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Preface

The Global Journal of Human-Social Science (GJHSS) is pleased to present this issue, bringing together a curated collection of high-quality research papers that explore diverse dimensions of human society, culture, and the social world.

This issue features research spanning topics including arts & humanities, sociology, history, anthropology, economics, political science, linguistics, education, and interdisciplinary social inquiry. Each paper has undergone a rigorous double-blind peer-review process to ensure scholarly rigor and originality.

We would like to express our sincere gratitude to the authors for entrusting their research with us, to the reviewers for their thorough and constructive evaluations, and to our readers for their continued engagement with the academic discourse.

We hope that the research presented herein inspires further inquiry and contributes meaningfully to the advancement of knowledge in the human and social sciences.

The Chief Editor
Global Journal of Human-Social Science
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Le financement de la protection sociale au Maroc : les options fiscales

Financing social protection in Morocco: tax options

Article Record

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Abstract

The purpose of this article is to reflect on the tax options available for financing social protection, taking into account the specific features of the Moroccan tax system. In light of the results obtained, it appears that Morocco has real room for maneuver to increase its revenues, particularly through direct tax reform, by revising capital income taxation, introducing a wealth tax, and taxing real estate assets. Furthermore, the transition from a predominantly informal economy to a formal framework appears to be an essential lever for broadening the tax base and optimizing public resources. This depends on genuine political will and effective social dialogue. The current situation is characterized by significant deficits that could jeopardize the long-term sustainability of social protection financing. However, the success of these reforms remains dependent on strong political will and effective social dialogue. In a context marked by structural deficits, such measures are crucial to ensuring the long-term sustainability of the social protection system.

financing Morocco social protection taxation Welfare state

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Le financement de la protection sociale au Maroc : les options fiscales

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Abstract

L'objectif de cet article est de mener une réflexion sur les options fiscales dans le financement de la protection sociale en prenant en considération les spécificités du système fiscal marocain. Au vu des résultats obtenus, il semble que le Maroc dispose de marges de manœuvre réelles pour accroître ses recettes notamment via la réforme de la fiscalité directe et ce à travers la révision de l'imposition des revenus du capital, l'introduction d'un impôt sur la fortune et la taxation du patrimoine immobilier. Par ailleurs, la transition d'une économie à dominante informelle vers un cadre formel apparaît comme un levier essentiel pour élargir l'assiette fiscale et optimiser les ressources publiques. Cela est tributaire à une véritable volonté politique et à un dialogue social effectif. La situation actuelle est caractérisée par des déficits importants pouvant remettre en question la pérennité du financement de la protection sociale à long terme. La réussite de ces réformes demeure tributaire d'une volonté politique ferme et d'un dialogue social effectif. Dans un contexte marqué par des déficits structurels, de telles mesures s'avèrent cruciales pour garantir la pérennité du système de protection sociale à long terme.

Keywords: *Social protection, Welfare state, Direct taxation, Informal economy, Morocco*

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1. Introduction

Après la crise sanitaire liée à la propagation du virus Covid-19, le Maroc à l'instar de bon nombre de pays s'est orienté vers la généralisation de la protection sociale. Ainsi, ont été prises un ensemble de mesures visant à assurer, de manière progressive, la généralisation de l'Assurance maladie obligatoire (AMO), des allocations familiales et l'extension de l'assiette d'affiliation aux régimes de retraite, ainsi que la généralisation de l'indemnisation de perte d'emploi , tout étalé sur un échéancier de cinq ans.

Selon le rapport de l'Organisation internationale du travail (OIT) publié en (2020) sur la protection sociale, le Maroc a bien du chemin à parcourir pour arriver à la généralisation de la couverture sociale. Ainsi, seulement 20,5% de la population est couverte par au moins une prestation de protection sociale (hors santé) au Maroc, contre 33,8% en Afrique du Nord, 17,4% pour tout le continent et 46,9 % dans le monde, ce qui montre l'ampleur de l'écart constaté par rapport aux standards internationaux et même par rapport à des économies comparables de la région.

Ce chantier s'inscrit dans un contexte international marqué par une triple crise énergétique, climatique et sanitaire, le Maroc se trouve ainsi face à de multiples chocs externes aggravés par la succession des années de sécheresse et des déficits budgétaires, ainsi l'instauration d'une véritable protection sociale se trouve heurtée à de multiples enjeux notamment ceux liés aux options de financement. Dans ce sens le conseil économique, social et environnemental dans son rapport sur la protection sociale publié en 2018 affirme que la limitation des ressources économiques ne devrait pas être considérée comme un frein rédhibitoire mais plutôt comme un motif supplémentaire de développement de la protection sociale en tant que, et à la fois, outil de réduction des risques sociaux, facteur de renforcement de la cohésion sociale, mécanisme de redistribution et levier de croissance économique (rapport CESE, 2018.p.17).

La protection sociale et la politique fiscale sont généralement examinées séparément, alors qu'elles sont étroitement liées. Les niveaux et la composition des recettes fiscales ont une incidence sur les ressources disponibles pour le financement de la protection sociale et sur leur viabilité dans le temps. Ils influencent également l'incidence nette et l'impact distributif de la politique fiscale. Si la réduction de la pauvreté et des inégalités est au cœur des préoccupations des pouvoirs publics, il convient d'examiner plus attentivement les impôts et les transferts, ainsi que la manière dont ils fonctionnent conjointement. D'ailleurs, le fonctionnement de toute société implique des coûts collectifs qui doivent être couverts par des ressources spécifiques notamment les impôts.

Les systèmes fiscaux des pays en développement présentent généralement de nombreuses faiblesses et la part de l'impôt dans l'économie reste inférieure à ce qui est nécessaire pour soutenir des services publics adéquats. Au niveau national, la combinaison d'une faible part de recettes et d'une accumulation de dettes généralement prudente limite les dépenses publiques, y compris celles consacrées aux filets de sécurité sociale et à l'assurance sociale.

Des stratégies de mobilisation des recettes ont été explorées dans certains pays en développement pour financer la protection sociale. Il s'agit notamment de réformes des taxes sur les ressources naturelles, des redevances et des droits, du transfert des dépenses des subventions et des exonérations fiscales vers la protection sociale, et de la redistribution. Les efforts visant à accroître la capacité fiscale en améliorant l'efficacité de l'administration fiscale et en élargissant l'assiette fiscale sont souvent essentiels, bien que la faisabilité de ces stratégies dépende souvent de considérations d'économie politique.

Le présent papier cherche à apporter une contribution spécifique à propos de la protection sociale en fournissant un aperçu analytique de l'expérience du Maroc, et ce en mettant l'accent sur le lien étroit entre la faisabilité de l'extension de la protection sociale et la capacité économique et politique du pays à générer des ressources durables qui rendent le financement public de ces initiatives viable à long terme. D'ailleurs, plusieurs auteurs se sont focalisés sur les mécanismes de financement de la protection sociale mais peu nombreux sont ceux qui se sont intéressés aux enjeux du financement par l'impôt. Et c'est pour contribuer à la relance du débat autour de cette question que nous avons choisi d'aborder ce thème.

Pour cela, nous allons aborder dans un premier temps le coût de financement de la protection sociale au Maroc, pour ensuite aborder les spécificités du système fiscal marocain, puis les options fiscales de financement.

2. Le coût de financement du système de protection sociale au Maroc

La pierre angulaire de ce projet demeure son mode de financement. En effet, le coût de la généralisation de la protection sociale au Maroc échelonné sur cinq ans, est estimé à 51 milliards de dirhams annuellement et que le financement reposera sur deux mécanismes, à savoir un système d'affiliation (28 milliards de DH) qui concerne les personnes ayant la capacité de participer au financement de la couverture sociale, et un dispositif basé sur la solidarité (23 milliards de DH) qui concerne les personnes n'ayant pas la capacité d'y participer.

Concernant la répartition des 51 MMDH, il faut relever que 14 MMDH ont été consacrés à la généralisation de l'AMO (dont 8,5 MMDH issus du budget général de l'Etat), 20 milliards à la généralisation des allocations familiales (dont 14,5 milliards auprès du budget général de l'Etat), 16 MMDH à l'élargissement de la base des adhérents au système de retraite et 1 MMDH à l'élargissement de l'accès à l'Indemnité pour perte d'emploi (IPE).

Actuellement, une aide directe mensuelle est accordée à 4 millions de ménage soit 12 millions de bénéficiaires dont 5 millions d'enfants et 1 million de personnes âgées.

L'offre de l'aide sociale directe comporte trois mesures essentielles et devrait coûter 25Mds de dirhams par an à l'Etat à partir de 2024, en plus de 10Mds de dirhams liés à la généralisation de l'AMO.

Le gouvernement a pris une série de mesures en vue de réunir les financements de ce programme, en mobilisant 20 MMDH sur les années de 2024 à 2026 à partir des ressources propres de l'Etat, 6 MMDH des revenus d'imposition relatives à la participation sociale solidaire sur les bénéfices et les revenus des entreprises, outres les recettes fiscales relatives à la mise en œuvre de la contribution libératoire au titre des biens et avoirs originaires de l'étranger.

En outre, une enveloppe de 15 MMDH a été mobilisée à travers la rationalisation et de regroupement et la réallocation de crédits budgétaires alloués à des programmes d'aide antérieurs, ainsi que 9 MMDS issus de la réserve du Fonds national de cohésion sociale au titre de 2024 et la mobilisation de 12 MMDH progressivement à l'horizon 2026.

3. Structure et spécificités du système fiscal marocain

Poussé par une situation fiscale difficile, le Maroc a introduit une première vague de réformes fiscales fondamentales au milieu des années 1980 : une TVA, un impôt sur le revenu des personnes physiques et des modifications de l'impôt sur le revenu des personnes physiques. L'impact a été immédiat : les recettes fiscales ont fortement augmenté entre le milieu des années 1980 et le milieu des années 1990, mais ont ensuite stagné pendant une décennie.

D'autres réformes ont été introduites à la fin des années 1990 et au début des années 2000 pour réduire les régimes fiscaux préférentiels, et les charges d'assurance sociale ont été introduites in 2005. En ce qui concerne les institutions, le Maroc a commencé à la fin des années 1990 à organiser des dialogues nationaux sur la fiscalité par le biais de ses Assises sur la Fiscalité (1999, 2013, 2019) afin de faire le point sur l'impact des réformes sur 5 à 10 ans et de définir de nouvelles stratégies à moyen terme par le biais d'une approche inclusive. En 2006, elle a fait œuvre de pionnier en Afrique en publiant ses premiers rapports sur les dépenses fiscales. Un projet audacieux de réforme fonctionnelle d'une administration fiscale fragmentée a été lancé au début des années 2000 et a duré une dizaine d'années.

Préalablement à l'examen des leviers fiscaux destinés au financement de la protection sociale, il convient d'analyser la configuration actuelle des recettes fiscales au Maroc. D'ailleurs, le système fiscal national se distingue par trois principales caractéristiques qui conditionnent son efficacité et son équité. Ces spécificités permettent de saisir les enjeux liés à la mobilisation des ressources publiques.

La première caractéristique du système fiscal marocain réside dans la prépondérance des recettes issues de la fiscalité indirecte, et plus particulièrement de la taxe sur la valeur ajoutée (TVA). Bien que les contributions au titre de l'Impôt sur les Sociétés (IS) et de l'Impôt sur le Revenu (IR) aient affiché une progression soutenue depuis 2014, la structure globale demeure dominée par la consommation. En effet, selon les données du ministère des finances, la TVA représente 29,55% des recettes du budget général au titre de 2025. Cette configuration rapproche le Maroc des modèles fiscaux observés dans de nombreux pays en développement (PED), où la difficulté à élargir l'assiette des impôts directs conduit à une dépendance accrue vis-à-vis des taxes indirectes, souvent jugées plus faciles à collecter mais moins redistributives. Malgré une dynamique de croissance des impôts directs (l'IS et l'IR) constituant désormais environ 28,50 % des recettes du budget général, le poids de la fiscalité indirecte reste le pivot de la mobilisation des ressources publiques au Maroc.

La deuxième caractéristique réside dans la concentration disproportionnée des incitations publiques au profit d'une minorité de secteurs d'activité, plutôt que dans une approche transverse de stimulation économique. Cette sélectivité fiscale se cristallise principalement autour de trois domaines clés : l'immobilier, l'agriculture et l'enseignement privé. Selon le rapport d'Oxfam (2021), le maintien de ces dispositifs de faveur apparaît économiquement injustifié au regard de la maturité ou de la nature de ces secteurs. Ainsi, le secteur immobilier capte une part prédominante des avantages alors qu'il mobilise déjà près de la moitié de la formation brute de capital fixe (FBCF) nationale. Parallèlement, l'agriculture bénéficie de rentes fiscales malgré des avantages comparatifs naturels dans la zone MENA qui la prémunissent de la concurrence internationale, tandis que l'enseignement privé jouit d'exonérations alors que son activité demeure structurellement limitée à une niche géographique et sociale urbaine.

La troisième caractéristique du système fiscal marocain réside dans l'ampleur de l'évasion et de la fraude fiscales. Selon les données du *Tax Justice Network (TJN)* publiées en 2023, le manque à gagner annuel pour les finances publiques nationales est estimé à environ 9,8 milliards de dollars. L'incidence de ces pertes sur le financement des services sociaux est significative : elles représentent l'équivalent de 36,14 % du budget alloué au secteur de la santé et 14,43 % des dépenses publiques consacrées à l'éducation.

4. Financement de la protection sociale au Maroc : les leviers fiscaux

4.1. Fiscalité indirecte et financement de la protection sociale

Le modèle de financement du budget général au Maroc se caractérise par une dépendance structurelle vis-à-vis de la fiscalité indirecte, au sein de laquelle la taxe sur la valeur ajoutée occupe une place prépondérante. Bien que ce mode de prélèvement garantisse une rentrée de fonds rapide et massive, sa prédominance soulève des interrogations majeures quant à sa compatibilité avec les ambitions de l'Etat social. En effet, une littérature économique croissante met en garde contre l'utilisation des taxes à la consommation comme levier principal de financement de la solidarité.

Selon une étude effectuée par la Confédération Syndicale Internationale (CSI, 2021), dont l'objectif était d'évaluer les effets de l'investissement dans la protection sociale en appliquant différents types d'impôts, au regard des principaux indicateurs économiques de huit pays sélectionnés (Bangladesh, Inde, Ghana, Rwanda, Géorgie, Serbie, Colombie, Costa rica), les résultats ont montré que l'étude de l'impact consécutif à l'investissement dans la protection sociale par le biais d'impôts indirects (taxes à la consommation, sur les ventes, le commerce, etc.) donne de moins bons résultats dans tous les pays. Cela est tributaire au fait que les impôts indirects provoquent une augmentation supplémentaire des prix à la production et, par conséquent, de l'ensemble des prix à la consommation, ce qui fait baisser les revenus réels, décourage la consommation et l'investissement, et annule tout effet positif des transferts de protection sociale. Ces résultats corroborent ceux d'Ortiz et al (2019) qui soulignent que la hausse des impôts indirects risque d'aggraver les inégalités de revenu à cause de la charge disproportionnée que les taxes à la consommation font peser sur les quintiles de revenu les plus faibles de la société.

Lustig et al. (2013) constatent qu'en Bolivie, au Brésil et en Uruguay, les taxes à la consommation réduisent l'impact redistributif du système fiscal. En Bolivie et au Brésil, les impôts indirects annulent presque complètement l'impact des transferts en espèces sur la réduction de la pauvreté. En effet, il apparaît regrettable que la structure des recettes fiscales marocaines présente une telle dépendance à l'égard d'une imposition au caractère régressif marqué. Cette situation est d'autant plus préoccupante que la contribution de la TVA au produit fiscal global s'inscrit dans une trajectoire ascendante depuis le début du XXIe siècle.

Ainsi, une véritable refonte du système fiscal marocain, garant d'une meilleure contribution au financement de la protection sociale notamment à travers le rôle redistributif de l'impôt, doit forcément porter sur les impôts progressifs, notamment en révisant à la hausse l'impôt sur les hauts revenus et l'imposition du capital et patrimoine non productif.

4.2. L'impôt sur le revenu : impôt favorable aux riches et préjudiciable pour la classe moyenne

Inspirées des doctrines néolibérales, les politiques fiscales des dernières décennies au Maroc ont privilégié un allègement de l'impôt pour les hauts revenus au détriment des classes moyennes et populaires. Cette politique a conduit à une pression fiscale accrue sur les salaires plutôt que sur le capital. Ce choix trouve sa justification dans la théorie du « ruissellement » selon laquelle les avantages accordés aux riches ou aux entreprises finiront par bénéficier aux classes inférieures sous forme de création d'emplois, d'investissements et de croissance économique.

L'injustice fiscale entre les salariés et les autres contribuables se manifeste par la contribution des salariés atteignant 75% au total de l'IR au Maroc contre 25% de contribution pour les revenus professionnels, fonciers, agricoles et des capitaux. De plus, la pression de l'IR est principalement supportée par les revenus de la classe moyenne, près de trois quarts de l'IR sont payés par 47% des salariés (Oxfam, 2020).

Quant au barème de l'IR, sa « progressivité » est essentiellement concentrée sur les tranches de revenus modestes ou moyens (10% à partir d'un revenu annuel de 30001 Dh, puis s'élevant rapidement à 30% dès que ce revenu atteint 80001 Dh), et disparaît lorsque le revenu dépasse 180000 Dh. Il s'agit en effet d'une « progressivité régressive » matérialisée par une charge fiscale supportée par la classe moyenne plutôt que par les classes aisées (Akesbi, 2017). De ce fait, le barème d'imposition de l'IR au Maroc prend une forme logarithmique traduisant une augmentation plus rapide pour les revenus faibles et moyens et une stagnation quand il s'agit de revenus élevés.

La configuration actuelle du système fiscal privilégie les revenus du capital au détriment de ceux du travail. Cette hiérarchie s'opère par une double modalité, d'abord par l'application de taux moins importants et puis par les taux libératoires et droits de restitution.

Cette asymétrie fiscale crée un déséquilibre structurel dans la mesure où la généralisation de la protection sociale ne s'accompagne pas encore d'une contribution équivalente des revenus issus du capital ou d'une fiscalité de patrimoine plus redistributive.

4.3. L'imposition du capital : entre théories du ruissellement et impératifs de justice sociale

L'opportunité d'un impôt sur la fortune (ISF) demeure au cœur des débats de politique fiscale, cristallisant des positions divergentes quant à sa légitimité économique. Les détracteurs de cette mesure soulignent une absence de consensus parmi les acteurs économiques, arguant d'une carence de justification empirique. À cet effet, les travaux de l'OCDE (2018) démontrent que l'impôt sur la fortune a globalement failli à ses ambitions redistributives. La faiblesse des recettes générées a conduit à un mouvement d'abrogation : alors que douze pays de l'organisation appliquaient cette taxe en 1990, ils n'étaient plus que quatre en 2017. Par ailleurs, des organisations patronales telles que la CGEM dénoncent une distorsion fiscale, assimilant l'ISF à une double taxation de revenus déjà assujettis à l'impôt au titre de leur progressivité.

À l'opposé de cette vision libérale, les partisans d'une fiscalité patrimoniale considèrent l'ISF comme un instrument structurel de lutte contre la concentration excessive du capital et des inégalités (Piketty, 2015a, 2015b). Cette perspective s'inscrit dans une volonté de corriger les mécanismes d'accaparement des richesses. Si l'argument de l'évasion fiscale et du risque de désinvestissement est fréquemment mobilisé notamment dans le contexte marocain, la validité scientifique de la « théorie du ruissellement » est aujourd'hui largement remise en question. Un rapport du FMI (2015) a ainsi infirmé l'idée selon laquelle l'allégement fiscal des plus hauts revenus stimulerait mécaniquement l'investissement et l'emploi. En outre, le rapport Oxfam (2021) souligne l'absence de corrélation empirique entre les exonérations fiscales et l'amélioration tangible de la performance économique ou sociale, l'impact sur l'investissement additionnel et la création d'emplois étant jugé marginal. Cette configuration suggère que ces incitations servent davantage à réduire la pression fiscale sur les grands opérateurs qu'à stimuler la productivité réelle des facteurs. Sur le plan macroéconomique, ce système génère un manque à gagner estimé à 3 milliards de dollars, soit environ 3 % du PIB. Ce coût d'opportunité, équivalent au double

des budgets cumulés de la santé et de l'éducation, fragilise l'équilibre budgétaire national et pose un défi critique en matière d'équité sociale et de redistribution des richesses.

Les analyses d'Oxfam proposent une taxation ciblée : ainsi une contribution de 5 % sur les revenus des individus les plus fortunés aurait permis de couvrir l'intégralité des besoins de financement liés à la crise sanitaire dans la région MENA. Sur le plan macroéconomique, le FMI (2015) souligne qu'une augmentation de 1 % de la part de revenu des 20 % les plus riches induit une contraction de la croissance de 0,08 %. À l'inverse, l'amélioration du revenu des tranches inférieures agit comme un catalyseur du dynamisme économique.

Ainsi, l'impératif de justice sociale exige une corrélation étroite entre capacité contributive et charge fiscale. Au Maroc, le rétrécissement de la base imposable fait peser de manière disproportionnée l'effort budgétaire sur la classe moyenne. Une réforme structurelle du système fiscal s'avère donc nécessaire pour pérenniser le financement de la protection sociale. Cela suppose un renforcement de la progressivité de l'impôt, incluant notamment une réévaluation de la fiscalité foncière et des transactions boursières, afin d'assurer une contribution équitable des hauts revenus à l'équilibre des finances publiques.

4.4. L'Impôt sur la Fortune Immobilière (IFI) : un compromis stratégique pour la redistribution

Si le débat national sur l'imposition globale de la fortune reste marqué par de fortes divergences et des craintes liées à la fuite des capitaux, une mesure plus ciblée et sectorielle consistant en l'instauration d'un impôt sur la fortune immobilière peut constituer une alternative pour concilier impératifs budgétaires et justice distributive. L'idée d'un tel impôt est de plus en plus discutée, notamment à la suite des travaux publiés en 2024 par l'Initiative arabe pour la réforme selon lesquels la structure fiscale actuelle présente un déséquilibre structurel en favorisant les revenus du capital, tandis que l'assiette fiscale demeure étroite et repose majoritairement sur les contributions de la classe moyenne. L'introduction d'un IFI progressif, ciblant environ 5 % des propriétés les plus valorisées avec des taux variant de 0,5 % à 1,5 %, permettrait de générer des recettes annuelles de près de 8,37 milliards de dirhams.

Ce potentiel de mobilisation de ressources constituerait un apport stratégique, représentant 26 % du budget 2021 dédié à la solidarité dans le cadre de la réforme sociale, et couvrant entre 14 % et 17 % des besoins globaux de financement annuel. En ciblant spécifiquement les actifs d'une valeur supérieure à 10 millions de dirhams, soit environ 36 000 propriétés sur les 8 millions recensées au Maroc, cette taxe serait en mesure de rééquilibrer l'assiette fiscale nationale. Elle permettrait ainsi de diminuer la dépendance vis-à-vis des revenus du travail et d'encourager la réallocation des capitaux vers des investissements productifs au sein de l'économie nationale (Kamal, 2024).

5. Le manque à gagner de la transition d'une économie informelle à une économie formelle

Le secteur informel représente plus de 70% de l'emploi total dans les économies émergentes et en développement et contribue à pratiquement un tiers du PIB. La prédominance de cette économie de l'ombre réduit la capacité des pays à mobiliser les ressources budgétaires nécessaires pour stimuler l'activité économique en période de crise, mener des politiques macroéconomiques efficaces et constituer le capital humain indispensable au développement à long terme (Banque mondiale, 2022).

En Europe-Asie centrale et en Amérique latine-Caraïbes comme au Moyen-Orient et en Afrique du Nord, le poids de la réglementation et de la fiscalité et la faiblesse des institutions sont deux facteurs importants de l'informalité. Dans ce sens, la Banque Mondiale dans son rapport sur l'informalité et la croissance inclusive dans la région MENA (2023), en mettant l'accent sur trois pays dont le Maroc, l'Egypte et la Tunisie, affirme qu'il existe un ensemble d'éléments qui incitent les agents économiques à opérer dans l'informel : les relations entrepreneur-travailleur, les impôts et les transferts et les conditions du marché.

Les relations de travail sont souvent informelles en raison des incitations en ce sens, encouragées par l'absence de cadres juridiques et réglementaires ou par des distorsions de ceux-ci, ce qui permet aux entreprises d'embaucher des travailleurs de manière informelle. Pour les impôts et les politiques de transfert, elles jouent un rôle important dans le développement de l'informalité car les entreprises peuvent réduire leur charge fiscale et disposer d'une plus grande flexibilité dans la gestion de leur main-d'œuvre lorsqu'elles opèrent à petite échelle et de manière partiellement informelle ; les travailleurs peuvent, dans certains contextes, bénéficier d'une assistance sociale tout en travaillant de manière informelle, sans payer d'impôts sur leurs revenus. En outre, les conditions du marché, notamment une concurrence limitée, un faible dynamisme du secteur privé, un accès difficile au crédit et à l'exécution du crédit, ainsi qu'aux contrats commerciaux contribuent à l'informalité.

Le même rapport incite au passage à un système de protection sociale plus inclusif, où les principes d'universalité par rapport à la population concernée et d'égalité des prestations remplacent la segmentation actuelle des régimes de protection sociale et la couverture implicite inégale des travailleurs et des familles. Cela contribuera aux sources de financement de la protection sociale : ainsi les risques communs à tous les citoyens seront financés par les impôts, les risques communs à tous les travailleurs seraient financés par les revenus des travailleurs, et les risques spécifiques aux travailleurs employés dans les entreprises seraient financés par les cotisations des entreprises et seraient proportionnels aux salaires des travailleurs.

Bien que le Maroc ait entrepris de multiples mesures pour contrôler l'économie informelle, entre autres, la simplification des procédures administratives à travers la création des Centres Régionaux d'Investissement, du système fiscal pour alléger le fardeau fiscal des entreprises, du marché financier pour faciliter l'accès au crédit, ainsi qu'au niveau de l'intégration commerciale avec les principaux partenaires (Medina et Schneider, 2018), l'économie informelle « au sens large » demeure un phénomène persistant et préoccupant, pesant jusqu'à 30% du PIB selon les dernières données de Bank Al-Maghrib datant de 2018[1]. Les institutions nationales et internationales estiment qu'entre 60% à 80% de la population active occupée au Maroc exercent une activité informelle.

Le Conseil économique social et environnemental (2021) souligne que l'économie informelle, dans son acceptation la plus large, est plurielle étant donné la multiplicité des catégories qu'elle renferme. Il est à préciser, néanmoins, que ce sont les formes « hors informel de subsistance » qui constituent la véritable menace pour notre pays, à l'image de la contrebande, des activités souterraines des entreprises « formelles » (sous-déclaration du chiffre d'affaires ou des employés, etc.), ainsi que l'informel « concurrentiel » au niveau duquel les

[1]L'économie informelle au Maroc pèse plus de 20% du PIB, hors secteur primaire et 10% des importations formelles. Elle impacte de manière variable les secteurs d'activités : 54% du poids de l'économie informelle dans le textile et habillement, 32% dans le transport routier de marchandises, 31% dans le BTP et 26% dans l'industrie agroalimentaire et tabac, hors secteur primaire.

opérateurs se soustraient délibérément de leurs obligations bien qu'ils disposent des ressources et des structures nécessaires pour s'en acquitter[2].

L'informalité permet, certes, à de larges franges de la population de subsister et d'échapper au chômage, mais favorise en même temps la précarité sur le marché de l'emploi, exerce une concurrence déloyale sur les entreprises formelles et pénalise l'économie nationale, avec un manque à gagner significatif en matière de recettes fiscales. Ce manque à gagner pour la recette fiscale est de 30 milliards de dirhams, d'une valeur ajoutée de 140 MMDH, correspondant à un PIB de 170 MMDH soit 21% du PIB national hors secteur primaire (CGEM, 2014). Ce manque à gagner pour l'Etat affaiblit ses capacités de financement et d'offre de services publics (manque à gagner estimé à près de 40 Mds DH en 2014). D'ailleurs, l'informel demeure un large pourvoyeur d'emploi avec 2,4 millions d'emplois.

Pour les emplois, le total des populations occupées en 2014 était de 10 632 000, la répartition des actifs occupés hors secteur primaire fait qu'ils étaient 6 432 000 actifs dont 2 659 000 dans l'informel soit 41% du total des occupés. Cette masse de travailleurs se répartit entre 90 % travaillant dans des unités de productions informelles, 8% travaille dans le noir (emploi non déclaré par les employeurs) et 2% ont des activités de contrebande.

Autre caractéristique, les emplois liés aux Unités de Production Informelles sont salariés à 17% seulement en moyenne le reste c'est soit du travail non rémunéré ou de l'auto emploi. Cela constitue un manque à gagner pour l'Etat de l'ordre de 34 milliards de DH, 4 millions de cotisations sociales potentielles, dont 28 milliards de TVA, 4 milliards d'IS et 2 milliards de droits de douanes. Ce manque à gagner pourra contribuer considérablement au financement de la protection sociale.

6. Conclusion

La protection sociale est un investissement dans le développement social et économique des sociétés et des individus. Ainsi, non seulement elle aide les personnes à faire face aux risques et à réduire les inégalités, mais elle leur permet également de développer pleinement leur potentiel d'épanouissement personnel et d'apporter une contribution significative à leur société tout au long de leur vie.

Au Maroc, la protection sociale est principalement financée par les contribuables, le budget de l'Etat et le recours à l'emprunt. Dans cette perspective, nous avons analysé les défis structurels inhérents à ce modèle de financement en mettant l'accent sur le levier fiscal comme instrument de pérennisation et d'équité.

Notre analyse montre que la protection sociale et la politique fiscale sont généralement abordées de manière dissociée, alors qu'elles devraient être analysées de façon conjointe. Dans cette perspective, nous avons examiné les principales caractéristiques du système fiscal marocain dont les recettes restent largement dominées par les impôts indirects notamment la TVA, la concentration disproportionnée des incitations publiques au profit d'une minorité de secteurs d'activité et la troisième caractéristique consistant en l'ampleur de l'évasion et de la fraude fiscales. Par la suite nous avons présenté les leviers fiscaux à travers lesquels l'Etat peut dégager des recettes fiscales permettant de contribuer au financement de la protection sociale, il s'agit de l'imposition du capital notamment à travers l'instauration d'un impôt sur la fortune sachant que les ressources issues de la TVA et destinés à financer la protection sociale n'ont qu'un effet redistributif marginal voire nul d'où l'intérêt de se baser sur des impôts plutôt progressif. Nous avons également porté l'accent sur l'impôt sur la fortune immobilière qui peut constituer une alternative ciblée de financement avec moins de risque en raison de l'inélasticité de la base des contribuables.

Nous avons analysé par la suite le manque à gagner de la transition d'une économie informelle à une économie formelle, ce manque affaiblit les capacités de financement de l'Etat et sa capacité d'offre de services publics, notamment en ce qui se rapporte aux services liés à la protection sociale. Dans ce sens, l'incitation à résorber l'économie informelle permettra de mobiliser un important potentiel de cotisations sociales potentielles à travers l'élargissement de la base des contribuables, mais également de dégager des recettes fiscales qui contribueront efficacement au financement de la protection sociale.

Au final, la réussite de toute réforme fiscale favorable à l'Etat sociale exige un engagement politique renouvelé, soutenu par une modernisation de l'administration fiscale et un renforcement de ses capacités analytiques, conditions *sine qua non* pour une communication efficace des objectifs de la réforme. Dans cette perspective, la transparence et la rigueur dans la lutte contre la fraude et l'évasion fiscale constituent des piliers indispensables pour asseoir la légitimité de cette transformation. Les autorités doivent impérativement intégrer dans leur stratégie les résistances émanant de divers groupes d'intérêt, d'une part, les groupes de pression influents et structurés, et d'autre part, une opinion publique et des consommateurs moins organisés mais sensibles aux impacts sociaux. À cette fin, il est crucial d'identifier précisément les verrous institutionnels et de déployer une action publique qui tienne compte de l'ensemble des facteurs d'économie politique, garantissant ainsi la viabilité et l'acceptabilité de la réforme sur le long terme.

Le dialogue social entre le gouvernement, les employeurs et les travailleurs ainsi que la société civile, les universitaires, et les agences internationales, entre autres, demeure fondamental pour exploiter les meilleures options possibles en matière de possibilités de financement de la protection sociale mais surtout pour assurer sa pérennité.

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Impacts of Prices on Brazil's Natural Rubber Exports in Four Historical Periods over 198 Years

Article Record

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Abstract

The objectives of the research are: a – to create a model that describes the trajectory of natural rubber exports from 1827 to 2024, with its price as an exogenous variable; b – to assess the impact of prices on the model that describes the trajectory of exports; c – to estimate the heterogeneities/homogeneities of natural rubber exports and prices in each of the four periods into which the series was divided in this study; d – to estimate the annual growth rates of natural rubber exports and prices in the four periods. The research covers annual time series of natural rubber exports and prices for the period 1827–2024. An ARIMAX model was used to describe the trajectory of Brazilian exports, with prices as exogenous variables.

The research identified four historical periods: The first (1827/1878) when Brazil held a monopoly on exports and, in this position, set the prices. The second period (1879/1912), which became known as the "Rubber Cycle," when exports and prices showed the highest growth rates. During this period, there was competition from natural rubber produced in Southeast Asian countries. The third period (1913/1950) was characterized by the loss of competitiveness of Brazilian exports. In the fourth period (1951/2024), Brazil became a net importer of the commodity. The research shows the great instability of Brazilian exports and natural rubber prices in the four periods studied, the significant growth in prices and quantities exported in the "rubber cycle," as well as the significant decline in these variables in the third and fourth periods, when Brazil lost its ability to compete in the international market for this commodity.

Commodity | Southeast Asia | Rubber cycle | ARIMAX model

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1. Introduction

The rubber tree *(Hevea brasiliensis)*, from which is extracted natural rubber, is native from the Amazon Region in South America, where it is found mainly in its native form. During the entire nineteenth century, and the first decade of the twentieth century, natural rubber was a product of great importance for Brazilian international trade. In this period, exports reached the same level as coffee exports. In that period this activity was an important source of employment in the Brazilian Amazon Region, in the various stages of preparation, from the bleeding of the trees, through collection and smoking of latex, to the first processing that took place within the areas of exploitation (Akers, 1912; Santos, 1980; Lemos, 1983; Pinto, 1984; Silva, 2022).

As labor was scarce in the Brazilian Amazon region, the extraction of latex from rubber trees also served as a work alternative for people plagued by the frequent droughts that occur in the semi-arid region of Northeast in Brazil. This contributed to increase the occupation of the Brazilian Amazon, with Brazilians coming from that region (Araújo, 2015).

Brazil led the production of natural rubber, probably starting in the late 1700's, but the first register occurred in 1827 when it was recorded that Brazil exported 31 tons of natural rubber that year. Until the late 1870's exports of natural rubber were totally dominated by Brazilian production from the Amazonian rubber native trees. This period was characterized by low levels of production and productivity, shortage of labor and high production costs. This was translated into the high prices at which natural rubber was sold until the year 1910. (Akers. 1912; Barham, Oliver, 1994; Collier, 1968; 1993; Dean, 1987; Frank, Musacchio, 2022; Lemos, 1983; Santos, 1980; Silva, 2022; Sudhevea, 1983; Weinstein, 1993).

Nevertheless, exports in this period made a great contribution to the accumulation of foreign exchange and the formation of wealth in the country. The exportation of natural rubber extracted from the native rubber trees in the Amazon region transformed small cities of that time, such as Belém and Manaus, into large centers, which were even compared, in the early 1900s, to European cities such as Paris, for example (Weinstein, 1993).

In 1913, natural rubber production in Southeast Asia surpassed rubber production in Brazil. Also, in 1913 natural rubber prices began to decline, initially quite rapidly (from 1913 to 1947), and then remained low from 1948 until the present days (Akers, 1912; Gonçalves et al 2021; Collier, 1968; Dean, 1987; Morales, 2002; Oliveira et al, 2012; Pandolfo, 1994; Santos, 1980; Lemos, 1983; Weinstein, 1983).

Natural rubber was an important raw material in the world and was of great relevance in the period of industrial development from the end of the nineteenth century. This development, especially

of the automobile industry, made the international demand for natural rubber grow rapidly. According to Weinstein (1983), the export economy resulting from this confluence of economic forces generated unprecedented commercial and demographic growth in the Amazon region and made this part of Brazil one of the most promising centers of commerce in this Country.

Also, according to this author (Weinstein,1983), in the early 1900's demand continued to grow, and when in 1909/1910 the price of natural rubber reached its highest level, rubber grown in plantations in Southwest Asia appeared on the world market in large quantities, causing prices to fall after those years.

In 1880 began to enter the production of natural rubber from rubber plantations grown in Southeast Asia, with higher productivity, and lower costs, which increased production, stimulated by the nascent automotive industry. In this phase the world production grew quite significantly, and the Brazilian production also participated in this phase with a growing expansion of Brazilian exports, although already with evident loss of competitiveness in terms of worker productivity and exploited trees (Lemos, 1983).

In previous research, Lemos (2023), using ARIMA models in both series, described the trajectories of exports and prices of natural rubber exported by Brazil between 1827 and 2021. In that study, the hypothesis tested was that errors in price forecasting would lead to errors in export forecasting. To achieve its objectives, the study estimated two models ARIMA (0,1,1) , to forecast exports and prices of natural rubber exported by Brazil during that period. The evidence found in that study showed that, in fact, errors made in price forecasting (remembering that between 1827 and 1878 Brazil held a monopoly on those exports and therefore set the prices) did indeed lead to errors in the quantities exported, both positively and negatively.

In this study, the hypothesis tested is that the price of natural rubber exported by Brazil between 1827 and 2024 is an exogenous variable and, for this reason, must have influenced Brazilian exports of this commodity during the 198 years studied. Therefore, the appropriate model for making this prediction is ARIMAX (Box and Tiao, 1975). Unlike the ARIMA model, which is univariate, this model is considered multivariate because it adds components also called exogenous variables (Bennet et al., 2014).

Until the end of the 19th century, only Brazil produced this commodity and, therefore, set its prices, which were also influenced by growing demand which will be shown in this research. Brazilian natural rubber was produced from the extraction of rubber trees, which are native to the Amazon Region. The evolution of Brazilian natural rubber's share of the international market has gone through at least four periods.

For this reason, the series of natural rubber exports was subdivided into four periods. The first period extends from 1827 to 1878. At that stage, Brazil was the sole exporter of natural rubber produced from native rubber trees in the Brazilian Amazon. The second period begins in 1879 and extends to 1912, a period that became known as the "Rubber Cycle." At this stage, rubber produced from rubber trees cultivated in Malaysia had already entered into the market, but Brazilian exports still dominated and showed their greatest expansion throughout the analyzed series.

Thus, Brazilian exports of natural rubber, in addition to being unique for 51 years (1827-1878) since records of these exports began to appear, had a major influence on both price formation and the quantities demanded by exports during the following 33 years (1879-1912).

The third period of the study begins in 1913 and extends to 1950 when Brazil became an importer of natural rubber (Esperante, 2020; Jacks, 2019). The fourth and final period began in 1951 and continues to the present day, when Brazilian exports of natural rubber collapsed and the country became a net importer of this important commodity.

Anchored in these scenarios of almost two centuries (198 years), the present research seeks to achieve the following objectives: a - estimate model to forecast natural rubber exportation from 1827 to 2025, with its price as an exogenous variable influencing these exports; b - assess the impact of prices on the export forecast model; c - estimate the heterogeneities/homogeneities of exports and natural rubber prices in each of the four periods into which the series was divided in this study; d - estimate the growth rates of natural rubber exports in the four periods in which the trajectory of Brazilian natural rubber exports was classified.

2. Brief historical background and perspectives

The opening of Brazilian ports, made in 1808 to friendly nations, enabled access to international trade in Amazonian rubber. According to Weinstein (1993), by the beginning of the nineteenth century, syringe and rubber balloons were already seen in Europe. Santos (1980), however, points out that there are no official records of exports before 1827, when 31 tons of rubber were exported. To have an idea of the growing demand, the Amazon region produced 156 tons in 1830, 388 tons in 1840 and reached 2673 tons in 1860 (Weinstein, 1993). At this time, Brazil had the monopoly on the production and export of rubber.

Nevertheless, this increase in exports represented little compared to what happened during the boom of the rubber cycle that, according to Gonçalves et al (2021), was from 1879 to 1912. In this period, there was the abolition of slaves in Brazil, which occurred in 1888, the fall of the monarchy and the beginning of the republic, in 1889. The abolition of slaves did not have much influence on rubber production, considering that slaves in the Amazon, according to Santos (1980), were more used in household services and in the food-producing plantation. Also, because no new slaves had entered the Amazon since 1834, due to the intense inspection by the British navy in the Atlantic.

However, the fall of the monarchy had a great influence on the collection of taxes from rubber exports. With the decentralization resulting from the federalism implanted in the Republic, the Brazilian States could keep their share of the taxes collected, which previously went directly sent to the central government. This provided greater freedom for local governments in Amazon Region States to apply internally (Weinstein, 1993). It was also during this period that the search for new areas of native rubber took place. This caused exploiters from the Brazilian Amazon, the so-called "rubber soldiers", to enter into the neighboring Amazonian part of Bolivia's territory, provoking a conflict that was only resolved with the signing of the Treaty of Petropolis in 1903, which gave rise to the current State of Acre (Homma, 2014; Silva, 2022).

As observed by Machado et al. (2012), rubber exports quantity only increased in the early twentieth century. In 1901, the product already had a relevant participation in Brazilian exports (21%) and, in the following years, it was only increasing in such a way that, in 1910, it came to represent 40% of everything that was exported by the country. Weaving a comparison with the export of coffee, the main Brazilian export product, it is observed that in 1910 the two commodities had almost the same share in the country's exports (40% rubber against 41% of coffee). This shows the relevance of rubber on the national scenario (Machado et al. 2012).

It was also important in the colonization process of the Amazon region, both at the time of the end of the Empire and the beginning of the Republic (1889), and in the colonization policies adopted for the Amazon, for recruiting workers from the Northeast region, especially during the periods of droughts, when these workers were left without an occupation that would provide them with remuneration. Therefore, its importance was both: regional and national (Babcock, 1966; Santos, 1980; Lemos, 1983; Pinto, 1984).

According to Lemos (2020) it is recorded that there were 20 years of droughts in the 1800s, of which 4 years were between 1877 and 1889. In the Year 1900, also occurred drought in Northeast. Therefore, between the years 1877 and 1900 droughts occurred in 5 years. In this period a total of 96,021 people emigrated from the Northeast to the Amazon Region, probably driven by drought, with an annual average of 24,005, with the largest contingent of 45,792 emigrating in 1900. There are no records of the number of emigrants from the Northeast to the Amazon region before 1877 (Lemos, 2020).

This migratory movement, associated with the production and export of natural rubber, had a significant impact on the population of the region. According to Santos (1980), the population of the Amazon region was approximately 278,250 people in 1860. In 1910, it was estimated at 1,217,024 people. It should be noted that its great expansion occurred between 1890 and 1910, when the population went from 389,997 to 1,217,024 people. An increase of more than three times in 20 years Santos (1980).

In 1870, the British collected seeds from native Amazonian rubber trees. The rubber tree was first domesticated in Southeast Asia, in Malaysia, in 1876. All the genetic improvement technology for the species was created and the first primary clones were produced. In 1898, Malaysia placed around 145 tons of natural rubber produced from these cultivated rubber trees on the market. From that year on, competition began, with natural rubber extracted in the Amazon at a technological disadvantage compared to rubber produced on plantations in Asia (Morales, 2002).

In Brazil, only after Asian production volumes entered the market did Brazil react by conducting studies and implementing the first cultivation experiments According to Cardoso et al (2021), it was in Bahia, in 1908, at the São Bento das Lages Agricultural School, located in the Recôncavo Baiano, that the first forest of 35 rubber trees was planted. A delay of more than thirty years later. However, during this period, the largest experiment in rubber cultivation was that of Ford between 1927 and 1945 with Fordlândia. Despite receiving advantages from the governments of the time, the project did not prosper, mainly because of the attack of "leaf blight" caused by the fungus *Microcyclus ulei* on rubber tree plantations, among other problems. (Cardoso, et al 2022; Morales, 2002; Weinstein,1993).

According to Paula (1980), in 1892 Brazil accounted for 61% of global rubber production. In 1910, world production of native rubber was 62,000 tons, while rubber produced from planted rubber plantations rose to 8,000 tons. In 1920, native rubber production fell to 42,000 tons, while planted rubber production grew significantly to 360,000 tons. In 1923, Brazilian native rubber accounted for only 8.4% of total production, while rubber extracted from plantations increased its market share to 91.6% . In 1926, Southeast Asian countries produced 93% of global production (Paula, 1980).

Also, according to Morales (2002), in 1913, Southeast Asian rubber production surpassed that of Brazil. In 1920 the natural rubber produced in the Brazilian Amazon supplied a little more than 10% of the world supply, and that from cultivated rubber plantations was close to 90% coming, almost entirely, from Southeast Asia. Nowadays, the main natural rubber producing countries are: Thailand, Indonesia and Vietnam. The Brazilian participation had been reduced to 6.8% . From then on, there was a reversal of the export curve. Rubber extraction in Brazil went into decline, leading to the collapse of the rubber economy. As a result, the Amazon region would enter a period of deep economic depression (Conab, 2019; Furtado, 2005; Lemos, 1983; SanTos, 1980; Souza, 2010).

The impact of the rubber market can also be observed through the behavior of its export prices, throughout the expansion of production and demand. According to Machado et al. (2012), the price of the exported ton of rubber was approximately 160 pounds/ton, at the beginning of the last decade of the 19th century; at almost 300 pounds/ton, in 1900; then reached 964,5 pounds/ton in 1910, its highest price during this historical series. In fact, rubber prices, after 1910, began to experience a significant decline. The decline in international prices was due to the Asian production that, after 1910 increased significantly, becoming a strong competitor of Amazonian production, resulting in a sharp decline in Brazilian natural rubber exports (Lemos, 1983; Furtado, 2005; Machado et al., 2012).

The rapid growth in demand for rubber soon showed that the supply of natural rubber alone could not satisfy the world demands. With the imminence of the outbreak of the First World War (1914-1918), Russia and Germany adopted the strategy of investing in research to develop rubber synthetically and no longer be dependent on the production coming from Southwest Asia. Between the first and Second World War there were many advances in the production of synthetic rubber, and the technique was already mastered for large scale production (Caetano, 2021; Machado et al, 2012).

The advent of World War II (1939 to 1945) forced the American government to invest massively in the production of synthetic rubber. Between 1942 and 1944, were built 87 plants in the United States, which had an estimated overall annual capacity of one million tons of synthetic rubber. Germany, for the same reasons, also increased the production of synthetic rubber, and five large factories were built, with a total production capacity of 175,000 tons (Fonseca, 1970; Santos, 1980; Morales, 2002; Furtado, 2005).

The demand for rubber in World War II was enormous, and the product became a strategic material. The United States, in 1939, was already working on steel, oil, and rubber as essential inputs. In 1940, with the advance of the Germans, the president of the United States at the time Franklin Roosevelt, drew up a defense plan, where rubber had a fundamental role. At first, the country began to buy and stock rubber and rationalize its use. However, when Japan closed the borders of Southeast Asia, cutting off the supply of American natural rubber, the country put the rubber plan into execution. One of the measures in the plan was to accelerate the production of synthetic rubber (Lemos, 1983; Machado et al, 2012; Morales, 2002 ; Pinizzotto, Jianfeng 2021).

Another was to encourage the production of natural rubber in regions where the opposing countries in the war had no dominion, and the Brazilian Amazon was chosen to fulfill this role. Soon the American agency Rubber Reserve Company (RRC) was created to manage the production that, in 1943, became the responsibility of the Rubber Development Company (RDC) (Lemos, 1983; Machado et al, 2012; Morales, 2002 ; Pinizzotto, Jianfeng 2021).

3. Material and methods

The variables used in the research were: quantities exported and prices of rubber between 1827 to 2024 (198 years including the years 1827 and 2024 in the series). The information for the period from 1827 to 1980 was extracted from the research by Lemos, 1983, who used it to estimate export and price cycles for this and other commodities in his Doctoral Thesis in Agricultural Economics. Data from 1988 to 2024 were extracted from site of the Ministry of Industry and Commerce (MIC, 2025). During this period, according to the Central Bank of Brazil (BACEN, 2007), there were nine (9) different types of currencies in Brazil. The prices were updated to 2024 Real (R$), using the general price index, domestic availability (IGP-DI) of the Getúlio Vargas Foundation. Then the average exchange rate of the end of 2024 was taken and the whole price series was converted into 2024 US Dollars.

3.1. Methodology applied to achieve objectives "a" and "b"

The objectives "a" and "b" of this research are respectively: estimate models to forecast Brazilian natural rubber exportations time series from 1827 to 2024 and estimate the impacts of prices time series in this exportation.

According to Enders (2009), a time series is a collection of values, ordered in time $\{X_t\} = \{X_1, X_2, ..., X_n\}$ which represent the change of a random variable over regular intervals. The main objective of time series analysis is to make forecasts. Box, Jenkins and Reinsel (1994) emphasize that this methodology establishes mechanisms in which future values of a series can be predicted based solely on its present and past values.

Some fundamental pillars are needed to understand and build accurate forecasting models. Among these foundations is the random or stochastic process, defined as a set of observations of random variables ordered in time. According to Gujarati and Porter (2011) and Wooldridge (2013), a stochastic process is considered stationary when its mean, variance and autocorrelation structure do not change over time, i.e. they remain constant over time. This fundamental property ensures that the statistical characteristics of the process do not change over time, allowing for a more robust and reliable analysis. So our first step is to analyze the stationarity of the series. This is made by using the unit root test.

3.1.1. Unit root test for stationarity

In the data preparation stage, it will be checked whether the series is stationary. If it is not, a transformation will be made to make it stationary using the successive differences procedure. Stationarity is then checked using the Augmented Dickey-Fuller (ADF) unit root test. Next, the autocorrelation (FAC) and partial autocorrelation (FACP) functions of the series are calculated, in addition to the graphical analysis which will allow the ARIMA model (p, d, q) to be selected. Once the identification stage is complete, the model parameters are estimated. The d parameter refers to the number of times the difference between the elements of the series was taken until it became stationary.

Calculating the autoregressive parameters p and moving average q involves analyzing the FAC and FACP functions respectively, as the FAC function will show the peaks that identify p, while the FACP function will show the peaks that identify the value of q. Finally, the result of the ARIMA (p,d,q) model is obtained (Enders, 2009; Gurajati and Porter, 2011; Li, Shuyu, et al. 2019).

3.1.2. Arimax model

The ARIMAX model is a generalization of the ARIMA method with the inclusion of exogenous variables (Box and Tiao, 1975). In this study, the exogenous variable is the price of natural rubber measured in period t. The main difference between this model and ARIMA is that ARIMAX has, in addition to the autoregressive (AR) and moving average parameters (MA), the input of exogenous and linear variables (Nunes, et al, 2014) ; Box and Jenkins, 1976 ; Box et all, 2015 ; Camelo et all, 2018). The ARIMAX model can be understood as a combination of the Auto-Regressive AR(p), Integrated (d), Moving Average MA(q) and Exogenous X(r) models, and can therefore be symbolized as ARIMAX (p,d,q,r). A simplified way of mathematically representing this model in a generalized form is described in the following equation (Bennett et al 2014).

$$Y_t = \left[p + \Sigma B_j Y_{(t-i)} + \Sigma B\mathbf{j}\xi\, O_{(t-i)}\right] + \left[\Sigma_{0j} X_{(t-i)} + \xi_t\right]$$

In this research, the variable Y_t is the amount of natural rubber exported by Brazil between 1827 and 2024 and X_t will be the price of rubber in year t.

3.1.3. Tests to gauge the qualities of the adjustments

In the choice of statistically appropriate models, one of the criteria was to look for the most parsimonious ones, in the perspective that the smaller the number of estimated parameters, the better will be the adjustment model. There are several tools to evaluate the quality of fit and performance of a forecast model, the most relevant measures to do this measurement, and which were used in this research, are: Test of R square ($\mathbf{R}^2$): Mean Absolute Error (MAE); Bayesian Information Criterion (BIC); Mean Absolute Percentage Error (MAPE); and Pearson's linear correlation coefficient between the observed and the forecasted series. All estimations in the paper were performed using Statistical Package for the Social Sciences (SPSS) software, version 27 (Box & Jenkins, 1976; Box et al., 2015; Wang et al., 2018; Wooldridge, 2015).

3.2. Methodology to achieve objective "c"

In objective "c," the research seeks to estimate the heterogeneity of exports and prices in each period. To address this objective, the coefficients of variation (CV) of the quantities exported and the prices of natural rubber by Brazil will be estimated throughout the entire studied period (1827/2024) and for the four periods (1827/1878; 1879/1912; 1913/1950 and 1951/2024); that characterized the evolution of exports of this commodity by Brazil in the analyzed period.

By definition, the CV measures the percentage relationship between the standard deviation of a random variable and its average. The higher this percentage, the more heterogeneous or unstable the trajectory of the variable will be over time (Gomes (1985) establishes and classifies four ranges of dimensions for the CV. Very high ($CV \geq 30\%$); High ($30\% \geq CV > 20\%$); Medium ($20\% \geq CV > 10\%$). Low ($CV \leq 10\%$).

3.3. Methodology to achieve objective "d"

In this fourth objective, the study sought to estimate the growth rates (GGR) of exports and natural rubber prices in each of the 4 periods. In general, the GGR of a continuous series of a non stationary random variable (Yt), by definition, is expressed by the following equation:

$$Y_t = \lambda_0 \cdot e^{(\lambda IT + \lambda t).}$$

In this equation "e" constitutes the base of natural logarithms; d[log(Yt)]/dT = λ_1 multiplied by 100 is the instantaneous GGR associated with the variable (Yt); T = 0, 1, 2, .., n). Its values will be defined in each of the periods in which the trajectories of prices and Brazilian natural rubber exports are studied. The random term (λ_t) also assumes the assumptions to be white noise (WOOLDRIDGE, 2015). In this study it is assumed that the geometric instantaneous growth rates (GGR) will be different in the four periods into which the trajectories of exports and prices of natural rubber have been divided.

4. Results and discussions

The results found in each of the research findings are presented in the chronology of the objectives pursued.

4.1. Results found for the first and second objectives

The visual evaluation of the long export series, as well as the auto-correlation (ACF) and partial autocorrelation (PACF) functions, and after performing unit root tests for both series, it was observed that neither is stationary and that only one difference (D=1) would be necessary to achieve this essential characteristic for forecasting models. Thus, the Brazilian export series and natural rubber price series are cointegrated and suitable for use in the tested model.

After transforming the original series into a stationary one, the adjustment was made. The best fit achieved for forecasting Brazil's natural rubber exports between 1827 and 2024, with prices ($P_{(t-l)}$ as exogenous variables was an ARIMAX(1,1,0,1) model. A summary of the results found in the adjustment are shown in Table 1 and illustrated in Figure 1.

Table 1. ARIMAX (1,1,0,1) Model fitted to forecast of Brazilian exportation (Y_t) of natural rubber from 1827 to 2024

			Parameters Estimates		
ARIMAX (1,1,0,1)			Estimator	t	Sig.
Variable	Diference (D)	1	-	-	-
Y_t	AR lag	1	-0.216	-3.095	0.002
P_t	Diference (D)	1	90.634	1.855	0.065
Accuracy Tests					
R squared (R^2)			0.948		
R Pearson between observed and forecasted Y_t			0.998		
Normalized BIC			15.680		
MAPE			251.191		
MAE			1422.561		

Sources of original Data: Lemos. 1983; MIC. 2022; IBGE. 2024.

As can be seen from the results shown in Table 1 and in Figure 1, the adjustments found were parsimonious and statistically robust, allowing us to perform the analyses proposed in this study. The adjusted coefficient of determination (R2) was 0.948, and the estimated Pearson correlation coefficient between the original series of Brazilian exportation of natural rubber and the one obtained for forecasting was 0.998, which means that the forecasted model shows that there is an almost perfect linear relationship between observed and predicted Brazilian natural rubber exports series during the evaluated period. It is also observed that the Normalized BIC coefficient had a low value (15.680), which indicates that the adjusted model is parsimonious. The other accuracy indicators were high, but it is believed that they did not interfere with the forecasting capacity captured by the other indicators, as shown in Figure 1 (BOX et al.. 2015; WANG et al. 2018 ; Vandeput. 2021; Wooldridge. 2015).

In response to the second objective, which sought to detect the influence of prices on Brazilian exports of natural rubber between 1827 and 2024, the adjusted ARIMAX model showed that this influence existed. The magnitude of the estimated coefficient was 90.634, which was significantly different from zero with a probability of error of 6.5%.

This result suggests that the price of natural rubber influenced demand for exports when Brazil held a monopoly on production of the commodity. It also began to influence demand when natural rubber produced in Asian countries entered the market with higher productivity and lower production costs. Prices continued to be decisive in the demand for exports with the introduction of synthetic rubber and improvements in Asian rubber tree cultivation technologies, which caused them to fall even further. It was the sharp decline in commodity prices that made it impossible to continue Brazilian exports of natural rubber at the levels observed, for example, in the Rubber Cycle between 1979 and 1912.

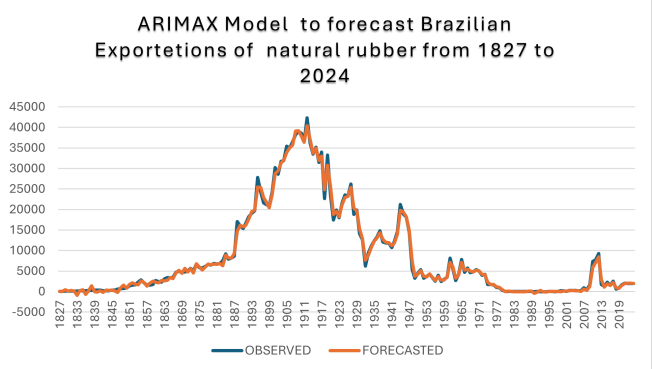

Figure 1. Observed and ARIMAX-forecasted series of Brazilian natural rubber exports from 1827 to 2024

Sources of original Data: Lemos. 1983; MIC. 2022; IBGE. 2025.

4.2. Results found for the third objective

The results presented in Table 2 show that both the quantities of natural rubber exported by Brazil and their prices were highly unstable, as captured by the respective coefficients of variation (CV), all of which were high or very high in Gomes' (1985) assessment for the four periods studied.

The evidence shown in Table 2 also shows that, despite the series of export quantities and natural rubber prices having shown high instability, captured by the respective coefficients of variation, the second period showed the lowest instability in both periods (Table 2).

Table 2. Averages quantities of Brazilian natural rubber exports, as well as standard deviations (SD) and coefficients of variation (CV) in the four periods studied

Periods	Brazilian natural rubber exportations(ton)			Prices of natural rubber(USD1000/ton)*		
	Averages	SD	CV(%)	Mean	SD	CV(%)
From 1827 to 1878	2937.18	2791.01	95.02	28.87	6.87	238.00
Period 1879 to1912	27442.96	8606.67	31.36	26.45	6.67	25.22
Period 1913 to 1950	18199.24	8843.67	48.59	6.63	3.94	59.43
From 1951 to 2024	2153.64	2362.52	109.70	3.30	1.64	49.70

Sources of original Data: Lemos. 1983; MIC. 2022; IBGE. 2025.
** Adjusted values for 2024.*

The results shown in Table 2 suggest that the average quantities of natural rubber exported increased over ninefold between the first and second periods. This evidence confirms that Brazil's

rubber exports peaked between 1879 and 2012, a period that became known as the "Rubber Cycle." In 1912, Brazil's natural rubber exports peaked (42,286.00 tons). Brazil's average exports during this period were also the highest (27,442.96 tons). In terms of average export prices, the highest occurred in the first period, when Brazil was the sole exporter of the product.

During this period (1879/1912), natural rubber produced in Southeast Asia was already competing with Brazilian rubber. Higher productivity in the production of rubber from raw material harvested from cultivated rubber plantations caused prices to decline, until Brazilian rubber production became uncompetitive, which began to happen in the third period (1913/1950). In 1951, Brazil became a net importer of natural rubber.

4.3. Results found for the forth objective

The results found to achieve the forth objective are presented in Table 3. The breakdown of the series of exports and prices of natural rubber shows that Brazil was the sole exporter of natural rubber in the period 1827-1878, the highest average annual growth in its exports of this commodity was observed, in the four periods studied, at around 8.5% per year. High prices tended to fall, as shown in Table 3, where prices decreased at an average annual rate of 0.7% . It is assumed that this combination of high prices, even though experiencing a slight downward trend, and the high growth rate of demand in the period 1827-1878, must have been some of the main factors that stimulated research into the production of natural rubber from trees with much higher productivity than that observed in native rubber plantations, resulting in lower average production costs.

It should also be noted that Brazilian natural rubber production at that time was entirely produced by extraction from native rubber plantations in the Brazilian Amazon. Thus, it is assumed that the synergy of these motivations led the British, in the early 1870s, to seek seeds from native rubber trees that grew spontaneously in the Brazilian Amazon to be cultivated in Southeast Asia (initially in Malaysia). This experiment, as we see today, was successful.

Table 3. Geometrical growth rate (GGR) of exports and price of Brazilian natural rubber from 1827 to 2024

Periods	GGR of exports	Sign.	GGR of prices	Sign.
1827 to 1878	0.085	0.000	-0.007	0.000
1879 to 1912	0.042	0.000	0.025	0.000
1913 to 1950	-0.039	0.000	-0.015	0.058
1951 to 2024	-0.025	0.087	-0.018	0.000

Sources of original Data: Lemos. 1983; MIC. 2022; IBGE. 2025.

In the second period (Rubber Cycle), prices that were high in the first period but declining experienced an increasing GGR (2.5% per year), the highest among the four periods studied. The GGR of quantities exported by Brazil, which was already facing competition from natural rubber produced in Southeast Asia, grew at an average rate of 4.2% per year between 1879 and 1912.

In the third and fourth periods studied, there were declines in both prices and quantities exported by Brazil. Between 1913 and 1950, export volumes declined at an average rate of 3.9% per year, and from 1951 onwards, Brazil became a net importer of natural rubber (imports exceeding exports). The combination of improved technologies that led to lower costs in the production of natural and synthetic rubber led to falls in commodity prices in the last two periods studied, as shown in the evidence presented in Table 3.

5. Conclusions

This article evaluated Brazilian rubber exports in four periods, starting from the moment they were first recorded:

Period 1: Occurred between 1827 and 1878. During this period, Brazil held a monopoly on natural rubber exports, all extracted from native Amazonian rubber trees, and as such, set the prices for the commodity.

The research showed that prices during this period tended to fall, but there was also a strong upward trend in demand, which stimulated the introduction of rubber tree seeds captured in the Amazon and which began to be cultivated rationally in Southeast Asia.

Period 2: Known as the "Rubber Cycle", which occurred between 1879 and 2012. During this period, natural rubber produced in rubber plantations cultivated in Southeast Asian countries entered the market. The evidence found in the research showed that competition from natural rubber production in Southeast Asia caused prices to fall relative to previous levels, but growth rates remained positive. Demand also experienced the highest growth rates in this period, which ended in 2012, when Brazil recorded its highest volume of natural rubber exports.

Period 3: Post-cycle period for natural rubber, which began in 2013 and lasted until 1950, when Brazil still exported more natural rubber than it imported, but was already experiencing significant declines in demand. Period 4 began in 1951 and continues to the present day, with Brazil now a net importer of the commodity.

The research sought to construct a parsimonious econometric model (ARIMAX) capable of capturing the trajectories of natural rubber exports influenced by their prices, in order to provide information that would allow us to understand what probably occurred during all those years (1827-2024) with exports, as well as to understand how prices interfered in the long trajectory of exports studied.

The research showed that prices had a statistically significant influence and demonstrated the average levels and instabilities in both: exports and prices in the four periods into which the trajectory of Brazilian natural rubber exports was divided. The study also achieved the objective of showing how exports and commodity prices evolved in the four periods analyzed.

As shown in this research, records of natural rubber exports by Brazil began in 1827. However, there are reports showing that the country was already exporting this commodity well before that date. Thus, the inevitable question is: how did a country that held a monopoly on natural rubber exports during the 19th century, with the first record dating back to 1827, remain in this monopolistic position until 1878 (51 years on record), continued to influence exports and price setting between 1879 and 1912 (33 years), a period known as the "Rubber Cycle" due to Brazil's exuberant participation in the market, manage to become a net importer of the commodity in the mid-20th century?

The answers to these questions, which constitute the overall conclusion of this research suggests that the decline in the production and export of natural rubber in Brazil, was mainly due to four reasons: 1 - the low production and productivity of native rubber trees, from which rubber was extracted in the Brazilian Amazon; 2 - the entry into the market of rubber cultivated in Southeast Asia from the end of the 19th century; 3 - the entry of synthetic rubber, especially during the First and Second World Wars; 4 - the negligence with which producers/exporters, as well as

Brazilian political decisionmakers, observed the evident advance of natural rubber production from Asian plantations.

Another inevitable question raised by the findings of this study is: Why did these agents (natural rubber producers/exporters and political decision-makers) not anticipate this and take consistent measures to ensure that Brazil began cultivating this native Amazonian tree in the region and in other parts of the immense geographical area that Brazil covers?

The attempts that were made in the beginning did not seem to be based on sustainable technical foundations. To complicate the process, the cultivation of rubber trees in the Amazon proved unfeasible in the first attempts due to the emergence of the "curse of the leaf," caused by a fungus that, as far as was detected, producers and political decision-makers were unaware of. They did not involve researchers at the time to solve the problem and, for these reasons, were unable to control it.

More recently, rubber tree plantations have emerged in states outside the Amazon region, such as São Paulo, Minas Gerais, and Espírito Santo in southeastern Brazil; Bahia in the northeast; and Goiás, Mato Grosso, and Mato Grosso do Sul in central-western Brazil, which successfully cultivate rubber trees.

However, the results found in this research show that the decline in natural rubber exports in the Amazon will be very difficult to reverse in the near future. The evidence captured in this study suggests that it will be difficult for this activity to regain its relevance for the region, either as a source of income or as an employer of labor.

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Impact of Road Infrastructure on Women Nutrition, Empowerment and Household Nutrition in Rural Nigeria

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Abstract

This study evaluates the impact of road infrastructure on women's empowerment and household nutrition in rural Nigeria. Using a Difference-in-Difference (DID) approach combined with Propensity Score Matching (PSM), the research analyzes data from the Value Chain Development Programme (VCDP). The findings indicate that improved road infrastructure significantly enhances market access, which in turn improves the dietary diversity of households and individual women. Specifically, the results show that households in areas with improved road connectivity had a higher dietary diversity score compared to the control group. However, these gains have important trade-offs. While infrastructure improvements expand economic opportunities and improve empowerment scores for women, they also substantially increase their total workload, thereby intensifying time poverty. Evidence from the decomposition of empowerment indicators shows that workload became the dominant contributor to women's disempowerment, accounting for over 60% in 2022, with nearly 90% of women working more than 10.5 hours daily. The study therefore concludes that for infrastructure projects to be fully effective in improving nutritional outcomes, they should be complemented with nutrition-sensitive interventions and labour-saving technologies that reduce women's time burden.

Road Infrastructure | Women Empowerment | Household Nutrition | Rural Nigeria | Difference-in-Difference | Value Chain Development | Dietary Diversity

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Keywords: *Road Infrastructure, Women Empowerment, Household Nutrition, Rural Nigeria, Difference-in-Difference, Value Chain Development, Dietary Diversity*

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1. Introduction

Infrastructure is one of the structural constraints that affect market functionality and market access of rural farmers (Ezeudu & Obimbua, 2024). Despite the central importance of infrastructure in national development, investment in infrastructure in Nigeria is low (World Economic Forum [WEF], 2025). This low level of infrastructure investment portends negative implications for the agriculture sector, which is characterized by many smallholder farmers, many of whom are women, low productivity, poor market access, underdeveloped value chains, and inadequate or non-existent infrastructure (Ezeudu & Obimbua, 2024). Road infrastructure comprises roads and a variety of structures, such as bridges, culverts, drainage systems, that enable the transportation of people, goods, and services, connecting communities, and with a potential to catalyse growth and development required for improved welfare of citizens (Dumas and Játiva, 2025; Ezeudu & Obimbua, 2024; Mtweve et al.,2025; Udoinyang, 2025). It is particularly critical to agriculture, which is the major income source in Nigeria's rural areas, making access to markets, extension and other services available(Isah & Ogundele, 2025; Yusuf et al., 2024). The appalling state of roads hinders effective agricultural development through high transportation cost, delays and consequently postharvest losses (Aboyeji & Aguda, 2024), impacting productivity and market access, especially for women who already face constraints at various points of the food system. It is believed that access to markets would enhance women's productivity, produce price and quality, incomes, food security, and reduction of poverty and hunger (World Bank, 2022; Ojo & Baiyegunhi, 2023). However, a topical issue of discussion is the poor condition or complete absence of rural road infrastructure further exacerbating women's inability to access markets and worsens their economic empowerment. which in turn impacts on the nutrition of their households (Ngomane, 2024; Odei et al., 2023).

Available statistics on nutrition in Nigeria reveal a worrisome situation. Between 2013 and 2018, women's nutrition worsened in terms of the burden of thinness from 11 to 12%, and obesity from 25 to 28% (FAO et al., 2025). This nutrition crisis disproportionately affects the Northern regions compared to the Southern zone, due to conflict and other crises such as drought, security challenges, and economic crunches (OCHA, 2024). Furthermore, almost one out of every 10 Nigerian children are wasted, while almost 40% of children less than five years old are stunted and 22% are under-weight (Awosan et al., 2024; USAID, 2022), with 27% and 45% of the burden of stunted children in urban and rural areas, respectively. The prevailing nutrition situation thus makes Nigeria's chances of attaining the Sustainable Development Goals

(SDGs) slimmer, with current progress pegging the country at 159th out of 162 countries (Aderogba & Aderogba, 2025).

Given that infrastructure fosters holistic growth and maximizes positive impacts on welfare, market participation, and livelihood outcomes across developing economies (Abdullahi & Sieng, 2023), empirical evidence on the impact of road infrastructure programmes on households' nutrition and women's economic empowerment outcomes remains limited. Households in Nepal experienced 21% and 31% increase in food and non-food purchases from the market following road improvements (Koirala, 2023), while household consumption in Ethiopia, increased by 16.1% - 27.9% in previously isolated communities, decreasing the probability of falling into poverty by 14.4% (OPEC Fund for International Development, 2024). Existing evidence in Nigeria have primarily focused on the effects of road infrastructure on income, transportation costs, and market access. For instance, Yusuf et al. (2024), using the Autoregressive Distributed Lag (ARDL) model, found a positive correlation between rural road improvements and household income arising from reduction in transportation costs and enhanced market access. Similarly, Ugwu et al. (2025) showed that poor road infrastructure increases market costs making barriers to market access, thus reducing agricultural market efficiency in Karu Local Government Area of Nasarawa State, Nigeria. However, these studies are limited in important ways. First, they largely overlook nutrition related outcomes, particularly dietary diversity at both household and individual levels. Second, they do not explicitly consider the multidimensional nature of women's empowerment, including aspects such as income use, decision making, access to resources and workload. Furthermore, past evaluation of the VCDP such as Omotoso and Obi-Egbedi (2025) only assessed its impact on poverty incidence of rural households, without linking the road investment component of the intervention to nutrition and gender equality outcomes.

The foregoing reveals that the impacts of road infrastructure intervention on women empowerment and nutrition are not clear-cut in the literature. It therefore becomes imperative to investigate a gender-inclusive and nutrition-sensitive approach in the planning and management of infrastructure delivery and development. This could help to improve women's economic empowerment and nutritional outcomes. On the other hand, restricting women's empowerment opportunities and outcomes holds economies back from experiencing growth and prosperity (Das, 2025). Thus, this study employed the Value Chain Development Programme (VCDP) dataset from 2019 to 2022, to examine the impact of road infrastructure on women empowerment and household nutrition among rural communities in Nigeria using the Difference-in-Difference (DiD) model.

The rest of the paper is structured as follows. The immediate section provides a brief background on value chain development programme in Nigeria, which is then followed by a conceptual framework and methodology sections. The results of the analysis and discussions are presented in the penultimate section while the last section concludes the paper by presenting recommendations on ways to enhance rural road infrastructure development in Nigeria.

2. Conceptual framework

Conceptually, the mechanisms and pathways by which a road infrastructure intervention(including activities during the construction) may positively impact women's economic empowerment and household nutrition are shown in Figure 1, with three possible pathways to improved nutrition and increase women empowerment considered. First, improved road infrastructure results in greater accessibility to both factor and product markets (Alao, 2021; Eissler & Heckert, 2024; Xu et al., 2024). Road infrastructure also expands employment opportunities for rural women, particularly during construction where trading activities are initiated along the road corridor, which ultimately increases the income of rural women (Osunmakinde et al., 2022; Das, 2025). Second, rural roads improve the speed and ease of travel, which ultimately saves time, creating more avenues for investment in productive activities, and enhancing effective distribution of farm produce from production areas to market and processing outlets, thereby reducing postharvest losses, especially for perishable crops (Ngezahayo et al., 2019; Stephen., 2024). Third, increased volume of private transport and competition, invariably reduces transportation and transaction costs (Biber-Freudenberger et al., 2025). Therefore, the savings in transportation costs and travel time will positively impact the income-earning potentials of rural households and women. Improvement in women's income generating capacity has been identified as an important contributor to their economic empowerment (Gupta et al., 2019; FAO, 2024). Women's economic empowerment, in turn, contributes directly not only to improvements in women's nutritional status but also to that of their household members (Etea et al., 2023; Adeyanju and Fadupin, 2023).

3. Methodology

3.1. Data and source

The study utilized secondary data from the baseline and result-level monitoring surveys of the Value Chain Development Project (VCDP) conducted in nine states (Kogi, Benue, Niger, Nasarawa, Taraba, Anambra, Ebonyi, Enugu and Ogun) in Nigeria which were the pilot states for the project. A rapid qualitative assessment was also conducted in six out of the nine states (Ogun, Ebonyi, Anambra, Benue, Niger and Taraba) of the VCDP programme in order to validate the data from secondary sources. This represents four out of the six geopolitical zones of the country. The surveys were conducted across 2019 and 2022. The 2019 survey served as the baseline data while the 2022 survey was the post-intervention dataset.

3.2. Measurements of outcome variable and empirical model

3.2.1. Women's empowerment

The study measured women empowerment using the Abbreviated Women Empowerment in Agriculture Index (AWEAI), an abridged version of the Women Economic Empowerment in Agriculture (WEAI). The VCDP data set contains all the sub-indicators included in the measurement of the AWEAI, but not for other versions which include additional modules and data not available in the dataset. Like WEAI, AWEAI retains all the domains of empowerment but only employs 6 out of the 10 indicators (Nacka et al., 2024). The index was computed using two subindexes: the 5 Domains of Empowerment (5DE) and the Gender Parity Index (GPI). According to Obayelu et al. (2024), the 5DE score shows how much women are empowered within the five domains of empowerment which are, input in agricultural production decisions; access and decision-making power over productive resources; control over the use of income; leadership in the

community; and time allocation. The GPI measures women empowerment relative to that of men through the comparison of the 5DE profiles of women and men who are considered primary decision-makers in each household.

3.2.2. Household and women's nutrition status

Household nutrition and women's nutrition status were evaluated using their dietary quality intake. The household dietary diversity score (HDDS) and minimum dietary diversity score for women (MDDW) were computed to measure the diet quality for households and women, respectively. Household dietary diversity score was adopted as a proxy for household nutrition outcomes and assessed on a scale of 1-12 as the number of food groups consumed by a household. The 12 food groups considered based on FAO's recommendation include cereals, vegetables, fruits, meat, egg, fish, and other sea products, nuts and seeds, legumes, milk and milk products, oil and fats, sweets, spices, beverages, and condiments, and roots and tubers (del Valle et al., 2024).

Mean household dietary diversity score was determined and household dietary diversity was categorized as low (≤ 3 food groups), medium (4-5 food groups), and high dietary diversity (≥ 6 food groups) following Ouedraogo et al. (2024). In addition, the MDDW, which measures the dietary diversity of female household members, was computed using a score of five or more out of ten recommended food groups as a representation of the MDDW met.

3.3. Difference-in-difference with propensity score matching (DID-PSM) method

The DID estimated the impact of the VCDP road infrastructure as the average changes in outcomes among beneficiary and non-beneficiary households before (pre-intervention) and after (post-intervention) the facilities were provided.Hence, it is assumed that for the intervention, the level of economic empowerment and nutrition among the households would be the same. However, certain heterogeneity may exist among the households pre intervention (Hu & Wang, 2023). Since we acknowledge that this initial heterogeneity may bias the impact estimates, we use PSM to ensure balance in the initial conditions between beneficiary and the non-beneficiary groups in the 2019 baseline data (Günther et al., 2025). This ensures, as opined by Peersman (2014) and Capacci et al. (2022), that the essential condition in impact evaluation is that the characteristics of the control and the treatment groups are similar except that one is treated. Hence, the outcomes of interest observed after intervention are attributable and measured as the impacts of benefitting in the VCDP road infrastructure. While road infrastructures were provided at the community level, the impacts of these facilities are expected to reflect in the outcomes of economic activities and nutrition of households within the benefitting communities. Hence, our analyses were conducted at the household level. In Figure 2, all the regions of matching overlaps show that the distribution of the observed covariates is balanced and there is effective matching for the treatment (beneficiary households) and control (non-beneficiary households) groups.

Once the balance between the beneficiary and non-beneficiary households was established using the 2019 baseline data, the impact of the road infrastructure development component of the VCDP on the empowerment of rural women, their nutrition and that of the households was measured using the Difference-in-Difference (DiD) method. There are three parameter estimates that are mostly used in identifying the average impact of any policy intervention (Blundell & Costa-Dias, 2009; Dong et al., 2023; Wang et al., 2024). With respect to the assumptions needed to make an inference, the parameters include: the overall population average treatment effect (ATE) which measures the average outcome if study participants were assigned to treatment randomly; the average treatment effect on the treated (ATT) that measures the average effect on those that were exposed to treatment; and the average effect on non-participants (ATNT). For the DiD, the parameter of interest is that which identifies the impact of exposure to treatment on individuals that were assigned to treatment denoted as ATT. For this study, the empirical DiD methodology adopted following Chen and Pan (2019) and Wang et al. (2024) is given as:

$$Y_i = \alpha + \beta P_t + \delta T_i + \gamma(P_t * T_i) + \lambda X_{it} + \mu_{it} \quad (1)$$

Where i represents household/individual i=1 ... N t = 0 , 1 denoting year which is the base period and follow-up period, respectively. The Y denotes the outcome variables which in the case of nutrition includes the dietary diversity index of households (HDDS) and women (MDD-W), while for women empowerment, it is the empowerment index generated for each woman. The P is a dummy variable, equal to 1 for a household/individual in 2022 (after the introduction of the project) and 0 otherwise. The T is a dummy variable, equal to 1 if a household/individual is resident in areas where road construction or rehabilitation took place, and 0 otherwise. The X is a vector of control variables, including sex of household head, level of education attained, cultivated farm size (ha), geo-political zone of residence, proportion of farm income to total household income, total household income, access to extension services, access to credit, and asset ownership index. The μ is the random unobserved error term which contains all unobserved variables omitted in the model, α is the constant term, β represents changes in the outcome before and after the intervention (i.e., pre- and post-intervention), δ is the treatment group specific effect gamma. The coefficient of interest γ is the interaction term which measures the true effect of the intervention or treatment and λ measures the change of outcome variable in covariates in household i and year t.

To account for the length (kilometers) of roads rehabilitated and constructed as well as the number of bridges constructed in the VCDP study sites, the model was further expanded. This was needed as new variables introduced helped to further ascertain the relevance of the intervention as a treatment that brings nutrition and gender benefits. The two new variables jointly interacted with the area of residence vector (T) of households, while the coefficient of interest associated with this interaction measures the true effect of the intervention based on kilometers of roads and bridges (in numbers) constructed and rehabilitated. Given that the variables in equation (2) remain the same as in equation (1), the expanded estimated DiD model, is specified as:

$$Y_i = \alpha + \beta P_t + \delta T_i + \gamma(P_t * T_i) + \rho R_t + \psi W_t + (R_t * W_t * P_t * T_i) + \lambda X_{it} + \mu_{it} \quad (2)$$

Where R is the roads constructed and rehabilitated in kilometers, and **W** is the number of bridges constructed. The coefficients ρ and ψ represent the direct effects of roads and bridges respectively on welfare outcomes.

4. Results and discussion

4.1. Descriptive statistics of respondents

Table 1 presents descriptive statistics for key socio-economic variables of beneficiary, and non-beneficiaries as well as the pooled sample households of VCDP road interventions. Most beneficiary (60.2%) and non-beneficiary households (60.9%) were male headed. The result substantiates the position of Bello et al. (2021) and Alawode et al. (2025) that males dominate the agrarian sector of Nigeria. The average age of the beneficiary and non-beneficiary households was about 45 and 43 years. More VCDP beneficiary households (61.6%) than non-beneficiaries (42.1%) had access to extension services, while households that cultivated at most 5ha were in majority as about 83.2% of beneficiaries, and average farm size of beneficiaries was significantly higher than that of the non-beneficiaries by 0.70ha. This agrees with Anderson et al. (2017), Oluwatunsin and Sekunmade (2016) and Obi-Egbedi and Lijadu (2024) that smallholders farming households cultivated average farm size between 1-3ha. Household heads who had up to tertiary education were about 48.0% and 53.6% among beneficiary and non-beneficiary households, respectively.

Access to financial credit was higher among beneficiaries than the non-beneficiaries (48.0% versus 36.4% , likely attributed to the availability of basic rural infrastructure including the road infrastructure driving availability and access to financial institutions (Nwude & Anyalechi, 2018). Furthermore, while the average farm income for beneficiary (₦ 366,439.4) was significantly higher than that of the non- beneficiary (₦ 314,569.8) by ₦ 51,869.64, the average non-farm income (₦ 182,649.4) for beneficiary was similarly significantly higher than that of the non-beneficiary by ₦ 31,279.4. This aligns with Purwanto (2020) and Yuan and Wang (2024) who found that infrastructure provides a boost for rural household income through enhanced nonfarming activities.

Table 1. Socio-economic Characteristics for Pooled VCDP Beneficiary and Non-beneficiary Households

Variables	Beneficiary (n = 844)	Non-beneficiary (n = 450)	Pooled (n = 1294)	Mean difference
Gender				
Male	508 (60.19)	274 (60.89)	782 (60.43)	
Female	336 (39.81)	176 (39.11)	512 (39.57)	
Age (years)				
≤ 35	145 (17.18)	100 (22.22)	245 (18.93)	
36–55	666 (78.91)	339 (75.33)	1,005 (77.60)	
> 55	33 (3.9)	11 (2.44)	44 (3.40)	
Mean ± SD	44.68 ± 9.45	43.00 ± 9.72	44.10 ± 9.57	1.68***
Marital status				
Single	24 (2.84)	28 (6.22)	52 (4.02)	
Married	766 (90.76)	394 (87.56)	1160 (89.64)	
Others	54 (6.40)	28 (6.22)	82 (6.33)	
Household size				
≤ 5	177 (20.97)	85 (18.89)	262 (20.25)	
6–10	632 (74.88)	346 (76.89)	978 (75.58)	
≥ 11	35 (4.15)	19 (4.22)	54 (4.17)	
Mean ± SD	7.30 ± 0.07	7.49 ± 0.10	7.36 ± 0.05	−0.19
Education Level				
Primary	183 (21.68)	63 (14.00)	236 (18.24)	
Secondary	256 (30.33)	152 (37.78)	384 (29.68)	
Tertiary	405 (47.99)	241 (53.56)	674 (50.00)	
Access to credit				
Yes	405 (47.99)	164 (36.44)	569 (43.97)	
No	439 (52.01)	286 (63.56)	725 (56.03)	
Mean ± SD (Amount, ₦)	77,041 ± 187,987	64,003 ± 101,756	72,507 ± 163,323	13,037**
Extension services				
Access (Yes)	520 (61.61)	190 (42.22)	710 (54.87)	
No Access	324 (38.39)	260 (57.78)	584 (45.13)	
Farm size (ha)				
≤ 5.00	702 (83.18)	450 (100)	1,152 (89.03)	
> 5.00–10.00	123 (14.57)	–	123 (9.51)	
> 10.00	19 (2.25)	–	19 (1.47)	
Mean ± SD	2.94 ± 2.13	2.24 ± 0.96	2.69 ± 1.84	0.70***
Total Income (₦)				
Total Household	546,088 ± 360,000	465,939 ± 345,059	520,173 ± 356,947	83,149***
Non-farm	182,649 ± 238,925	151,370 ± 186,599	171,771 ± 222,556	31,279***
Farm	366,439 ± 229,598	314,569 ± 244,531	348,401 ± 236,102	51,869***

*, ** and *** represent statistical significance for t-test of the mean difference at 10%, 5% and 1%. Figures in parentheses represent the percentage distribution.

4.2. Women empowerment of beneficiaries and non-beneficiaries

Table 2 presents the AWEAI estimates and its sub-indices (5DE and Gender Parity Index-GPI) showing the extent of women empowerment among benefitting cum non-benefitting households across 2019 and 2022. According to IFPRI (2021 & 2020) and Brago et al. (2025), higher values of AWEAI and its indices imply improvement in empowerment. As shown in Table 2, the AWEAI index and the 5DE sub-index did not distinguish between the beneficiaries and nonbeneficiaries in the baseline period (2019). This suggests similarities in characteristics and represents an essential condition in impact evaluation as the control and the treatment groups are expected to be initially similar except that one is treated (Peersman, 2014; Capacci et al., 2022). Disaggregation by 5DE score, however, shows slight differences in the empowerment status of the beneficiaries and nonbeneficiaries in 2019, with 18.3% and 14.1% of the women beneficiaries and non-beneficiaries, respectively empowered. Furthermore, the beneficiaries and nonbeneficiaries achieved weighted adequacy scores of 59.0% and 58.0% , respectively. In 2022, the achievements of women in terms of the empowerment domains were considerably higher among the beneficiaries than non-beneficiaries, as disempowerment headcount in 2022 reduced by 43.7% for the beneficiaries and 18.8% for non-beneficiaries. This greater reduction in disempowerment as found for the beneficiaries in this study indicates that access to road infrastructure may have improved empowerment among the beneficiary women.

The GPI score which measures intra-household differences in empowerment (Nacka et al., 2024) is higher for the women beneficiaries than the non-beneficiaries following the introduction of the intervention, indicating greater parity among beneficiaries than the non-beneficiaries and aligns with a study in Ghana by Fuseini (2024). Parity with the primary male decision maker in the household was achieved by 24.1% of the women beneficiaries and 11.6% of non-beneficiaries, while their average empowerment gaps were 14.1% and 25.6% , respectively. Expectedly, the AWEAI score is also higher for the beneficiaries than the non-beneficiaries (0.81 versus 0.72). In terms of improvement in empowerment status for men in beneficiary households generally, the empowerment scores were higher. This aligns with Alao (2021), and Agénor and Agénor (2023) who opined that increased access to infrastructure may lead to increase in women's bargaining power in the family and higher long-run growth rates. Results of the disaggregated 5DE indicators of empowerment are presented in Figures 3 and 4.

While the contributions of other indicators to empowerment can be directly linked to income generation and decision making, membership in a group can provide individuals with access to resources, information, and opportunities they might not have had otherwise. For example, women's self-help groups often provide access to credit, training, and livelihood opportunities, which can empower members economically. In addition, input in decisions regarding production activities and workload had the highest disempowerment index for men and women in both beneficiary and non-beneficiary households. In 2022 however, inadequacies in all the indicators decreased greatly except for workload indicators whose inadequacy not only remained high but intensified for all the sampled households. The key informant interviews conducted in the study areas further corroborates these findings as stated below:

> "With the road intervention in our community, women now take active part in decision making within their households. However, they tend to spend more than 9hours on productive activities which significantly increase in their workload" Ogun State "As a result of the road construction, there is about 30% increase in involvement of women in decision relating to the use of input in production" - Taraba State

Table 2. AWEAI Scores for Beneficiaries and Non-beneficiaries in 2019 and 2022

	Beneficiaries (2019)		Beneficiaries (2022)		Non-beneficiaries (2019)		Non-beneficiaries (2022)	
Indicators	Women	Men	Women	Men	Women	Men	Women	Men
Observations	167	255	165	257	88	137	91	134
5DE Score	0.66	0.64	0.79	0.80	0.66	0.64	0.69	0.72
Disempowerment score	0.34	0.36	0.21	0.20	0.34	0.36	0.31	0.28
% achieving empowerment	18.29	15.02	54.05	51.52	14.12	13.97	30.26	34.23
% not empowered (H)	81.71	84.98	45.95	48.48	85.88	86.03	69.74	65.77
Mean Disemp. Score (Ap)	0.42	0.42	0.45	0.42	0.39	0.42	0.44	0.42
Mean adequacy score	0.59	0.58	0.56	0.58	0.61	0.58	0.57	0.58
Gender Parity Index (GPI)	0.971		0.968		0.974		0.949	
% achieving parity	31.67		24.07		38.98		11.63	
Avg. empowerment gap	0.138		0.293		0.141		0.256	
AWEAI Score	0.691		0.81		0.691		0.72	

Source: Authors' Computation from VCDP Data, 2019 and 2022

More specifically, about 89.7% of the women beneficiaries are not yet empowered and overburdened with workload, 57.4% lack access to credit and 48.5% do not have adequate control over income use. Thus, the disempowerment index value was highest for workload in all the groups. For visual illustration of the disempowerment index, the proportion of each disempowerment indicator to the disempowerment score of the beneficiaries and nonbeneficiaries are presented in Figures 3 and 4. Taking all the samples together, the number of disempowered women reduced from 83.13% in 2019 to 54.02% in 2022 and the proportion achieving gender parity increased only marginally. The level of women empowerment as measured using the AWEAI-score also increased by 14% in 2022. A similar trend in empowerment status was observed for the men, however, on the average, they had fewer inadequacies than women.

4.2.1. Decomposition of women disempowerment by dimensions of empowerment

The percent contributions of the different dimensions of empowerment to women disempowerment are decomposed as shown in Figure 5. The domains contributing the most to disempowerment among women beneficiaries are input in production decisions (37.9%) , workload (26.6%) and group membership (26.1%). Similarly, these factors are the leading contributors to disempowerment among the non-beneficiaries; the corresponding values are input in production decisions (40.9%) , workload (28.6%) and group membership (20.0%). The contribution of these domains to women disempowerment was however redistributed in 2022 with workload accounting for the highest share of total disempowerment 61% for beneficiaries and 58.6% for nonbeneficiaries); income (17.8% versus 16%) and resources (9.0% versus 11.6%). The contribution of workload to women's disempowerment was more than doubled in 2022 and shows that women spent more hours on productive and domestic activities in 2022. By implication, about 90% of women worked for more than 10.5 hours a day, corroborating the studies of Adeyanju and Fadupin (2023) and Musyoka et al. (2025). Interestingly, workload also contributed the most to disempowerment among men, regardless of whether they are beneficiaries or not (see Figure 5). This therefore raises a concern as to what aspect of time poverty contributes to disempowerment among men and women. Is it inadequacy in productive activities or reproductive activities? At this point, the authors argue that the AWEAI measure of women empowerment does not adequately represent the contribution of time domain to individual disempowerment and thus opine that the AWEAI be revised to further disaggregate the time domain into participation in productive activities and reproductive activities, of which the associated adequacy cut-off is equally revised.

4.3. Nutritional status of beneficiary and non-beneficiary

Results in Table 3 show the nutritional status of the beneficiaries and non-beneficiaries of the VCDP road infrastructure in 2019 and 2022. In 2019, most of the beneficiary (62.8%) and nonbeneficiary (67.6%) households had low dietary diversity. However, in 2022 after the VCDP intervention, the proportion of beneficiary households with high dietary diversity increased to 89.6% , while that of the non-beneficiary decreased to 51.6% . Moreover, the mean household dietary diversity score (HDDS) for the beneficiary households almost doubled between 2019 and 2022, from 3.41 to 6.76. This shows that while beneficiary households experienced more diversity in their diets, their non-beneficiary counterparts experienced less. This suggests that access to rural road infrastructure improves economic opportunities and income among rural households, hence improving nutrition outcomes (Rahman, 2014; Osunmakinde et al., 2022: Fuseini, 2024).

The MDDW estimates showed that in 2019, 22.8% beneficiary and 15.9% non-beneficiary households headed by females consumed more than five groups of food. However, in 2022 after the road intervention, the proportion of beneficiary households headed by females who consumed more than five food groups increased to 93.6% , while that of the non-beneficiary increased to 32.7% . Overall, the minimum dietary diversity scores also increased from 20.4% in 2019 to 73.8% in 2022. This is also evident in the MDDW which increased from 3.43 ± 1.72 to 7.32 ± 1.70 (for beneficiary) compared to 3.27 ± 1.70 to 3.32 ± 1.46 (for non-beneficiaries). Although both categories of households experienced an increase in the number of food groups consumed, the increase experienced by beneficiary households was far higher. Various food groups consumed across the study locations are as shown in Figure 6.

These findings are supported by those of Usman and Haile (2022) and Nyan et al. (2025) that improvement in dietary diversity of rural households often accompany improved physical infrastructure like market improvement. Moreover, the qualitative survey carried out in the communities studied show that more food varieties, fresh and processed, became available after VCDP intervention as food marketers could now come from the town to sell varieties of food items in the rural area. This also aligns with the fact that good roads facilitate the influx of varieties of food commodities which are not locally produced to strengthen the local food system and improve dietary diversity (El-Said, 2025). Furthermore, there was more diversification in livelihood and value addition in the food production. This may have enhanced a household's income, leading to improved economic access and affordability of nutritious foods, particularly among the beneficiaries. These follows as noted in some of the qualitative interactive sessions:

> "New business opportunities like poultry, (promotes) better nutrition, among youth, (there is) reduction in social vices due to empowerment" – Benue FGD
> "Women … now process their cassava to garri (value addition) before selling especially during the off-farm season which make them to get higher value for their production" – Ebonyi FGD
> "There is increase in production of already available foods like rice, cassava, vegetables, melon, garden egg and sugar cane; and new ones are introduced like Vitamin A cassava, yellow potatoes, diabetic rice, Sesame/benniseed, soya beans, palm fruit, sweet melon, watermelon, and coconut" - Bida, Niger State.

In addition, the road infrastructure saves time, reduces the cost of transportation, and enhances the farming household's confidence in increasing the cultivation area. This further widens the profit margin of the people in benefitting communities and increases the availability of some indigenous nutritious foods.

> "Road intervention makes access to farmland, ……, reduces the cost of transportation …, increases the production and productivity of farmers, makes food more available and reduced the cost. The road construction increased our income, reduced drudgery and reduced hours spent in the farms" – Anambra FGD.
> "Farm size has increased, higher productivity and higher income and influx of different food items to the community have occurred…" - Ogun FGD.

4.4. Impact of rural road infrastructure on household nutrition women nutrition and empowerment

This section therefore focuses on the impact of the rural road infrastructure development component of the VCDP project on household nutrition (HDD), women nutrition (MDDW) and women economic empowerment. Table 5 presents the DiD regression estimates of two models—the restricted and unrestricted models. The restricted model presents the results of the effect of the rural

Table 3. Level of Dietary Diversity among VCDP Beneficiaries and Non-beneficiaries

	Household Dietary Diversity Score (HDDS)			Minimum Dietary Diversity for Women (MDDW)		
Year	Overall	Beneficiary	Non-Beneficiary	Overall	Beneficiary	Non-Beneficiary
2019	3.41 ± 1.70	3.47 ± 1.74	3.29 ± 1.64	3.37 ± 1.7	3.43 ± 1.72	3.27 ± 1.70
% Met MDD	64.45	62.80	67.56	20.39	22.75	15.91
2022	6.74 ± 1.98	7.30 ± 1.57	5.25 ± 2.16	6.44 ± 2.34	7.32 ± 1.70	3.32 ± 1.46
% Met MDD	79.08	89.57	51.65	73.75	93.60	32.72
Pooled	4.99 ± 2.48	–	–	4.35 ± 2.30	–	–

Source: Author's Computation from VCDP Data, 2019 and 2022. Figures in parenthesis indicate the number of households involved.

road intervention on the study outcomes excluding the number of bridges and kilometers of roads constructed (and/or rehabilitated), while the unrestricted model extends the interaction analysis to demonstrate how infrastructure improvements in terms of kilometers of roads and numbers of bridges further impact the outcome variables. This helps to understand not only the direct impact of the intervention but also to reveal how project's effects may vary in the context of changes in infrastructure, specifically through Year treatment*Road*Bridge interaction. The significant F-values of all the models suggest an overall significance of the models, while the Rsquared values depict the proportion of variance in the dependent variables as explained by the models. Prior to the estimations, a multicollinearity diagnostic was performed using Variance Inflation Factors (VIF) to ensure that the individual effects are truly being identified and the variables are not highly correlated. The VIF test results, presented in Table 4, confirm the absence of multicollinearity among the predictors with a mean VIF of 1.67.

The coefficient of the interaction terms (Year*treatment ATT1) in the restricted model captures the effect of the road intervention on the outcome variables. Also, an extra investment in road infrastructure is associated with an increase ($p < 0.01$) in household dietary diversity score (HDDS) by 2.806. This simply implies that better infrastructure facilitates improved access to diverse food sources, leading to greater dietary diversity within households. Similar significant ($p < 0.01$) positive improvements could be observed to be associated with women nutrition (MDDW) and women empowerment with 0.929 and 0.034 increases respectively. Improved access to roads and infrastructure increases market proximity, a critical factor in improving household well-being and nutrition. In addition to lower transportation costs arising from reduced distance and travel time, rural households with access to improved infrastructure may receive a "double dose" of income growth arising from both farm and non-farm income generated through increased sales and employment opportunities available along the road corridor. While improved markets access offer more diverse foods than can be produced by any given individual household, the multiple income sources further increase their capacities to purchase and consume more diversified food products (Kihiu & Amuakwa-Mensah, 2021; Qaim et al., 2016; Niazi et al., 2025).

Furthermore, results in Table 5 reveal that the size of household and being resident in the southern part of the country had a positive effect ($p < 0.01$) on women empowerment. This positive relationship suggests that larger households and living in the southern region may provide women with greater opportunities for participation in decision-making, resource allocation, or social engagement, which are critical aspects of empowerment. Similarly, farm income expressed as percentage of total household income,

Table 4. Variance Inflation Factor Test Results of Variables Experimented with in the DiD

Variable	VIF	1/VIF
ter_dum	2.83	0.353549
sec_dum	2.57	0.388840
road1_km	2.54	0.393749
no_bridges	2.41	0.415152
pry_dum	2.05	0.488190
logtinc	1.51	0.663206
logaginc	1.50	0.666293
locsthdum	1.29	0.775168
hhsize	1.17	0.852281
frmsiz	1.14	0.876303
age	1.13	0.886535
acceyes2_ext	1.12	0.891470
asset_index	1.07	0.936129
credtfm_dum	1.04	0.964023
Mean VIF	1.67	

total household income and the possession of assets showed a positive significant ($p < 0.01$ & $p < 0.05$) relationship with MDDW and HDDS. The observed response of MDDW to changes in income may be due to the ability of women to utilize resources available to them significantly in enhancing dietary diversity within the household (Kihiu & Amuakwa-Mensah, 2021; Azeez, 2023).

For the unrestricted model, both the ATT1 and ATT2 (i.e, Year*treatment*Road*Bridge) interaction terms were all positive and significant ($p < 0.01$) for the HDD, MDDW and women empowerment outcomes. This indicates that for the three outcomes, the impact of the project is not only related to roads, but it is further enhanced when bridges are included. Also, the same set of significant variables influencing the study outcomes in the restricted model were similarly observed to be significant in the unrestricted model. However, in both models, the credit variable was observed to negatively influence MDDW significantly. This negative effect may stem from the gendered dynamics surrounding access to credit. Accordingly, when women do access credit, gendered control of resources within households may affect how the funds are allocated. Decisions about the use of credit may be dominated by other household members, particularly men, and may not prioritize improving dietary diversity. Also, cultural norms often cast women in sacrificial roles within households, requiring them to prioritize the needs of others over their own, including eating least and last, which may further impair their ability to meet their dietary requirements. There is pro male bias in food consumption at the intrahousehold level with women

Table 5. Estimates of the impact of road and bridge infrastructure development on VCDP beneficiaries

	Restricted Model I			Unrestricted Model II		
Variables	HDD	MDDW	Empowerment	HDD	MDDW	Empowerment
Year dummy	−0.4814***	1.5753***	0.0100**	−0.4518**	1.5465***	0.0108**
	(0.1269)	(0.3669)	(0.0041)	(0.2080)	(0.3681)	(0.0051)
Treatment status	0.1171	0.2057	−0.0191	0.1092	0.1916	−0.0193
	(0.1633)	(0.2832)	(0.0244)	(0.1619)	(0.2834)	(0.0244)
Year*treatment (ATT1)	2.8063***	0.9290***	0.0336***	3.1571***	1.1111***	0.0704**
	(0.2354)	(0.1698)	(0.0071)	(0.3455)	(0.0866)	(0.0063)
Roads (Km)	–	–	–	−0.2531***	−0.1561***	−0.0067
				(0.0690)	(0.0220)	(0.0140)
No. Bridges	–	–	–	0.0110**	−0.0066	−0.0071
				(0.0048)	(0.0055)	(0.0045)
Year*treatment*Road*Bridge (ATT2)	–	–	–	0.0090**	0.0079***	0.0704***
				(0.0041)	(0.0012)	(0.0069)
Sex (1 if male)	−0.6096***	–	–	−0.5815***	–	–
	(0.1192)			(0.1184)		
Age (years)	0.0028	0.0128	0.0009	0.0018	0.0127	0.0008
	(0.0064)	(0.0150)	(0.0012)	(0.0088)	(0.0155)	(0.0012)
Household size	−0.0040	−0.0153	0.0038***	−0.0048	−0.0173	0.0038***
	(0.0178)	(0.0164)	(0.0008)	(0.0168)	(0.0139)	(0.0009)
Primary education	0.0791	−0.0601	0.0252	0.0502	−0.0783	−0.0265
	(0.0758)	(0.0735)	(0.0705)	(0.0399)	(0.1002)	(0.0701)
Secondary education	0.0940	0.1147	0.0137	0.0678	0.1008	0.0098
	(0.0863)	(0.4048)	(0.0345)	(0.0576)	(0.3785)	(0.0381)
Tertiary education	0.0153	−0.0194	−0.1962	0.0130	−0.0176	−0.1656
	(0.0475)	(0.0557)	(0.1359)	(0.0647)	(0.1511)	(0.0460)
Farm size (ha)	−0.0148	−0.1586	−0.0176	–	–	–
	(0.0298)	(0.1124)	(0.0240)			
South location	0.4655**	0.6564**	0.0593***	0.7239***	0.5653***	0.0619***
	(0.1569)	(0.1970)	(0.0205)	(0.1569)	(0.0812)	(0.0210)
Farm income (%)	0.0005	0.0075***	−0.0003	0.0018	0.0078***	−0.0003
	(0.0043)	(0.0011)	(0.0004)	(0.0035)	(0.0014)	(0.0002)
Log of total income	0.4737***	0.7004**	0.0040	0.4899***	0.7119**	0.0033
	(0.1440)	(0.2779)	(0.0135)	(0.1429)	(0.2948)	(0.0226)
Extension services	−0.0100	−0.0424	−0.0125	−0.0146	−0.0461	−0.0140
	(0.0147)	(0.2598)	(0.0290)	(0.1195)	(0.2551)	(0.0306)
Asset ownership index	0.0481**	0.1858***	0.0494**	0.1851***	–	–
	(0.0169)	(0.0507)	(0.0189)	(0.0525)		
Access to Credit	−0.2226	−0.5665**	−0.2528	−0.5239*	–	–
	(0.2355)	(0.2823)	(0.2212)	(0.2864)		
Constant	0.8636**	−1.0624	0.5392***	0.6830***	−1.1594	0.5453***
	(0.2963)	(1.1309)	(0.0732)	(0.1735)	(1.2103)	(0.0835)
No. of observations	1,170	403	370	1,170	403	370
F-Value	35.24***	10.82***	3.11**	31.38***	9.17***	2.88**
Prob > F	0.0000	0.0000	0.0533	0.0000	0.0000	0.0450
R-squared	0.3284	0.2954	0.1483	0.3415	0.3006	0.1565
Adjusted R-squared	0.3191	0.2681	0.1263	0.3306	0.2678	0.1302

*Standard errors are in parenthesis; *, ** and *** indicate significance at 10%, 5% and 1% respectively.*

often receiving lower quantity of food and lower nutritional intake (Harris-Fry et al., 2017; Ghatak et al., 2024).

CONCLUSION AND RECOMMENDATIONS

The analysis of the impact of rural road infrastructure development on household nutrition and women's empowerment provides evidence that the provision of road infrastructure has had a substantial positive effect on these key dimensions. Drawing from the VCDP dataset, access to improved road infrastructure has led to increased dietary diversity and empowerment, particularly among beneficiary households. Specifically, the study confirmed that between 2019 and 2022, the proportion of disempowered women reduced more for VCDP beneficiaries with a lesser disempowerment gap compared to the non-beneficiaries. Dietary diversity for most households, particularly female-headed beneficiary households, was also higher relative to their nonbeneficiary counterparts. Based on the empirical evidence, road infrastructure significantly impacts household dietary diversity, women's dietary diversity and women's empowerment. These outcomes underscore the crucial role of road infrastructure in fostering well-being, gender equality, and income distribution in rural communities. Therefore, government in conjunction with the private sector and supporting international agencies/organizations should consider the infrastructure provision of roads to communities as part of its nutrition, empowerment, and income inequality policy. Specifically:

- Efforts to promote better nutrition outcomes among rural households should incorporate infrastructural development such as roads and culverts construction. Such interventions should be deliberately designed to ensure nutrition sensitivity. Similarly, efforts should be intensified to prevent erosion of healthful practices such as high intake of fruits and vegetables, the consumption of underutilized food crops such as wild vegetables, and unchecked access to poor quality foods.

Furthermore, nutrition education should be intensified in agricultural development programme to promote optimal benefits of such programmes to rural households. Most efforts could be championed by local and international agencies, NGOs etc., partnering with the government to improve infrastructure and welfare of the rural populace.

- To strategically improve the level of women empowerment in Nigeria, there is a need to focus on workload, income and production dimensions as these factors have been shown to account for about eighty percent of their disempowerment. More rural road infrastructure programmes can help address these inadequacies experienced by women through the reduction in their travel time while creating more access to quality education, job market, economic resources and complementary sources of income.

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5. APPENDICES

Appendix A

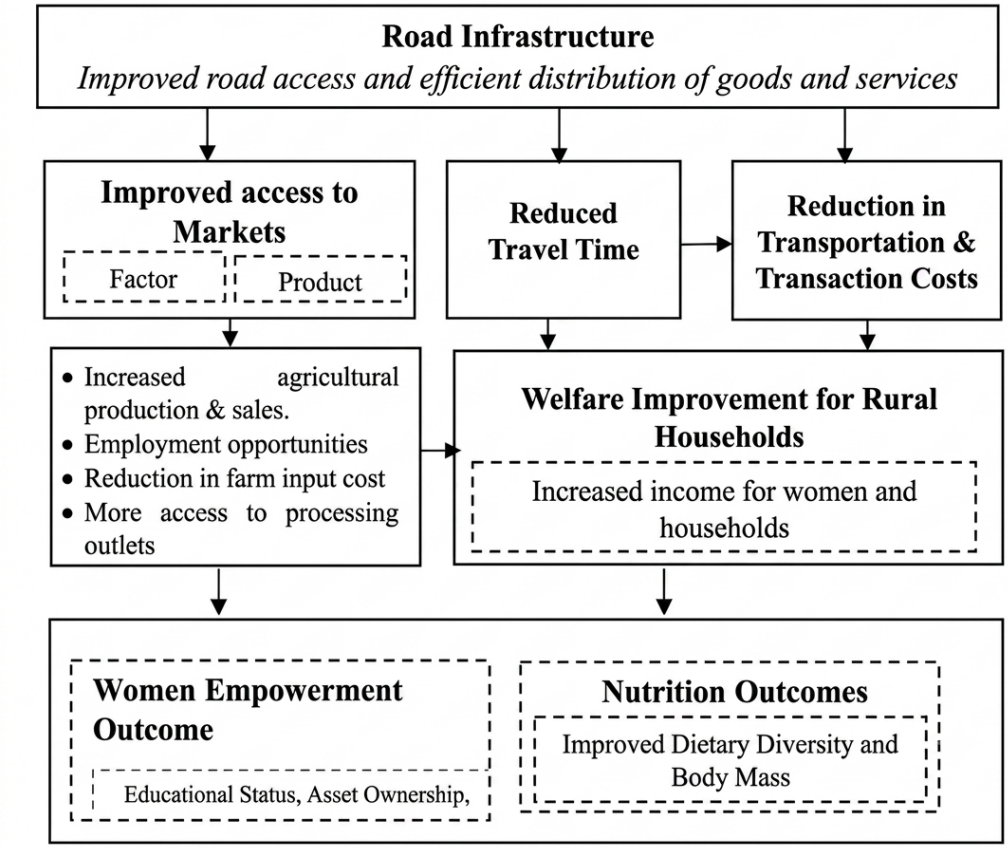

Figure 1. Conceptual Framework on the Effect of Road Infrastructure on Women's Empowerment and Nutrition.

Source: Authors' concept synthesized from Biber-Freudenberger et al. (2025); Adeyanju and Fadupin (2023) and Etea et al.(2023)

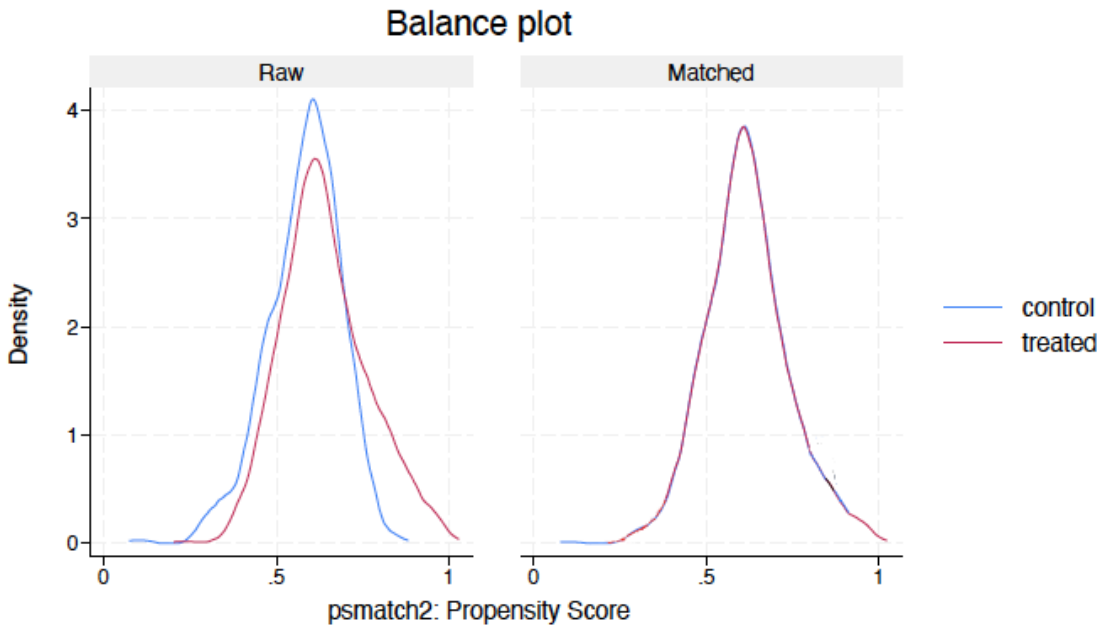

Figure 2. PSM in full sample in 2019 showing samples before matching (raw), and samples after matching (matched). The solid red line plot scores represent the treatment group, while the blue lines plot scores represent the control group

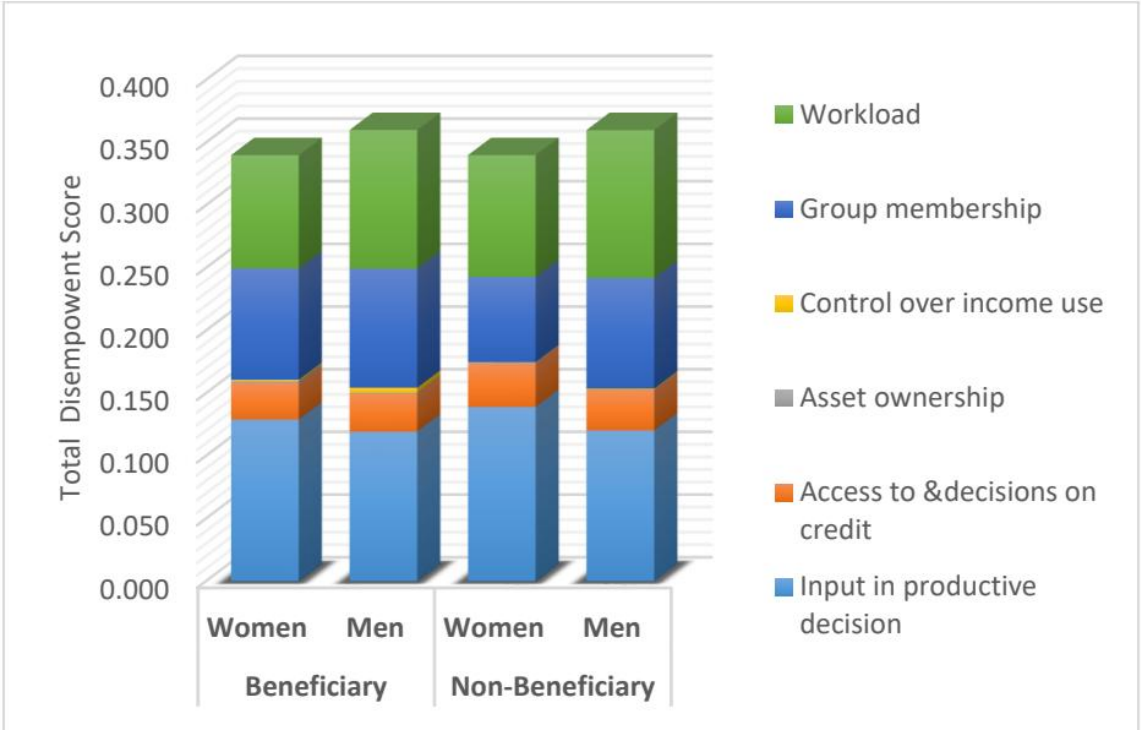

Figure 3. Contribution of the indicators to disempowerment in 2019

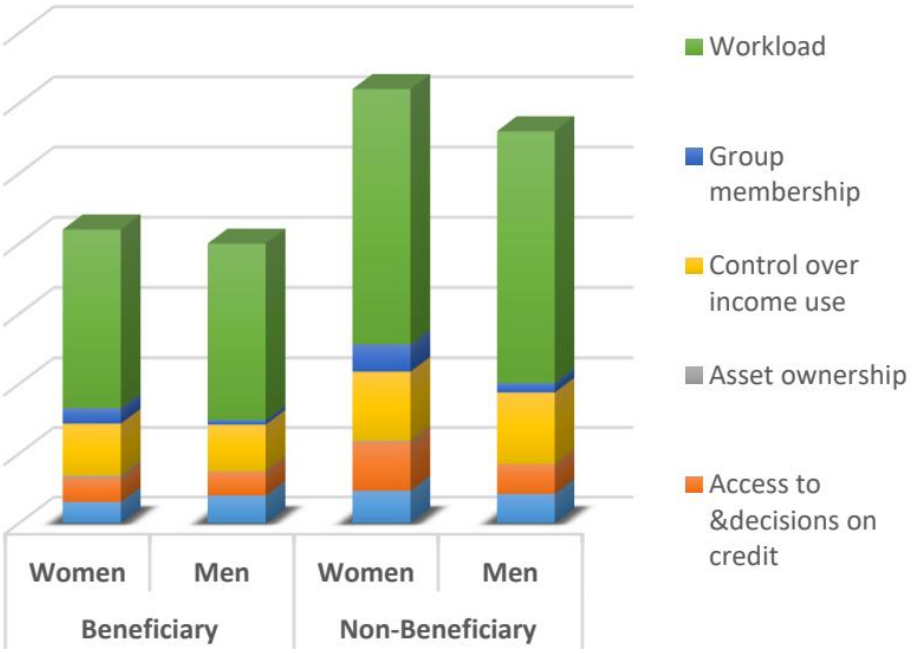

Figure 4. Contribution of the indicators to Disempowerment in 2022

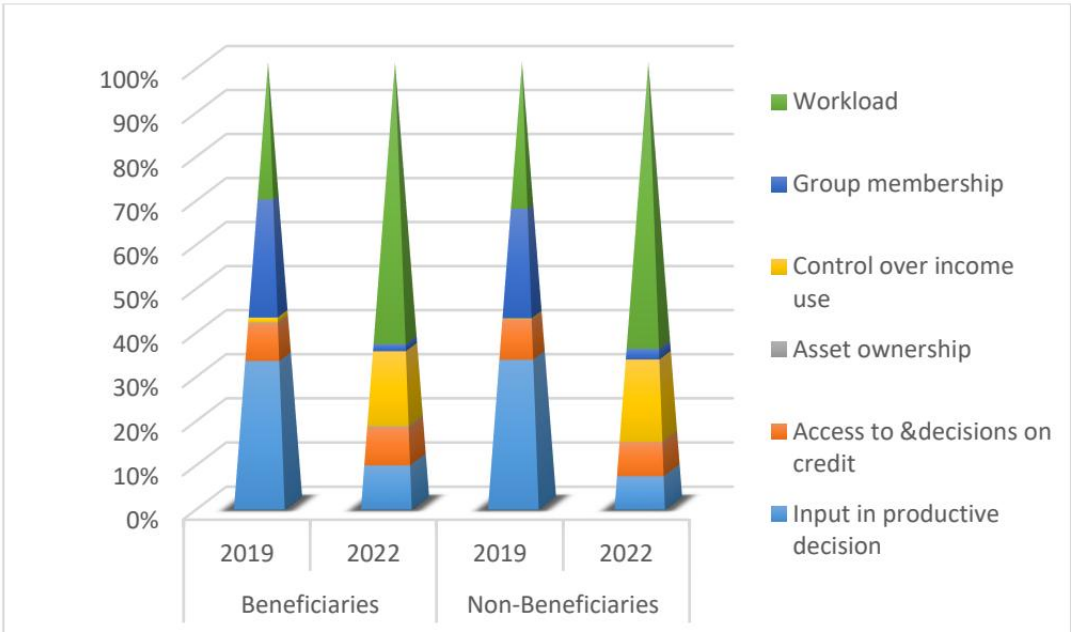

Figure 5. Percent Contribution each indicator to disempowerment of men

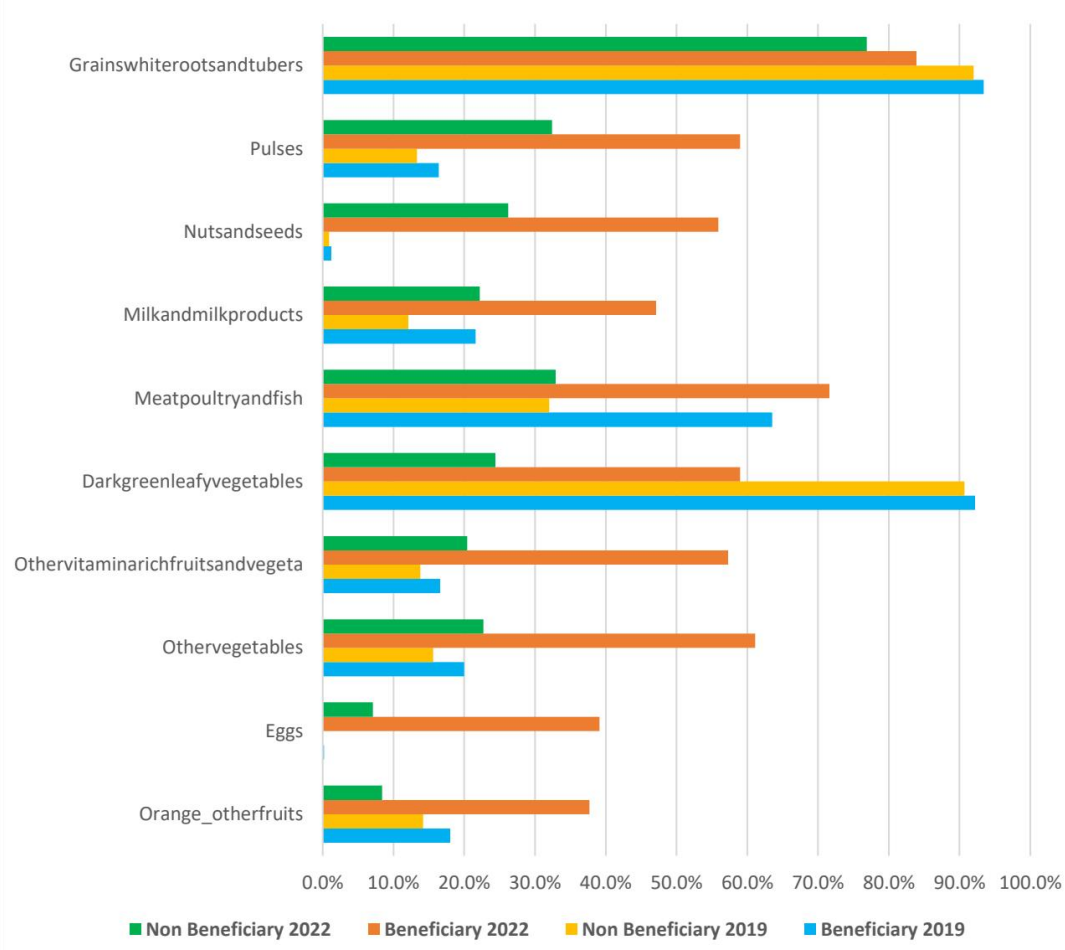

Figure 6. Various food groups consumed across the study locations

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NIRF and Global Rankings: A Comparative Academic Analysis

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NIRF | Global Rankings | Higher Education Policy | Internationalization | Bibliometrics | Sustainability | SDGs

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1. Introduction

Higher education rankings have emerged as influential mechanisms for evaluating institutional performance, shaping educational policy, and enhancing global academic reputation.

Global ranking systems largely emphasize research citations, academic reputation, and international faculty and student representation as indicators of institutional excellence.

In contrast, India's National Institutional Ranking Framework (NIRF) prioritizes national development goals by focusing on teaching quality, inclusivity, regional representation, and graduate employability.

This study investigates how NIRF indicators interact with global ranking metrics and explores the potential of NIRF to serve as a bridge between domestic educational priorities and global academic standards.

2. Literature Review

Global ranking frameworks emphasize research productivity and citation impact as core indicators of academic excellence. National ranking systems, including NIRF, aim to address socio-economic disparities and ensure inclusive educational development. Recent scholarship highlights the growing integration of sustainability indicators into ranking methodologies. Hybrid models combining global benchmarks with national priorities provide more comprehensive assessments of institutional performance.

2.1. Globalization and the Rise of University Ranking Systems

The expansion of globalization has transformed higher education into a competitive international marketplace where university rankings play a central role in shaping institutional reputation and policy development. Ranking systems provide comparative benchmarks that influence student mobility, research collaborations, funding allocation, and governmental policy decisions. Scholars argue that rankings have become instruments of global academic governance, promoting standardization and competition across higher education institutions.

The development of global ranking systems reflects the increasing demand for transparency, accountability, and performance measurement. These systems generally prioritize research productivity, citation impact, faculty credentials, and internationalization indicators as measures of institutional excellence. Consequently, universities frequently restructure institutional strategies to align with ranking performance metrics, thereby reinforcing the global hierarchy of academic institutions.

2.2. Global Ranking Systems and Research-Centric Performance Indicators

Research literature highlights that global ranking frameworks primarily emphasize research output and academic reputation as determinants of institutional success. Studies indicate that rankings incentivize universities to focus on high-impact publications, citation visibility, and international collaboration networks. This focus has led to increased investments in research infrastructure and faculty development programs.

However, critics argue that research-centric evaluation models may disadvantage institutions operating in developing economies, where teaching quality, accessibility, and community engagement remain significant priorities. Furthermore, excessive emphasis on citation metrics has been linked to academic homogenization, where institutions prioritize publication output over local relevance and societal contributions.

Research also suggests that reputation surveys, which constitute a significant portion of global ranking methodologies, introduce

subjectivity and reinforce existing institutional hierarchies. The reliance on international perception surveys may favor historically established universities while limiting recognition of emerging institutions.

2.3. National Ranking Frameworks and Contextual Relevance

In contrast to global ranking systems, national frameworks are designed to address country-specific educational priorities and developmental objectives. National ranking models evaluate institutions based on broader performance indicators, including teaching effectiveness, graduate employability, inclusivity, and regional outreach.

Studies emphasize that national frameworks play a critical role in promoting equitable access to higher education and addressing socio-economic disparities. These frameworks incorporate contextual factors such as affordability, gender balance, and regional representation, which are often overlooked in international ranking methodologies.

The National Institutional Ranking Framework (NIRF) represents a distinctive example of a national ranking system that balances academic performance with social accountability. By incorporating parameters such as teaching quality, research productivity, graduation outcomes, outreach initiatives, and institutional perception, NIRF reflects India's strategic emphasis on inclusive educational development.

2.4. The Emergence of Sustainability and Social Impact Metrics

Recent academic discourse highlights a paradigm shift in higher education evaluation toward sustainability and societal impact. Universities are increasingly assessed based on contributions to global development goals, including environmental sustainability, social equity, and community engagement.

Scholars argue that sustainability metrics provide a holistic evaluation framework that extends beyond traditional academic performance indicators. The integration of Sustainable Development Goals into ranking methodologies reflects the growing recognition of universities as agents of societal transformation.

The inclusion of sustainability indicators also aligns higher education institutions with global development agendas, encouraging interdisciplinary research and community-based initiatives. This shift highlights the importance of measuring institutional contributions to broader societal outcomes alongside academic achievements.

2.5. Internationalization and Institutional Reputation

Internationalization has emerged as a critical factor influencing global ranking performance. Research demonstrates that international faculty mobility, student exchange programs, and cross-border research collaborations significantly enhance institutional visibility and citation impact.

Studies indicate that internationalization contributes to knowledge exchange, academic diversity, and global research networks. Institutions with strong international partnerships often demonstrate higher research productivity and enhanced academic reputation.

However, literature also highlights disparities in internationalization opportunities, particularly for institutions located in developing countries. Structural challenges such as funding limitations, policy constraints, and limited global collaboration networks can restrict international engagement and reduce ranking performance.

2.6. Hybrid Ranking Models and Integrated Evaluation Approaches

Scholarly research increasingly advocates for hybrid ranking models that combine global benchmarking standards with national developmental priorities. Hybrid models recognize the limitations of both global and national ranking systems and propose integrated frameworks that capture research excellence alongside social impact.

Hybrid evaluation models emphasize multidimensional performance assessment, incorporating research productivity, teaching quality, inclusivity, and sustainability metrics. Such approaches provide comprehensive institutional evaluation while accommodating diverse educational contexts.

The adoption of hybrid ranking frameworks is particularly relevant for developing higher education systems seeking to balance international competitiveness with domestic policy objectives. These models facilitate strategic alignment between national educational goals and global academic expectations.

2.7. Research Gap and Conceptual Contribution

Although extensive literature exists on global and national ranking systems, limited research explores the interaction between national ranking indicators and global ranking outcomes using advanced statistical modeling techniques. Most studies analyze ranking frameworks independently without examining structural relationships between domestic performance indicators and international academic visibility.

This research addresses this gap by applying Structural Equation Modeling to evaluate how NIRF parameters influence global ranking performance. The study contributes to the literature by providing empirical insights into the pathways through which national educational policies translate into global academic competitiveness.

2.8. Summary

The literature demonstrates that higher education ranking systems operate at the intersection of global competitiveness and national development priorities. Global rankings emphasize research productivity and international reputation, while national frameworks focus on inclusivity and contextual relevance. The growing integration of sustainability metrics and hybrid evaluation models highlights the evolving nature of institutional performance assessment.

By examining the relationship between NIRF indicators and global ranking performance, this study extends existing scholarship and provides a multidimensional framework for understanding institutional competitiveness in the global higher education landscape.

3. Methodology

3.1. Research Design

This study adopts a **quantitative, explanatory research design** using **Structural Equation Modeling (SEM)** to examine the relationship between NIRF parameters and global university ranking outcomes. SEM was chosen because it allows simultaneous estimation of multiple latent constructs (e.g., global visibility,

internationalization, reputation) and their causal pathways toward global ranking performance.

3.2. Data Sources

- **NIRF Data**: Institution-level scores across five dimensions (Teaching & Learning, Research & Practice, Graduation Outcomes, Outreach, Perception).
- **Global Ranking Data**: QS, THE, and ARWU indicators, including citation impact, international faculty/student ratios, and reputation survey results.
- **Bibliometric Indicators**: Citation counts, Field-Weighted Citation Impact (FWCI), and co-authorship networks from Scopus/Web of Science.
- **Institutional Variables**: Faculty mobility, student exchange programs, partnerships, and funding allocations.

3.3. Variables and Constructs

- **Global Visibility (GV)**: Citations per faculty, co-authorship, FWCI.
- **Internationalization (INT)**: Faculty mobility, student mobility, partnerships.
- **Reputation (REP)**: Academic reputation, employer reputation, NIRF perception.
- **Sustainability Alignment (SDG)**: Outreach initiatives, inclusivity measures, SDG-linked programs.

3.4. Analytical Framework

1. **Measurement Model**: Confirmatory Factor Analysis (CFA) was conducted to validate constructs, ensuring reliability (Composite Reliability > 0.7) and convergent validity (AVE > 0.5).
2. **Structural Model**: SEM was applied using AMOS/SmartPLS to estimate path coefficients between constructs and global ranking outcomes.
3. **Mediation Analysis**: SDG alignment was tested as a mediating variable between NIRF indicators and global visibility.
4. **Moderation Analysis**: Internationalization was examined as a moderator amplifying the effect of research productivity on citation performance.

3.5. Model Fit and Validation

Model fit was assessed using multiple indices:

- **CFI** and **TLI** (>0.90) for comparative fit.
- **RMSEA** (<0.08) and **SRMR** (<0.05) for residual error.
- **HTMT Ratios** (<0.85) to confirm discriminant validity.

3.6. Sampling and Scope

The dataset includes top-ranked Indian institutions from NIRF (2018–2024) cross-matched with their performance in QS, THE, and ARWU rankings. Institutions were selected based on availability of complete bibliometric and internationalization data.

The empirical framework requires institution-level data including NIRF parameter scores, citation impact and bibliometric indicators, international faculty and student ratios, research collaboration metrics, and institutional funding data.

Global ranking performance is modeled as a function of NIRF dimensions and institutional control variables.

4. Results

NIRF research and perception indicators demonstrate strong positive correlations with global ranking performance.

International collaboration amplifies the impact of research productivity on citation performance.

Institutions aligning inclusivity initiatives with Sustainable Development Goals are expected to demonstrate improved global recognition.

5. Discussion

The findings suggest that NIRF dimensions can serve as predictors of global academic success when institutions translate domestic strengths into internationally recognized outputs.

Higher education institutions should promote open-access publishing, international research collaboration, structured exchange programs, and improved bibliometric reporting.

6. Conclusion

NIRF represents a distinctive national framework balancing domestic accountability with global academic aspirations.

Statistical modeling suggests that NIRF parameters can predict global ranking success when combined with international collaboration and sustainability alignment.

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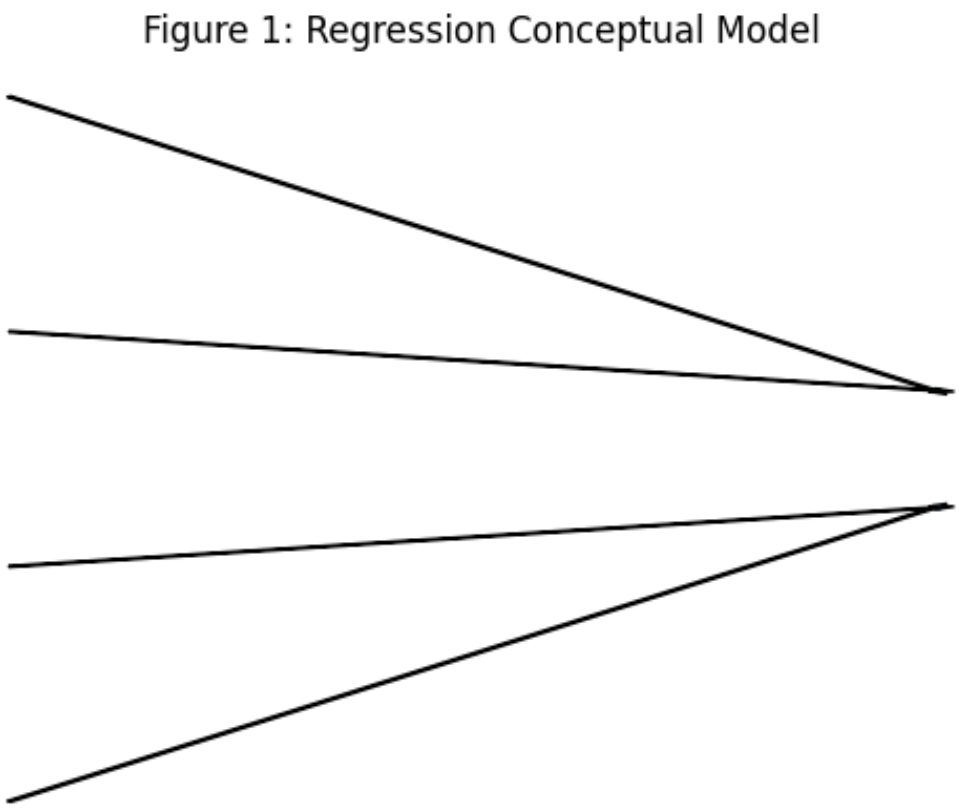

Figure 1. Regression Conceptual Model

Table 1. Comparative Dimensions of Ranking Frameworks

Dimension	NIRF	Global Rankings (QS, THE, ARWU)
Primary Focus	Teaching quality, inclusivity, graduation outcomes	Research citations, international reputation
Core Parameters	Teaching & Learning, Research & Practice, Graduation Outcomes, Outreach, Perception	Research influence, international outlook, employer reputation
Data Sources	Institutional data with verification	Bibliometric databases and reputation surveys
Innovations	SDG integration, penalties for retracted papers	Sustainability and collaboration indicators

SEM INTERPRETATION FRAMEWORK

The SEM layout models the structural relationship between latent constructs representing global visibility, internationalization, and institutional reputation. The model follows AMOS and SmartPLS conventions, where outer measurement indicators represent observable variables and inner paths represent causal relationships between latent constructs. Path coefficients (λ values) indicate the strength of influence each construct exerts on global ranking performance. The model enables mediation analysis and evaluation of indirect effects.

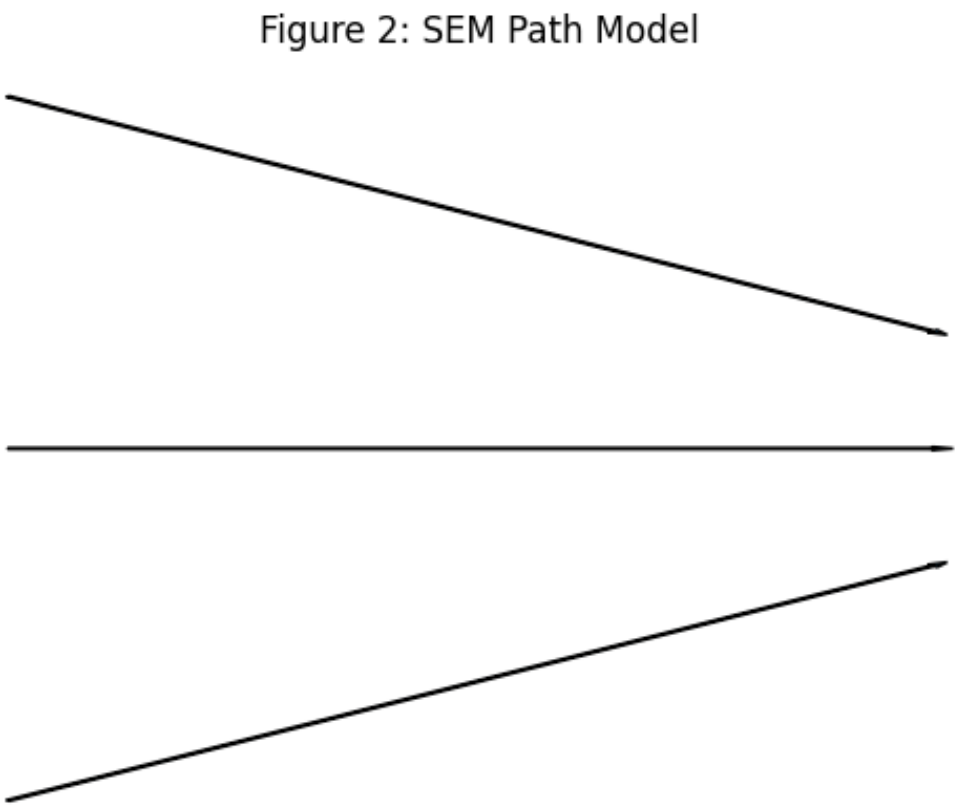

Figure 2. Structural Equation Model (SEM)

Table 2. Measurement Model Evaluation (Factor Loadings, CR, AVE)

Construct	Indicator	Factor Loading	Composite Reliability (CR)	Average Variance Extracted (AVE)
Global Visibility	Citations per Faculty	0.82	0.91	0.72
Global Visibility	Co-authorship	0.79	0.91	0.72
Global Visibility	FWCI	0.85	0.91	0.72
Internationalization	Faculty Mobility	0.81	0.89	0.69
Internationalization	Student Mobility	0.78	0.89	0.69
Internationalization	Partnerships	0.84	0.89	0.69
Reputation	Academic Reputation	0.86	0.92	0.75
Reputation	Employer Reputation	0.83	0.92	0.75
Reputation	NIRF Perception	0.87	0.92	0.75

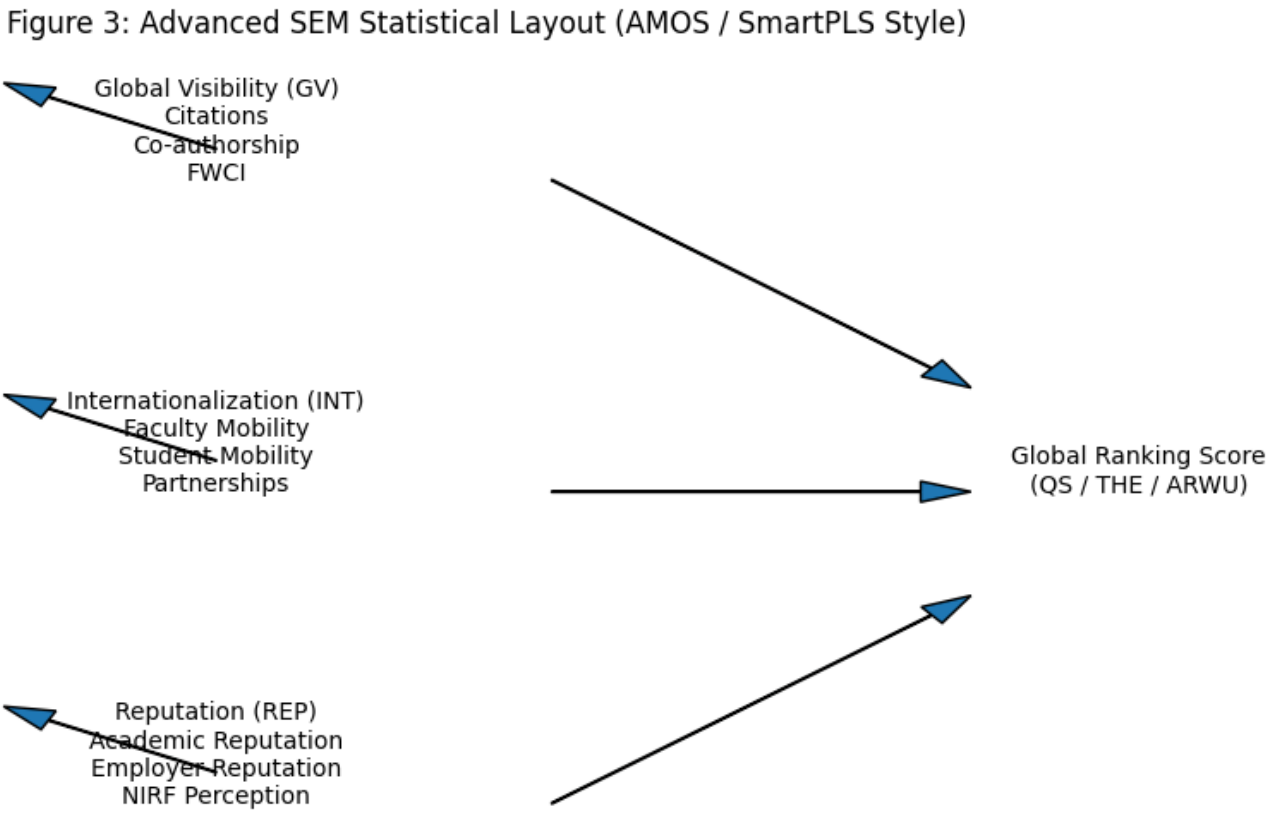

Figure 3. Advanced SEM Statistical Layout (AMOS / SmartPLS Style)

Table 3. Discriminant Validity (HTMT Ratios)

	GV	INT	REP
GV	1.00	0.65	0.59
INT	0.65	1.00	0.63
REP	0.59	0.63	1.00

Table 4. Structural Model Evaluation (Path Coefficients)

Hypothesis	Path	Beta	t-value	Result
H1	GV → Global Ranking	0.41	5.12	Supported
H2	INT → Global Ranking	0.36	4.75	Supported
H3	REP → Global Ranking	0.44	5.43	Supported
H4	INT × GV → Global Ranking	0.29	3.89	Supported
H5	SDG Mediation	0.31	4.02	Supported

Table 5. Model Fit Indices

Fit Index	Value
CFI	0.94
TLI	0.92
RMSEA	0.05
SRMR	0.04

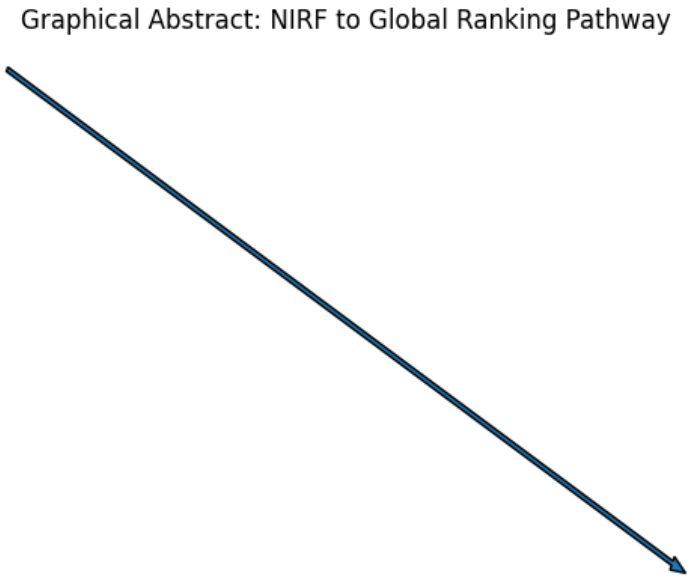

Figure 4. Graphical Abstract

Highlights

• This study compares national and global university ranking frameworks.

• SEM analysis demonstrates relationships between research, internationalization, and ranking outcomes.

• SDG alignment strengthens global visibility of higher education institutions.

• The study provides policy guidance for improving global ranking performance.

■ GLOBAL HIGHER EDUCATION RANKINGS FRAMEWORK

|
|— Research Productivity and Bibliometrics
| |— Citation Impact
| |— Publication Output
| |— Research Collaboration
|
|— National Educational Priorities
| |— Teaching Excellence
| |— Inclusivity
| |— Graduate Employability
|
|— Sustainability and Societal Impact
| |— SDG Alignment
| |— Community Outreach
| |— Social Responsibility
|
|— Internationalization
| |— Faculty Mobility
| |— Student Exchange
| |— Global Partnerships
|
|— Institutional Reputation
| |— Academic Perception
| |— Employer Recognition
| |— Global Visibility

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The Impact of the Covid-19 Pandemic on Latin American Capital Markets

Article Record

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Abstract

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Stock Exchange | Latin America | COVID-19

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CONFLICT OF INTEREST
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DATA AVAILABILITY
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ETHICS
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CONSENT
Not applicable for this article.

TRIAL REG.
Not applicable.

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Abstract

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Keywords: *Stock Exchange, Latin America, COVID-19*

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1. Introduction

The process of globalisation is putting increasing pressure on publicly traded organisations to live in an ambiguous, risky and competitive environment, which deepens in times of crisis. Each company's individual strategic decision increasingly depends on factors that are also external to the organisation. In this sense, decision-making and the formalisation of concise strategies - whether public or private - are becoming increasingly vital and sometimes need to be done quickly and effectively.

There is an interdependent relationship between the capital market and public policy in countries. Through the capital market, companies can expand their borrowing to make investments and create jobs, which stimulates the generation of income for the population and thus tends to increase public revenue through taxes. Carvalho (2000) notes that, historically, the most advanced societies have continuously growing capital market structures, i.e., the financial development process of the main capitalist economies has also been characterised by the expansion of the financial securities market.

Similarly, the way in which politics is conducted also has a direct impact on the maintenance of the capital market. Aspects such as exchange rate policies, the basic interest rate, the level of taxation and economic openness - among others - can affect the continuity of companies and the flow of business. Vargas (2020) observed that conjunctural and economic aspects can stimulate the growth or bankruptcy of publicly traded companies, affecting their level of activity.

Latin America and the connections between the countries that make it up have been covered in various studies with the aim of understanding movements and integrations, as well as their behaviour during crises. In their research, Arshanapalli and Doukas (1992) found high degrees of international correlation in the 1982 financial crisis, which saw the Mexican financial system collapse and spread throughout Latin America.

In addition to essentially financial crises, countries and their financial markets are also susceptible to shocks from other sectors. The novel coronavirus crisis began in the city of Wuhan, China, and subsequently became a global health crisis, declared a pandemic by the World Health Organization (WHO) on March 11, 2020.

Although the crisis was initially a health crisis, it has gone beyond this concept and has also become relevant in economic and social terms. Recent studies are also seeking to understand the disruptions that may have been caused in organisations due to the COVID-19 pandemic.

Heyden and Heyden (2020) state that the pandemic has had an unprecedented negative effect on capital markets around the world. Zhang, Hu and Ji (2020) study the effect of the pandemic on twelve world stock exchanges and show that financial market risk has increased substantially in response to the pandemic.

The Economic Commission for Latin America and the Caribbean - ECLAC (2022), highlights that even in 2022 - two years after the start of the pandemic - Latin America faces major economic recovery challenges. In this ECLAC report, in addition to slow economic growth after the pandemic, there are challenges of inflationary pressure, slow job creation and strong social issues, reinforcing that increased investment is vital for economic recovery.

Given the importance of the capital markets for their respective countries and the need for new approaches related to the pandemic, research in this direction is extremely important, deepening the analyses and, through this, making the information more robust for managers, investors, the community in general and the public

sector. In this context, this paper seeks to answer the following question: what is the impact of the new coronavirus on the main Brazilian, Mexican and Chilean stock exchanges?

Given that Latin America is an important part of the world market and its economic similarities - as stated above - this study focuses on the three main stock exchanges in Brazil (B3, Bolsa de Balcão), Mexico (BMV) and Chile (Bolsa de Santiago). According to Bastos and Nakamura (2009), Brazil, Mexico and Chile are among the largest economies in the region and can be considered the main players in the world.

In order to answer the research problem, the aim is to evaluate the three main stock exchanges in Latin America: Brazil, Mexico and Chile between 2020 and 2022, a period of systemic crisis caused by the COVID-19 pandemic. These evaluations were carried out in two parallel, complementary but distinct analyses.

Firstly, a time window was set for the years 2017 to 2019 (the period before the pandemic) and 2020 to 2022 (the period when the pandemic is in progress). Following the basic method of Güereña de la Llata et al. (2014), by comparing the periods (prior to and in progress of the pandemic) of the number of companies listed on each of the three stock exchanges and their capitalisation values, we sought to understand whether the period of the pandemic crisis had an impact on the continuity or bankruptcy of the listed companies, as well as their level of valuation on the stock market.

The second analysis corresponds to the period from 2020 to 2022 and is related to the last two specific objectives. Based on the method of Albulescu (2021), we sought to relate the number of COVID-19 cases and deaths in each of the countries in the study with the fluctuations in the indices of each stock market to assess the interference of the pandemic with the volatility of the capital markets. Also in this context, the number of global cases and fatalities of the new coronavirus and their relationship with possible market fluctuations in the study countries are evaluated. Based on Ji et al. (2021), the daily volatility of the Bovespa (B^3), S&P/BMV IPC (BMV) and IPSA (Santiago Stock Exchange) indices was used as a proxy for the volatility of the capital markets in Brazil, Mexico and Chile, respectively.

The article is structured in five sections, the first of which comprises this introduction. Section 2 contains the literature review, subdivided into four sub-items. Section 3 contains the methodology followed, which presents the study variables, the characteristics of the sample, as well as the methods and tests used to conduct the research in question. Section 4 then presents and discusses the results obtained and finally, section 5 summarises the main results achieved.

2. Literature review

2.1. The financial system and the capital market

Within the financial market, there are four other segments: the financial market, the credit market, the foreign exchange market and the capital market. The capital market was the subject of this work, but specifically the stock market, which is worked on together due to its connection to the financial market.

Within the capital market there are the Stock Exchanges. Ponce (2010) defines the Stock Exchange as a self-regulated institution with the aim of providing duly registered intermediaries with all the information and services necessary to carry out transactions in a transparent and orderly manner. The effects of a stock exchange's fluctuations can be measured through its indices, which measure the performance of a portfolio with the weighted composition of the main shares traded on the respective market. Peixoto (2021) emphasises that indices are important indicators for investors, as they generally detect market fluctuations.

Brazil's largest and only stock exchange is B^3, which, according to the organisation itself, is "one of the world's leading financial market infrastructure companies". B^3's main index is the Ibovespa, and its headquarters in Brazil are in the city of São Paulo. According to information from Economática (2020), the total financial volume of the Brazilian stock exchange in June 2020 was US$ 655 billion. The Brazilian Stock Exchange is supervised by the Central Bank of Brazil (BCB) and the Brazilian Securities and Exchange Commission (CVM).

Mexico's main stock exchange is the BMV, an acronym for the Mexican Stock Exchange. It is headquartered in Mexico City and, according to the BMV's own data, is the second largest stock exchange in Latin America with a total market capitalisation of over $520 billion. The main index of the Mexican stock exchange is the S&P/BMV IPC, which shows the shares of the largest listed companies. The Mexican Stock Exchange is supervised by the Comisión Nacional Bancaria y de Valores (National Banking and Securities Commission).

Chile's main stock exchange is the Santiago Stock Exchange, which has the IPSA index, which, as described by the organisation, measures the price variations of the largest and most liquid Chilean issuers listed on the exchange. Although it is less representative in Latin America than the main stock exchanges in Brazil and Mexico, according to Economática (2016), in December 2016 the Santiago Stock Exchange had a market value of US$179,733 million. The regulatory body for the Chilean Stock Exchange is the Superintendencia de Valores y Seguros (Superintendency of Securities and Insurance).

The sum of the values of the shares on a given stock exchange is given by market capitalisation, which is an important trading indicator. Market capitalisation, according to Ponce (2010), is the market value of shares measured by the sum of the market value of the shares listed on that exchange.

Another important aspect of the capital market is the number of companies listed on each market, which has a better impact on the sustainability of a country's companies, since listed companies generally have a higher level of governance, control and transparency than other companies, even though the requirements may change in each country. According to B^3, in the IPO (Initial Public Offering) Guide, an IPO significantly alters a company's strategic positioning.

Relevant and intrinsic to the capital market are risks and uncertainties. Risk comes from market uncertainties, according to Lima (2018), and the financial market is highly unpredictable and predisposed to fluctuations due to internal and external factors. Moving further into economic theory, Keynes (1985) was one of the first economists to study and link the concept of uncertainty and the concept of choice by convention (individual choice, but following "collective" standards) to markets. Through the concept of uncertainty, the author emphasises that it is extremely difficult to predict exactly when a crisis will occur. In relation to Keynesian theory, Carvalho (2014, p. 248) explains:

> "The definition of convention is relatively straightforward: it is a belief shared by a certain number of individuals. [...] A convention, therefore, is a reducer of uncertainty by making the behaviour of those who are assumed to share the same belief predictable. [...] Keynes used the idea of convention

> in the sense of a dominant belief at a given time, one that is capable of explaining not just the behaviour of an individual but, in fact, the economy as a whole. (CARVALHO, 2014, p. 248)

The complexity of the financial market and the foundations of the capitalist system were also explained by Minsky (1986), who sought to explore instability as a phenomenon intrinsic to the market itself. With his theory based in part on that of Keynes, the author reports on the relationship between investment and savings and economic cycles.

For Minsky (1982), institutions play an important role in intervening and sustaining the stability of the capitalist system. As Oliveira (2013, p. 22) points out, "the combination of effective government policies and the intervention of the Central Bank as a guide for the banking system can avoid peaks of deflation and depression in the economy".

It can be understood that the notion of risk is inherent in the stock market; however, it tends to become more noticeable in times of crisis. Siegel (2008) analyses the effect of wars - such as Iraq (2003-2011) - on the stock market, finding that times of peace have higher returns. The author concludes that world events can have a profound impact on the market in the short term, but would still be incapable of diminishing long-term stock returns.

Since crises tend to interfere with countries' capital markets, the next section seeks to relate aspects of pandemic crises to their impact on the world economy. Through these aspects, it is possible to emphasise that other health crises have transcended health issues and had a strong negative impact on the economy.

2.2. Pandemics and the economy: Spanish flu and swine flu

A pandemic is defined as when the transmission of a particular disease reaches a global level, reaching all continents, according to the United Nations (UN, 2020). Even before COVID-19, there were other pandemics. The largest known pandemic caused by the H1N1 virus was the Spanish Flu in 1918.

Marson and Siviero (2021, p. 7) emphasise that "a pandemic, such as the Spanish flu, can affect the economy in different ways in both the short and long term". The authors conclude that the level of mortality has a direct impact on the labour market and the level of production in nations. As a result, the goods and services needed by the population can be limited, raising the price level.

According to Tomasi (2020, p. 27-28), the Spanish flu pandemic had various economic impacts. The author emphasises that the infection was not limited to humans, infecting and killing pigs on farms, affecting the production sector. As the disease progressed, hospitals did not have enough beds to care for the population, and pharmacies restricted the sale of medicines and adjusted prices upwards due to the high demand. In addition, several insurance companies went bankrupt as a result of the mass deaths of people infected with the disease, as well as the negative impact on the labour market in the countries.

Almost a century after the Spanish flu pandemic, 2009 saw the emergence of the second pandemic caused by the H1N1 virus, known as Swine Flu. According to Dominguez et al. (2020), this flu initially only infected pigs, however, the virus mutated and humans became infected in Mexico, spreading to other countries.

With symptoms and transmission methods very similar to the Spanish flu, in July 2009, according to the British Broadcasting Corporation News (BBC News, 2009), Latin America was the region hardest hit by swine flu. Even so, the crisis situation in the markets was systemic. According to Agência Estado (2009), the fall in the world's stock markets was generalised by investors' fear: "the fear that swine flu will turn into a pandemic is driving down the shares of airlines and pork producers".

In addition to the impact on the stock markets, the swine flu pandemic crisis may have had an impact on the level of exports and imports by nations. Ceci (2020) concluded in his research that there were noticeable impacts on the volume of Brazilian exports and imports during the initial months of swine flu. Even so, the author emphasises that the creation of a vaccine for the disease in 2009 may have minimised the deleterious effects of the crisis from 2010 onwards.

In light of the above, it is possible to consider that pandemics also have a profound influence on the economy as a whole. There are repercussions on both demand and supply, where government decisions have an influence on the effectiveness of human and, not excluding, economic protection measures.

2.3. The COVID-19 pandemic and its impact on the world economy

The novel coronavirus pandemic began in Wuhan, China, and later became a global crisis, declared a pandemic by the World Health Organization (WHO) on March 11, 2020. Proof of the ability of information to spread and interact in the globalised world, as Albulescu (2021) points out, the world's stock markets have already been experiencing shock waves since February 2020.

According to data from the World Bank (2022), Latin America and the Caribbean experienced a downturn in real GDP during the pandemic period very close to the 2008 financial crisis, as shown in Figure 1. Another characteristic is that the impact of the pandemic on real GDP growth has not been limited to certain undeveloped regions.

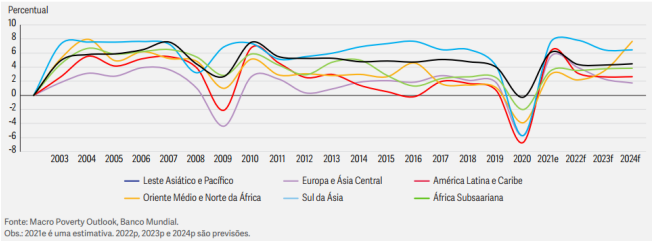

Figure 1. Real GDP growth, 2003 to 2020 (2021 estimated, 2022-2024 forecast)

Source: World Bank (2022, p. 9)

Although the health crisis initially differed from other financial crises, it is clear that the impacts went beyond public health issues. Using ordinary least squares and recursive least squares methods, Albulescu (2021) took an empirical look at the official announcements of infected people and the fatality rates of the new coronavirus on the US financial market. The study found that the global level of fatalities and infection has a greater impact on the volatility of the S&P500 index than local variables, concluding that the health crisis increases volatility in the US market.

Various studies have sought to better understand the effect of the COVID-19 pandemic on countries' economies. The consensus among researchers is that the novel coronavirus crisis has brought profound changes to markets around the world.

3. Methodology

As described, this work establishes two parallel and distinct analyses, with different time windows and data: a) descriptive analysis, covering 2017 to 2022; b) time series analysis, covering 2020 to 2022. For the descriptive analysis, monthly data was collected on the number of listed companies and their capitalisation value on each of the stock exchanges in the study. For the time series analysis, the daily indices of each of the stock exchanges (dependent variable) and the number of COVID-19 cases and fatalities at local (country) and global levels (independent variables) were collected.

3.1. Descriptive analysis

Monthly data was collected for the years 2017 to 2019 (prior to the pandemic) and 2020 to 2022 (after the start of the pandemic) in order to assess possible impacts of the pandemic on the capital markets of each country in both periods.

Table 1. Data display for Descriptive and Comparative Analysis

Exchange I, II and III	Period 1 - Before the Pandemic	Period 2 - After the Pandemic Starts
No. of Listed Companies Capitalisation Value (USD)	Mean, median, standard deviation, minimum and maximum value	Mean, median, standard deviation, minimum and maximum value

Source: Elaborated by the authors (2022).

Table 1 shows the compilation of this first analysis for later comparison. Based on the research problem listed above, data was collected on the companies listed on each of the three stock exchanges in the countries in this study, as well as their capitalisation value.

3.2. Time Series model

Using time-series econometric modelling, we sought to understand the number of COVID-19 fatalities and infections in each of the countries, in relation to the fluctuations in the stock market indices of each nation. Six time-series econometric models were developed, two for each country, in order to assess the effects and magnitude of COVID-19 deaths and cases (local and global) on the respective stock market indices. The proposed time-series multiple regression models are specified as follows:

$$Stock\,Exchange\,Index = \beta_0 + \beta_1 Deaths_{it-1} + \beta_2 Cases_{it-1} + u_{it} \quad (1)$$

$$Stock\,Exchange\,Index = \beta_0 + \beta_1 DeathsM_{it-1} + \beta_2 CasesM_{it-1} + u_{it} \quad (2)$$

Equations 1 and 2 correspond to the time series model, where the subscript i = country; t = 2020 to 2022, in days; u_i are the residue vectors for the country analysed. The variables *DeathsM* and *CasesM* correspond to the numbers related to global data, while *Deaths* and *Cases* portray the local numbers for the respective country.

The six models establish that a change in the independent variables with a time lag has an effect on the Ibovespa, S&P/BMV CPI and IPSA. The independent variables of the number of fatalities and cases were lagged by one level due to the fact that the accounting of this data takes place during the course of the day and is released to the market with a delay. Based on Ji et al. (2021), the daily volatility of the Bovespa (B[3]), S&P/BMV IPC (BMV) and IPSA (Santiago Stock Exchange) indices was used as a proxy for the volatility of the financial markets in Brazil, Mexico and Chile, respectively. After compiling the data, the tests and analyses were carried out using Stata 15.1® software.

Unit root tests are used to detect whether or not a time series is stationary. To check for stationarity, the Dickey-Fuller (DF)[1] unit root test was applied. To obtain the result of the DF test, two hypotheses are considered: $H_{0:}\ \delta = 0$, the series is stationary; $H_{1:}\ \delta \neq 0$, the series is not stationary.

The Jarque-Bera (1987) normality tests were carried out, testing the null hypothesis of normality, $H_{0:}$ the residuals follow a normal distribution. However, it is important to emphasise that as the model worked with more than 1094 observations, it is possible to admit asymptotic normality and the validity of the hypothesis tests.

After estimating the models, the possibility of heteroscedasticity in the data was checked using the Breusch-Pagan and Cook-Weisberg test proposed by Greene (2012). If the null hypothesis of the Breusch-Pagan[2] and Cook-Weisberg test was rejected, it was decided to correct the errors using the *Newey-West*[3], Robust Inference method, which, according to Gujarati and Porter (2011), ensures that the results are consistent with regard to autocorrelation and heteroscedasticity.

3.3. Data Sources

For the descriptive analysis, which corresponds to the years 2017 to 2022, the monthly data on the number of listed companies and capitalisation values for each of the markets was collected from the Statistics Portal of The World Federation of Exchanges and covers the years 2017 to 2022.

To analyse the time series, corresponding to the years 2020 to 2022, the variation of the daily IBovespa, S&P/BMV IPC and IPSA indices was collected from the websites of the stock exchanges themselves. The daily data on fatalities and the number of COVID-19 cases in each country was taken from the Ministry of Health: Ministry of Health, in the case of Brazil; Ministry of Communications, in the case of Chile; and, the Government of Mexico, in the Mexican case. For information on the novel coronavirus in the world, data was collected from the World Health Organization (WHO).

4. Analysis and Discussion of Results

4.1. Descriptive analysis

The descriptive analysis revealed three distinct behaviours for each country, in terms of the number of listed companies and the total capitalisation value. Considering both indicators - listed companies and capitalisation value - in the case of Brazil, the sample for the 2017-2019 period was more homogeneous than the 2020-2022 period. The opposite situation occurred in Chile, where the period after the start of the COVID-19 pandemic was more homogeneous than the previous one. In the case of Mexico, the period after 2020 showed greater fluctuation in the total capitalisation value of listed companies, but stability in the number of listed companies. Table 1 compiles the results for each of the countries.

With these results, it can be said that in parts, the behaviour of Brazil and Mexico is similar, since the depreciation of their average capitalisation value after the start of the pandemic fell by 6% and 2% respectively, with an even greater reduction in the minimum capitalisation value, however, with a higher maximum

[1]See Wooldridge, 2005.
[2]See Breusch, Pagan (1979).
[3]See also Bueno (2011).

capitalisation value after 2020 in both cases. The sample of the capitalisation value of these countries from the comparative period after the start of the pandemic was also less symmetrical and homogeneous - showing a period of greater volatility between 2020 and 2022.

Chile, despite having a more symmetrical sample in the period after the start of the pandemic, showed greater fluctuations in the average total capitalisation value in the period after the start of the COVID-19 pandemic, reaching a depreciation of 34% in the average value and 26% in the minimum value and 33% in the maximum value - comparing the two periods of analysis. It can be seen that the historical minimum of the market capitatisation (USD) of the periods took place between 2020 and 2022, in addition to the maximum value during the pandemic being lower than the previous period. It's important to bear in mind that when Chile entered the pandemic period, it had already been going through one of its biggest political and social crises since 2019, which culminated in major protests involving more than 5% of its population, as reinforced by Leopoldino (2020) and Desir (2022).

In the case of Mexico, the average number of listed companies from 2017-2019 and 2020-2022 was similar. In the case of Brazil and Chile, the average number of listed companies after 2020 increased, with greater significance in the case of Brazil, and the opposite effect in the case of Mexico. One hypothesis for this effect was the different measures taken by the Brazilian, Chilean and Mexican governments to contain the pandemic, given that, according to Cota (2021), Mexico was the country - among the largest in Latin America - that spent the least as a percentage of GDP to contain the damage caused by the pandemic, with 0.7 per cent - compared to 14 per cent for Chile and 9.2 per cent for Brazil. Simioni Neto (2023, p. 44) emphasises that Chile has spent resources on unemployment insurance and payroll subsidies to prevent companies from going bankrupt, in the same way that Brazil has increased public spending in this regard.

As for market capitalisation (USD), all the stock exchanges in the countries analysed had negative impacts after the start of the pandemic compared to the previous period, where Chile showed greater depreciation. Even so, the period before the pandemic showed a less symmetrical distribution in the Chilean case in terms of the number of listed companies and similar in both periods in terms of market capitalisation.

In general, it can be said that the COVID-19 pandemic has had negative effects on the three stock exchanges in the three countries studied, mainly considering the market capitalisation of these markets. This result corroborates other preliminary studies related to market pricing with Covid-19, such as the work by Avelar (2020), which identified high losses in the value of companies and an increase in their level of indebtedness.

Chart 1. Comparison of periods between indicators of the number of listed companies and capitalisation value B3, Santiago Stock Exchange and BMV

Country	Indicator	2017-2019		2020-2022	
		No. of Listed Companies	Capitalisation Value	No. of Listed Companies	Capitalisation Value
Brazil	Average	337,97	946.365,57	361,61	890.586,65
	Minimum	326,00	771.081,01	327,00	605.067,53
	Maximum	350,00	1.187.361,69	388,00	1.198.298,09
	Median	339,00	945.458,11	369,50	867.666,79
	Asymmetry	More symmetrical	More symmetrical	Less symmetrical	Less symmetrical
	Standard Deviation	6,05	107.925,98	19,92	150.762,36
Chile	Average	287,92	255.712,42	291,58	168.141,29
	Minimum	204,00	185.532,58	277,00	136.563,39
	Maximum	298,00	314.057,01	299,00	211.343,23
	Median	291,50	256.192,85	295,00	167.556,77
	Asymmetry	Less symmetrical	Similar	More symmetrical	Similar
	Standard Deviation	15,26	30.271,32	8,15	16.264,53
Mexico	Average	145,81	413.121,39	144,81	404.875,28
	Minimum	144,00	355.723,41	144,00	275.086,58
	Maximum	149,00	463.361,60	146,00	497.919,25
	Median	145,00	413.910,87	145,00	426.233,98
	Asymmetry	Less symmetrical	More symmetrical	More symmetrical	Less symmetrical
	Standard Deviation	1,49	28.387,72	0,86	62.175,10

Source: Statistics Portal *do* The World Federation of Exchange*, elaborated by the authors (2023).*

4.2. Time Series analysis

For the time series analysis, two equations were drawn up for each of the countries, in one of which the index of each stock exchange was used as the dependent variable in relation to the number of new cases and fatalities computed within the nation. For the days when the variations in the stock market indices were not available (weekends and public holidays), the values were mirrored, i.e., values closed on Friday were mirrored for Saturday and the values of the variation in the index on Monday were mirrored for Sunday.

In both models, the Dickey-Fuller (DF) unit root test showed that the Brazilian and Chilean models were stationary, failing to reject H_0: $\delta = 0$. The null hypothesis was rejected for the Mexican model, where H_1: $\delta \neq 0$ means that the series is not stationary at the level, making it necessary to model the variables in one difference. In one difference the model becomes stationary, on which we worked out.

In the two regressions for the three countries, the Jarque-Bera normality test for the residuals rejected H0: residuals follow a normal distribution, with a p-value < 0.05. However, as the models worked with more than 1,094 observations, asymptotic normality was accepted and the hypothesis tests were valid.

The Breusch-Pagan and Cook Weisberg heteroscedasticity test suggested the presence of heteroscedasticity in the Brazil and Chile regressions, meaning that the variance for each observation is uniform only in the Mexico models. Based on these results, robust estimates were also used in the regressions for Brazil and Chile, using Newey-West Robust Inference, which showed no significant signs, values or other changes in the results. As described in chapter 4.2, using Newey-West robust inference ensures that the results are consistent with regard to autocorrelation and heteroscedasticity.

4.2.1. Time Series model: National Cases and Fatalities

As can be seen in Tables 2, 3 and 4, the number of national COVID-19 cases and fatalities do not - individually or collectively

- explain the fluctuations in the stock market indices of their respective countries.

Table 2. Regression (1), Ibovespa (Brazil)

Ibovespa	Coefficient	Std. Error	t	P>|t|	Note No.	1095	
No. of CasesCountryDef	0.00000079	0.0000	0.37	0.708	F (2, 1092)	1.57	Independent variables do not
No. of DeathsCountryDef	0.0001216	0.0001	1.24	0.217	Prob > F	0.2076	jointly or individually predict the
_cons	-0.142385	0.0871	-1.64	0.102	R^2	0.0029	dependent variable

Source: Elaborated by the authors (2023).

Of the three models, the one with the lowest explanatory power was Mexico's, followed by Brazil and Chile. This may be related to the size of the stock exchanges, i.e., the number of companies listed on Chile's stock exchange is smaller than the other two.

IPSA	Coefficient	Std. Error	t	P>|t|	Note No.	1095	
No. of CasesCountryDef	0.0000002	0.0000001	2.02	0.044 **	F (2, 1092)	2.51	Independent variables do not
No. of DeathsCountryDef	- 0.0000017	0.0000016	-1.09	0.277	Prob > F	0.082	jointly or individually predict the
_cons	-0.0011256	0.0006939	-1.62	0.105	R^2	0.0046	dependent variable at 5% statistical significance.

Table 3. Regression (5), IPSA (Chile)

*** Significant at 5%*
Source: Elaborated by the authors (2023).

The equation for the Mexican model, evaluating the BMV index in relation to cases and fatalities within the country, obtained 1094 observations, due to the need for a difference because the model is not stationary in level. Even so, it did not prove to be a robust model for explaining the oscillations that occurred between 2020 and 2022.

BMV (Dif)	Coefficient	Std. Error	t	P>|t|	Note No.	1094	
No. of CasesCountryDIF	- 0.000000020	0.000000087	-0.23	0.817	F (2, 1092)	0.06	Independent variables do not
No. of DeathsCountryDIF	- 0.000003200	0.000014700	-0.22	0.828	Prob > F	0.9414	jointly or individually predict the
_cons	- 0.000038200	0.000428900	-0.09	0.929	R^2	0.0001	dependent variable

Table 4. Regression (3), BMV (Mexico)

Source: Elaborated by the authors (2023).

The preliminary results of the equation that evaluated the impact of the number of cases and fatalities within the country related to the new coronavirus on the volatility of the Ibovespa, IPSA and BMV indices did not have good explanatory power. The next section looked at whether the new cases and deaths of the disease around the world had an impact on the fluctuations of each country's index.

4.2.2. Time Series model: Worldwide Cases and Fatalities

In the second estimated model - no longer taking into account domestic COVID-19 cases and fatalities, but rather global ones in the volatility of the Ibovespa, BMV and IPSA indexes - the results for Brazil and Mexico were similar. While Chile's result was antagonistic to the others.

In the case of Chile, the model shown in Table 5 reduces the explanatory power, as well as the joint significance of the two independent variables in relation to the dependent one - when compared to the model in Table 3.

IPSA	Coefficient	Std. Error	t	P>|t|	Note No.	1095	
No. of CasesCountryDef	0,000000001	1E-09	1,3	0,195	F (2, 1092)	2,29	Independent variables do not
No. of DeathsCountryDef	0,000000209	1,38E-07	1,51	0,13	Prob > F	0,1013	jointly or individually predict the
_cons	-0,0022209	0,001052	-2,11	0,035	R^2	0,0042	dependent variable

Table 5. Regression (6), IPSA (Chile)

Source: Elaborated by the authors (2023).

Unlike the results for Chile, the models for Brazil and Mexico with the number of fatalities and global COVID-19 cases showed a greater explanatory capacity for the Ibovespa and BMV fluctuations respectively, corroborating the results of the work by Albulescu (2021). In the results for both countries, the R^2 increases, showing that the global data on the new coronavirus had a greater influence on the volatility of the Ibovespa and BMV indices during the study period.

Ibovespa	Coefficient	Std. Error	t	P>|t|	Note No.	1095	
No. of CasesCountryDef	0,0000001	1E-07	1,61	0.10 *	F (2, 1092)	4,21	Independent variables jointly
No. of DeathsCountryDef	0,000033	1,52E-05	2,17	0.03 **	Prob > F	0,015	predict the dependent variable at
_cons	-0,32125	0,116081	-2,77	0.006 ***	R^2	0,0076	5%

Table 6. Regression (2), Ibovespa (Brazil)

*** Significant at 1%; ** Significant at 5%; * Significant at 10%*
Source: Elaborated by the authors (2023).

In the Mexican regression model, cases of global deaths from the disease showed greater statistical significance in the impact on BMV in the period than the number of cases; however, the F test showed that the independent variables have the explanatory capacity to predict the dependent variable together, with a 10% significance level, with Prob > F of 0.0859. This result may demonstrate the country's dependence on external factors.

BMVDIF	Coefficient	Std. Error	t	P>|t|	Note No.	1094	
No. of CasesCountrYDIF	-0,0000000004	0,000000002	-0,17	0,865	F (2, 1092)	2,46	Independent variables jointly
No. of DeathsCountryDIF	-0,000000798	0,000000390	-2,05	0.041 **	Prob > F	0,0859	predict the dependent variable by
_cons	-0,0000324	0,000428	-0,08	0,94	R^2	0,0045	10%

Table 7. Regression (4), BMV (Mexico)

** Significant at 5%*
Source: Elaborated by the authors (2023).

In general, the time series models showed that the number of new cases and fatalities of the new coronavirus in the world had a more significant influence on the volatility of the stock market indices in Brazil and Mexico, without having the same effect in Chile. This difference may be linked to various aspects that differentiate Brazil and Mexico from Chile, such as the size of the stock exchanges studied and the lower representation of foreign organisations in the composition of companies listed on B3 and BMV.

Table 8 compiles the results shown in sections 4.2.1 and 4.2.2. As explained above and compiled in the respective table, Brazil and Mexico are the most similar in terms of the behaviour of new cases and fatalities of the new coronavirus in relation to the fluctuations of their Ibovespa and BMV indices. Even so, each country has shown itself to be unique in the results of this study, and further research is suggested in the future.

Table 8. Compiled Time Series Regression Results

Country	**Regression**	**I - Internal Cases**	**II - Worldwide Cases**
Brazil	Cases	Unexpected but not significant signal	Unexpected signal, but significant at 10%
	Fatalities	Unexpected but not significant signal	Unexpected signal, but significant at 5%
	R^2	Low explanatory capacity	162% increase over the previous model
	Joint Prediction	No	Yes, at 5% significance
Chile	Cases	Unexpected signal, but significant at 5%	Unexpected but not significant signal
	Fatalities	Expected signal, but not significant	Unexpected but not significant signal
	R^2	Low explanatory capacity	Low explanatory capacity
	Joint Prediction	Yes, but at 10% significance	No
Mexico	Cases	Expected signal, but not significant	Signal expected, but not significant
	Fatalities	Expected signal, but not significant	Signal expected, significant at 5%
	R^2	Very little explanatory capacity	4400% increase over the previous model
	Joint Prediction	No	Yes, at 5% significance

Source: Elaborated by the authors (2023).

5. Conclusion

This study sought to analyse the impacts of the COVID-19 pandemic on the stock markets of three Latin American countries: Brazil, Mexico and Chile. Using a methodological approach that combined descriptive and time series analyses, the oscillations in the number of listed companies and the capitalisation value of the stock exchanges were investigated, as well as the impact of the number of COVID-19 cases and fatalities, both domestic and global, on the oscillations of each country's indices.

In the descriptive analysis, established in correspondence with the first and second specific objectives, three distinct behaviours were observed for each country. Chile showed a greater depreciation in the total capitalisation value of the Santiago Stock Exchange during the pandemic, although the number of listed companies recovered after 2020. However, the country was already facing a political and social crisis before the pandemic, which may have influenced the results.

Brazil, on the other hand, showed less depreciation in the average capitalisation value of the B^3 compared to Chile after the start of the pandemic, but considerable market volatility in this respect. Even with a loss of market value in terms of capitalisation, the average number of companies listed on the Brazilian stock exchange increased after 2020. Mexico also showed less symmetry in the capitalisation value of listed companies after 2020, but maintained stability in the number of listed companies and was the country that showed the least variation in average capitalisation values between the two periods.

The time series analysis, linked to the third and fourth specific objectives, revealed that the number of domestic COVID-19 cases and fatalities did not explain the fluctuations in the stock market indices of the countries studied. However, when considering global data on cases and deaths, the models for Brazil and Mexico showed greater explanatory power for the variations in the Ibovespa and BMV indices, respectively. On the other hand, global data did not have the same impact on Chile's IPSA index.

These results suggest that the stock markets of Latin American countries have been influenced differently by the COVID-19 pandemic. Brazil and Mexico were more sensitive to global data, while Chile appeared to be more resilient to these external variations.

Several factors can explain these differences. The size of the stock exchanges, the representation of foreign companies and the policies adopted by each country to combat the pandemic are some of the aspects that may have influenced the results. Brazil, for example, was the first country to show cases of infection and death from the new coronavirus, but started vaccinating its population later than Mexico and Chile. The political uncertainty surrounding the 2022 Brazilian presidential elections may also have contributed to the greater instability of the market during the period analysed.

In addition, the economic policy and macroeconomic decisions of the countries after the start of the pandemic, such as the increase in the basic interest rate, may also have had an impact on the volatility of the capital markets. High inflation in the three countries studied led to an increase in interest rates, which may have made credit more expensive and dampened demand for goods and services, affecting companies' profitability.

It is important to note that the results presented cannot be generalised and other variables can be considered in the analysis. Fluctuations in the capital markets are complex and can be influenced by a number of factors, not just the COVID-19 pandemic.

To summarise, the COVID-19 pandemic had negative effects on the stock markets of the countries studied, but these impacts were perceived differently in each of them. The descriptive and time series analyses provided an accurate understanding of the fluctuations in the stock markets, but the economic scenario and government decisions also had a significant influence. Continued research in this area is essential for a better understanding of the mechanisms that govern the capital markets and for the development of more effective economic recovery policies.

Therefore, future studies could delve deeper into these issues and consider other variables that could better explain the variations in the stock markets of Latin American countries. In addition, it is essential that the governments and economic authorities of the countries continue to monitor and implement appropriate policies to mitigate the economic impacts of the pandemic and promote the recovery of the capital markets.

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Author Guidelines

Comprehensive Guide to Publishing with GJHSS

Global Journal of Human-Social Science | Open Access | Peer Reviewed | COPE Compliant

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I. Our Commitment to Authors

The Global Journal of Human-Social Science (GJHSS) is an internationally recognized, **open-access** academic journal dedicated to publishing high-quality, peer-reviewed research across the entire spectrum of human and social sciences - including Arts & Humanities, Sociology & Culture, History, Archaeology & Anthropology, Economics, Political Science, Linguistics & Education, Geography, Environmental Science, and interdisciplinary social inquiry.

GJHSS is published by Global Journals Publishing Group Inc., indexed in major global academic databases, archived in leading digital repositories, and distributed to institutional subscribers worldwide in prestigious **hardbound volumes**.

We believe that the purpose of an academic journal is to amplify the voice of the researcher. Every operational decision we make - from submission workflows to publication formats - is guided by a single principle: *the author should never be distracted from the scholarship.* Our professional editorial and production teams exist to handle every technical and logistical complexity so that you can devote your full energy to your social science research.

II. One-Click Submission: Publish Without the Hassle

GJHSS has pioneered a **One-Click Submission** system designed to eliminate the traditionally burdensome process of paper submission.

A. Submit in Any Format

We accept manuscripts in **any common document format**, including but not limited to:

- Microsoft Word (.doc, .docx)
- Adobe PDF (.pdf)
- LaTeX source files (.tex)
- Rich Text Format (.rtf), Apple Pages, LibreOffice, or plain text

You do **not** need to install specialized software, learn LaTeX, or adhere to a rigid template before submission. Simply write your research in the format you are most comfortable with.

B. What You Need to Submit

To submit a manuscript, you only need to provide:

1. Your **full name**
2. Your **email address**
3. Your **manuscript file**

That is all. No lengthy registration forms, no complex metadata entry, no mandatory template compliance. Submit directly via our portal at https://globaljournals.org/submit-an-article/.

Heading style: In the final typeset article, author-created headings are normally set in sentence case for readability. Fixed journal headings such as Abstract, Introduction, Materials and methods, Results, Discussion, Conclusion, References, and Acknowledgements are standardized by the production team. Acronyms, proper nouns, gene/species names, chemical notation, brand names, and Roman numerals are preserved.

C. What Happens After Submission

1. **Instant Confirmation:** You receive an automated email confirming receipt of your manuscript. If you do not receive a confirmation, please reach out via our Contact Us form at https://globaljournals.org.
2. **Professional Formatting:** Our dedicated production executives convert your manuscript into our advanced internal LaTeX template - producing a sleek, typographically pristine document ready for review - entirely on your behalf.
3. **Author Dashboard:** We create a secure account for you on the **Author Dashboard** and email your login credentials. You may log in at any time to review pre-filled metadata, update co-author details, or track your submission status.
4. **Review Initiation:** Your professionally formatted, fully anonymized manuscript is assigned to expert reviewers through our rigorous double-blind peer-review process.

III. Rigorous Double-Blind Peer Review

Academic credibility is the cornerstone of GJHSS. Every manuscript undergoes a **strict double-blind peer-review process** in which neither the authors nor the reviewers are aware of each other's identities. This guarantees that every paper is evaluated purely on its scholarly merit, methodological rigor, originality, and contribution to the humanities and social sciences.

A. The Review Workflow

1. **Desk Screening:** The editorial office performs an initial screening for scope, completeness, and adherence to ethical standards.
2. **Reviewer Assignment:** Two or more independent, domain-expert reviewers - specialists in your specific discipline of human-social science - are assigned to evaluate your manuscript.
3. **Detailed Evaluation:** Reviewers assess the paper on criteria including originality, significance, clarity, theoretical framework, methodology, and presentation quality.
4. **Editorial Decision:** Based on reviewer recommendations, the Editorial Board renders one of three decisions: *Accept*, *Revise and Resubmit*, or *Decline*.

B. Complete Review Report & Research Assessment Sheet

Upon completion of the review, you will receive a **comprehensive Review Report** along with a detailed **Research Assessment Sheet**. These documents provide:

- Line-by-line reviewer comments keyed to **specific line numbers** in your typeset manuscript, enabling precise, unambiguous identification of every comment.
- A structured assessment covering originality, significance, clarity, methodology, and overall quality.
- Constructive feedback and actionable suggestions for improvement.

C. Responding to Reviewer Comments

Addressing reviewer feedback is simple and flexible. You have two options:

Option A - Author Dashboard: Log in to your Author Dashboard, navigate to **Manage Submission**, and create a **support ticket**. Simply quote the relevant line numbers from your review report and clearly describe your corrections or responses.

Option B - Email: If the Dashboard is not convenient, you may simply send an email with a numbered list of corrections referencing the line numbers, along with your responses to each reviewer comment.

Important: You do **not** need to reformat the document yourself at any stage. Our production executives will implement all your requested text changes directly in the typeset manuscript. Reviewer comments may be addressed and resolved right up until the Early View stage.

IV. Publication Lifecycle: Complete Transparency

A. Early View (Galley Proof)

- Upon acceptance, a **galley proof** (Early View edition) of your article is prepared according to the journal's publishing schedule.
- The Early View version includes **line numbers** for convenient reference during final corrections.
- You may still provide corrections at this stage by referencing specific line numbers via email or the Author Dashboard.

B. Ahead of Print

- Following the Early View, an **Ahead of Print** version is published before the final issue compilation.
- This version represents the final, corrected article but **does not yet include Volume or Issue numbers**.

C. Digital Publication (eJournal)

- After all corrections are finalized, the **digital eJournal edition** is published with line numbers removed.
- Your article receives its official **DOI (Digital Object Identifier)** and is indexed across global academic databases.
- The article becomes freely and permanently accessible online under our open-access policy.

D. Hardbound Print Publication

- Approximately **15 days after digital publication**, the article enters our offset production pipeline.
- Your research is printed in **premium hardbound volumes** and distributed to institutional subscribers, major university libraries, and social science research centers worldwide.
- The corresponding author receives a **complimentary hardbound copy** dispatched via government courier at no additional cost.

V. Advanced Technology & AI-Enabled Research Broadcasting

While GJHSS is rooted in the traditions of humanistic and social inquiry, our publishing infrastructure harnesses the latest advancements in technology to maximize the impact and discoverability of your scholarship.

A. Multi-Format Native Publication

Every accepted article is published natively across multiple formats:

- **Interactive Digital eJournals** optimized for desktops, tablets, and smartphones.
- **Premium Hardbound Print Editions** for institutional archives and personal collections.
- **Machine-Readable XML & HTML** for web accessibility, automated indexing, and integration with global research repositories.

B. AI-Powered Discoverability & SEO

We deploy cutting-edge Artificial Intelligence to generate rich semantic metadata for every article, dramatically increasing its search engine visibility. Our proprietary AI systems:

- Automatically tag, categorize, and cross-reference your work across international academic databases.
- Optimize article metadata for maximum **Search Engine Optimization (SEO)**, ensuring your paper appears prominently when scholars search for your research topics and theoretical frameworks.
- Actively broadcast your research to targeted humanities and social science communities worldwide, amplifying your citation count and global influence.

VI. Ethics, Integrity & COPE Compliance

GJHSS maintains the highest standards of publication ethics, guided by the principles of the **Committee on Publication Ethics (COPE)**.

A. Plagiarism & Originality

All submissions are screened using state-of-the-art plagiarism detection software. Manuscripts with significant textual overlap with previously published work will be declined. Authors must ensure that all content is original or properly attributed through accurate citations.

B. Conflicts of Interest & Funding Transparency

Authors are required to disclose all sources of funding and any financial or non-financial conflicts of interest. Full transparency is mandatory and is enforced at every stage of the publication process.

C. Data Availability & Reproducibility

Authors are encouraged to make their datasets, interview transcripts, survey instruments, and supplementary materials available in recognized repositories to support the reproducibility and verifiability of their findings. A data availability statement is required in all published manuscripts.

D. Ethical Approval & Informed Consent

Research involving human participants, sensitive communities, or vulnerable populations must include a statement of ethical approval from a recognized institutional ethics committee, along with confirmation that informed consent was obtained where applicable.

E. Comprehensive Ethics Portal

Our enhanced, COPE-based ethical publishing guidelines - covering authorship criteria, editorial responsibilities, reviewer obligations, corrections & retractions, and misconduct procedures - are available in detail on our website at https://globaljournals.org. We encourage all authors, reviewers, and editors to familiarize themselves with these standards.

VII. Perpetual Archiving & Geo-Distributed Data Infrastructure

GJHSS is backed by Global Journals' enterprise-grade archiving infrastructure. Your published research is not stored on a single server - it is **redundantly archived across multiple geographically distributed data centers** spanning several continents, including advanced **deep-sea data center facilities** engineered for unparalleled environmental resilience and longevity.

This infrastructure guarantees:

- **Lifetime Hosting:** Your article will remain permanently accessible online for the lifetime of the publication. We do not sunset, deprecate, or remove published content under any circumstance.
- **Disaster Resilience:** Multi-site redundancy ensures that no single point of failure - natural disaster, hardware degradation, or network disruption - can compromise access to your research.
- **Immutable DOI Resolution:** Every article is assigned a permanent Digital Object Identifier (DOI) that will resolve to your work indefinitely, regardless of future platform migrations.

VIII. Open Access: Free Knowledge for All

GJHSS is a Fully Open Access Journal.

We firmly believe that humanistic and social scientific knowledge is a public good. Every article published in GJHSS is **freely and permanently available online** from the moment of publication - accessible to researchers, students, educators, policymakers, and the general public worldwide **without any subscription fees, paywalls, or access restrictions**.

Our open-access model ensures:

- **Immediate Availability:** Your research is accessible globally on the day of publication.
- **Maximum Reach:** Barrier-free access dramatically increases readership, citations, and real-world policy impact.
- **Equitable Knowledge Distribution:** Scholars in developing nations, independent researchers, and the public benefit equally from the latest advances in human-social science.

IX. The LaTeX Author Package (Entirely Optional)

For researchers who already compose their manuscripts in LaTeX, we provide a comprehensive, professionally designed **LaTeX Author Package** (`gj-author`) featuring STIX Two serif typography, TeX Gyre Heros sans-serif headings, complete Unicode math support, and brand-coordinated layouts.

However, we must emphasize:

Reading or using the LaTeX Author Package is entirely optional.

If you do not use LaTeX, simply send us your manuscript in Word, PDF, or any other format. Our production team will expertly convert it into our advanced typesetting system and produce the identical, pristine publication-quality output.
You do not need to learn or install anything.

Contact & Support

Submission Portal: https://globaljournals.org/submit-an-article/
Website: https://globaljournals.org
Email: helpdesk@globaljournals.org

At GJHSS, your scholarship illuminates the human condition.

We handle the complexities of publishing so you can focus on what matters most - understanding and shaping society.

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