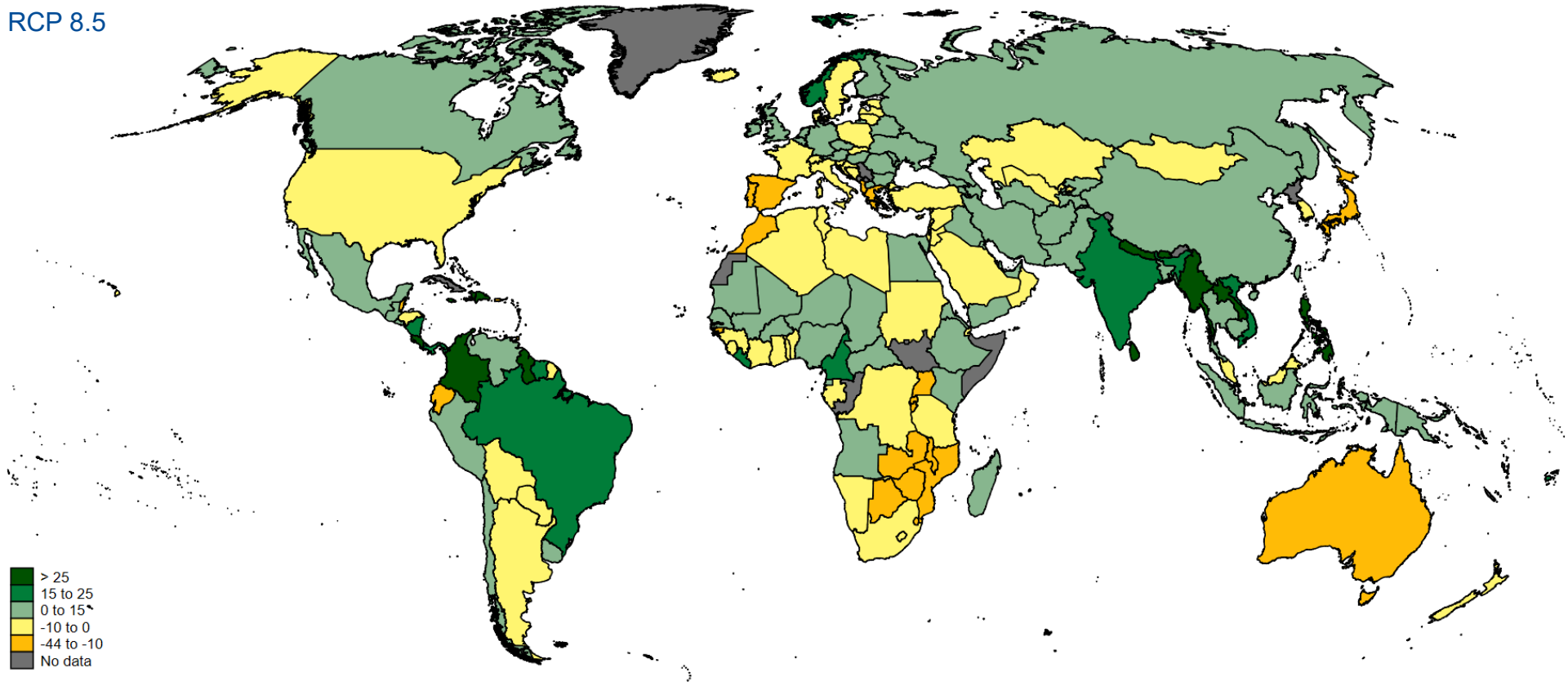
Notes: Dashed lines indicate the 95 percent confidence intervals.

Figure 4.A3: Change in temperatures, 2050 relative to 2010-14



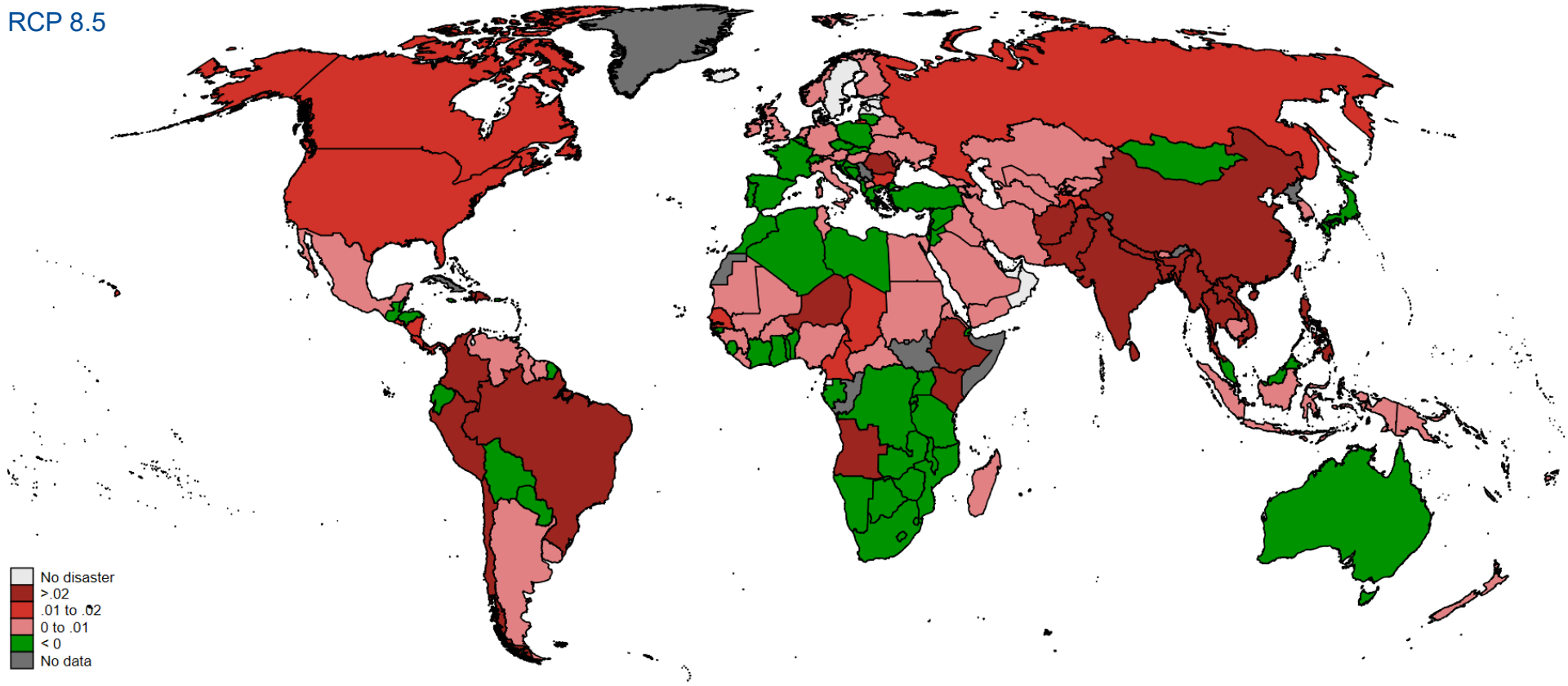
Sources: National Aeronautics and Space Administration (NASA) Earth Exchange Global Daily Downscaled Projections (NEX-GDDP), World Bank Group Cartography Unit, and authors' calculations.

Figure 4.A4: Change in precipitation patterns, 2050 relative to 2010-14



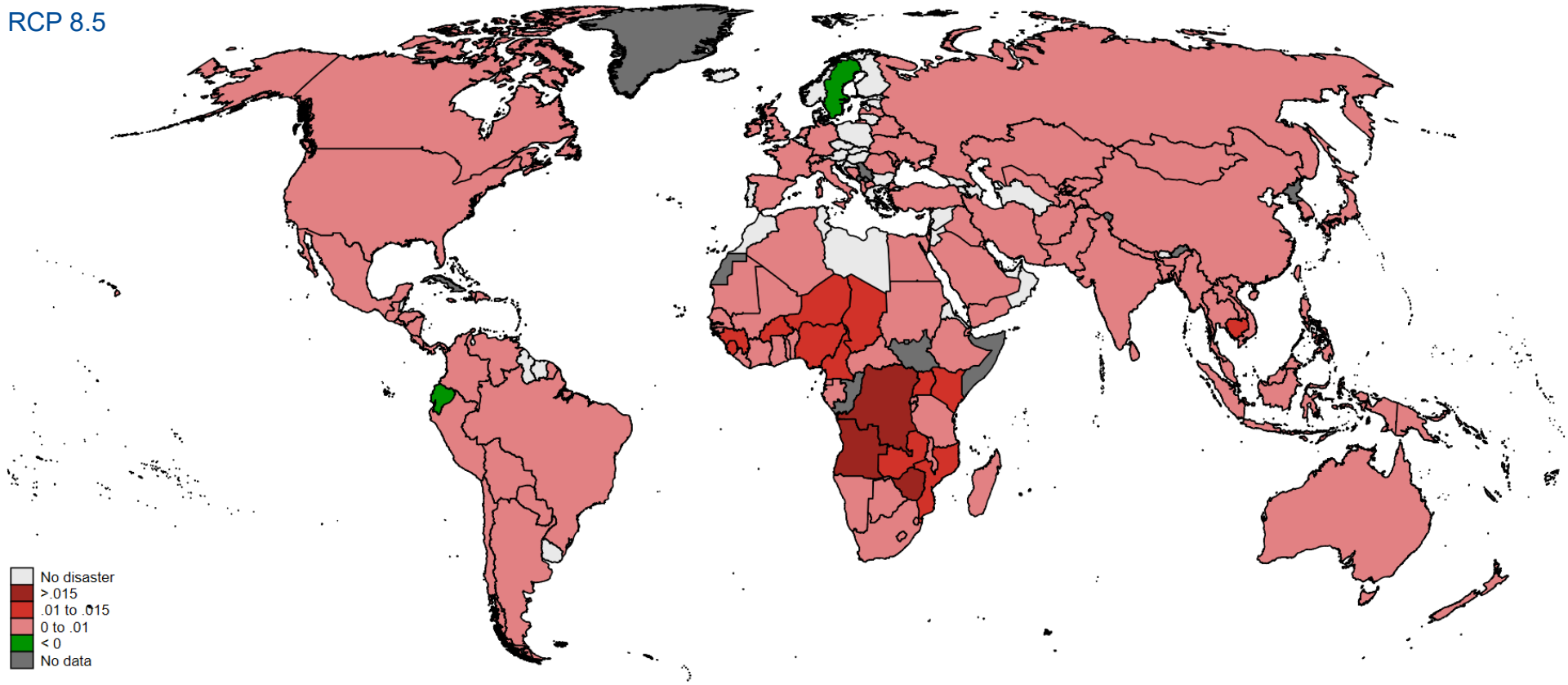
Sources: National Aeronautics and Space Administration (NASA) Earth Exchange Global Daily Downscaled Projections (NEX-GDDP), World Bank Group Cartography Unit, and authors' calculations.

Figure 4.A5: Change in monthly estimated probability of floods due to climate change, 2050 relative to 2010-14



Sources: National Aeronautics and Space Administration (NASA) Earth Exchange Global Daily Downscaled Projections (NEX-GDDP), World Bank Group Cartography Unit, and authors' calculations.

Figure 4.A6: Change in monthly estimated probability of epidemics due to climate change, 2050 relative to 2010-14



Sources: National Aeronautics and Space Administration (NASA) Earth Exchange Global Daily Downscaled Projections (NEX-GDDP), World Bank Group Cartography Unit, and authors' calculations.

Conclusion Générale

Cette thèse propose quatre essais empiriques s'intéressant tour à tour à la stabilité du secteur bancaire, la digitalisation financière, l'économie informelle et les catastrophes naturelles. Ces quatre thèmes représentent tous des enjeux de politique économique. En conclusion, un résumé des principales contributions de chacun des chapitres sera présenté, ainsi que l'ensemble des perspectives de recherche.

Contributions et implications en termes de politiques publiques

Le premier chapitre de cette thèse porte sur l'impact de la concurrence bancaire sur le risque de crédit en Afrique subsaharienne (ASS). A partir d'un échantillon de 221 banques sur la période de 2000 à 2015, nous avons mis en évidence l'existence d'une relation non-linéaire en forme de U, entre le développement de la concurrence bancaire (mesuré par l'indice de Lerner) et la qualité des portefeuilles bancaires. Ceci suggère qu'au-delà d'un certain seuil, les effets positifs de la concurrence sur la stabilité bancaire peuvent être annihilés par d'autres effets, débouchant en fin de compte sur l'instabilité du secteur bancaire. L'indice de Lerner étant par nature incomparable d'un pays à un autre, le niveau de concurrence optimale sera par conséquent propre à chaque secteur bancaire et dépendra de ses fondamentaux. Les autorités monétaires devraient, de ce fait, porter une attention particulière à la stabilité des systèmes bancaires à mesure que la concurrence s'intensifie.

Notre étude s'intéresse également à d'autres déterminants du risque de crédit en ASS, relatifs à l'environnement macroéconomique et réglementaire. Elle met par exemple en lumière l'importance de la structure économique et de l'inclusion financière en tant que facteur d'amélioration de la qualité des portefeuilles bancaires. Le poids des prêts non-performants dans les bilans bancaires est notamment plus faible dans les pays économiquement plus diversifiés, en raison de leur faible exposition aux chocs externes. Aussi, un secteur bancaire inclusif n'est pas seulement un objectif de

développement, mais contribue également à améliorer la solidité des établissements de crédit, via la réduction des asymétries d'information.

Nos résultats fournissent ainsi des indications utiles sur la façon de concevoir et d'adapter les cadres prudentiels et réglementaires en fonction des caractéristiques et besoins spécifiques des pays d'Afrique subsaharienne.

Dans le chapitre 2, nous nous intéressons à l'impact des services financiers mobiles (SFM) sur l'économie informelle, à l'aide d'un échantillon de 101 pays émergents et en développement sur la période de 2000 à 2015. Nos travaux relèvent l'existence d'une relation décroissante entre l'adoption des SFM et la taille du secteur informel. Cette relation découlerait à la fois des gains d'efficacité (baisse des coûts de transaction), d'un meilleur accès au crédit et d'une croissance plus rapide du secteur formel, induits par l'utilisation des SFM. Les deux premiers effets constituent donc une incitation puissante, pour les firmes informelles, à entrer dans le secteur formel.

Afin de ne pas entraver le processus de « formalisation » en cours dans les pays en développement, nos résultats suggèrent qu'il est nécessaire de trouver un équilibre entre les avantages et les risques potentiels générés par l'utilisation des SFM. Comme toute innovation financière, les SFM peuvent présenter de nouveaux risques (faux dépôts, fraudes sur les retraits, vol d'identité, hameçonnage, etc.) auxquels il faudrait s'attaquer au moyen de cadres réglementaires appropriés.

Pour accélérer le processus de digitalisation financière, il conviendrait par ailleurs d'abolir les barrières entre les établissements de crédit et les opérateurs de téléphonie mobile. Pour ce faire, les autorités de régulation ou banques centrales gagneraient à encourager l'établissement de partenariats entres les banques et les opérateurs de téléphonie. Elles pourraient en outre créer de nouveaux statuts ou délivrer des agréements permettant aux compagnies de téléphonie de proposer des produits de crédit, d'épargne ou d'assurance mobiles.

Dans l'ensemble, cette étude jette les bases d'une littérature, peu développée jusqu'ici, sur les implications macroéconomiques des SFM, une dimension majeure de la digitalisation croissante des transactions économiques.

Le chapitre 3 examine pour sa part, l'effet des systèmes éducatifs sur le secteur informel en Afrique. A partir d'un échantillon de 30 pays sur la période 2000 à 2015, nous constatons un poids de l'économie informelle relativement plus important dans les pays où le système éducatif est principalement porté sur l'enseignement général au détriment de l'enseignement professionnel. Ceci est illustre l'inadéquation entre les systèmes éducatifs et les besoins du marché du travail dans certains pays africains. L'enseignement général serait ainsi une entrave à l'insertion professionnelle dans la mesure où il met l'accent sur l'acquisition de connaissances générales au détriment de savoir-faire et compétences recherchés dans le secteur formel. En Afrique, un individu aurait donc plus de chance de trouver un emploi dans le secteur formel lorsqu'il a été formé pour une catégorie de professions ou un métier donné, ce qui est le cas avec l'enseignement professionnel.

Compte tenu des risques auxquels est confronté le continent (forte croissance démographique, recrudescence d'événements climatiques extrêmes, etc.), les pays africains doivent profondément repenser leurs systèmes éducatifs. Il conviendrait d'établir un équilibre entre l'enseignement général et l'enseignement professionnel afin de permettre aux 22,5 millions de jeunes qui frapperont chaque année à la porte du marché du travail, de trouver un emploi dans le secteur formel. Repenser les systèmes éducatifs suppose également de favoriser la continuité et l'articulation entre l'enseignement secondaire et l'enseignement supérieur. Tout comme il est important que les systèmes éducatifs en Afrique s'intéressent davantage à la transmission de connaissances, compétences et aptitudes indispensables pour faire face aux nombreuses mutations en cours et bâtir le monde de demain.

Dans le chapitre 4 enfin, nous étudions les principaux facteurs à l'origine de l'incidence des catastrophes naturelles à l'aide d'un échantillon mondial comprenant près de 200

pays sur la période de 1990 à 2014. Tout d'abord, nous soulignons le rôle central que jouent les conditions climatiques dans l'occurrence des catastrophes naturelles. L'augmentation des températures ou du niveau des précipitations influent donc sur la probabilité d'occurrence des catastrophes, tant positivement que négativement selon le type de catastrophes. Deuxièmement, nous montrons que le passage d'un aléa naturel à une catastrophe naturelle dépend aussi d'un ensemble de facteurs en lien avec l'environnement macroéconomique et financier, les conditions de vie des populations, la dégradation des sols, tout comme le cadre institutionnel.

Avec le changement climatique, la fréquence et l'intensité des catastrophes naturelles sont appelées à continuer à croître. Pour y faire face et mieux s'adapter, les pays doivent renforcer leur résilience en promouvant par exemple une croissance inclusive et durable pour éradiquer la pauvreté et les inégalités. Il convient par ailleurs d'accélérer le développement financier dans les pays en développement, en mettant un accent particulier sur l'inclusion financière des pauvres ou personnes à faible revenu, généralement plus vulnérables aux catastrophes naturelles. Le reboisement et la promotion de systèmes agricoles climato-intelligents sont également indispensables pour atténuer la dégradation des sols et limiter par ce fait l'incidence de certaines catastrophes naturelles induites par la sécheresse et les inondations par exemple. Il conviendrait par ailleurs d'accompagner la croissance démographique et l'urbanisation galopante dans certains pays, d'un cadre législatif approprié relatif à l'utilisation des sols, la planification et le zonage afin de limiter l'exposition des populations aux catastrophes naturelles. Améliorer la qualité des institutions (lutte contre la corruption, meilleure bureaucratie) et investir dans le capital humain (éducation et santé) sont tout aussi importants. Plus précisément, plus une population est instruite, plus elle est à mesure d'anticiper et de s'adapter aux événements climatiques extrêmes. Les dépenses sociales jouent donc un rôle crucial pour renforcer la résilience face au changement climatique et aux catastrophes naturelles.

Perspectives de recherche

L'ensemble des questions abordées dans la présente thèse, en plus d'apporter une réponse à quatre enjeux contemporains de politique économique, nous ouvre également à cinq nouvelles perspectives de recherche.

Nous envisageons tout d'abord de mêler nos travaux sur les services financiers mobiles avec ceux sur les catastrophes naturelles. L'un des avantages liés à l'utilisation des SFM concerne le recul de l'exclusion financière qui se traduit par un meilleur accès au crédit des populations pauvres ou à faible revenu. Il existe plusieurs évidences empiriques (Jack et Suri, 2014 ; Munyegera et Matsumoto, 2016, 2018 ; Riley, 2018) de l'impact positif des SFM sur la consommation des ménages à la suite d'un choc négatif, les transferts de fonds étant le principal mécanisme économique sous-jacent. Sur la base de ces travaux, nous entendons conduire un projet de recherche qui s'intéressera à l'utilisation des SFM comme facteur de résilience face aux catastrophes naturelles, en adoptant une approche macroéconomique, à la différence des travaux de Riley (2018). Il s'agira pour nous de fournir des indications utiles sur la façon dont la digitalisation financière peut permettre d'atténuer l'effet adverse des catastrophes naturelles sur le bien-être des ménages.

Deuxièmement, si plusieurs études se sont intéressées aux conséquences des catastrophes naturelles sur le secteur financier (Klomp, 2014 ; Keerthiratne et Tol, 2017, Brei et al, 2019), aucune n'a jusqu'à présent exploré les effets sur la structure du crédit. Plus précisément, nous souhaiterions analyser l'impact que pourraient induire les catastrophes naturelles sur la déformation de la structure de crédit selon le type d'agents (entreprises et ménages) et la maturité (court et long termes). Dit autrement, observe-t-on une croissance ou une contraction du crédit aux ménages ou aux entreprises à la suite d'une catastrophe naturelle ? Quelles sont par ailleurs les implications en termes de maturité ? Autant de questions auxquelles nous essayerons d'apporter une réponse dans ce futur projet de recherche.

Comme relevé dans le chapitre 1, l'inclusion financière mesurée en termes de réseau d'agences bancaires contribue à l'amélioration de la qualité des portefeuilles de prêts en limitant les asymétries d'information en ASS. Seulement, l'augmentation du nombre d'agences bancaires dépend foncièrement du développement des infrastructures. D'après le Rapport de la Banque africaine de développement sur les perspectives économiques de l'Afrique en 2018[83], le déficit d'infrastructures auquel est confronté le continent, nécessite des investissements annuels de l'ordre de 130 à 170 milliards de dollars. Si les banques peuvent être considérées comme une partie de la solution pour financer le déficit en question, nous souhaiterons aussi évaluer dans quelle mesure le développement des infrastructures en Afrique peut influer sur la solidité des secteurs bancaires.

Enfin, la période récente a été marquée par un endettement croissant des pays à faible revenu dont la grande majorité est située en Afrique subsaharienne. A fin 2018, le ratio de la dette publique exprimée en pourcentage du PIB était supérieur dans 22 pays d'Afrique subsaharienne, au taux de référence de 55 % défini par le Fonds monétaire international. Plusieurs facteurs de vulnérabilité sont dès lors apparus, parmi lesquels nous pouvons citer l'alourdissement du service de la dette, l'accroissement du risque de refinancement et la réduction des marges de manœuvre budgétaires en cas de ralentissement de l'activité économique. Aussi, selon un Rapport de la Banque mondiale en 2019[84], une part substantielle de la dette publique dans les pays à faible revenu est utilisée pour financement le budget de consommation. Une telle approche ne fait qu'amplifier les vulnérabilités liées à l'accroissement de l'endettement dans la mesure où elle ne crée aucune capacité de production additionnelle pour assurer le remboursement du service de la dette. L'Afrique se caractérise également par un attrait important des banques pour les titres publics ; les banques commerciales sont notamment détentrices d'une part considérable de la dette publique intérieure. D'après

[83] Voir le chapitre 3 du Rapport : "*Africa's infrastructure: great potential but little impact on inclusive growth"*.

[84] The January 2019 Global Economic Prospects report (chapter 4: "Debt in low-income countries: Evolution, implications, and remedies").

les données de Fitchconnect, la part des titres publics dans les bilans bancaires africains était en moyenne égale à près de 20 % en 2017, contre environ 14 % dix ans plus tôt. Au regard de toutes ces considérations, il serait intéressant d'examiner la relation entre l'accroissement de la dette publique et la solidité des secteurs bancaires en Afrique. Ce projet de recherche nous permettra en outre d'évaluer les effets de rétroaction entre les finances publiques et le secteur bancaire.

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