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Highlights

- Data Plan Choice in Brazil
- The Digital Renminbi and Its Impacts
- The Structural Power of the Dollar
- Competitiveness of African Companies

Discovering Thoughts, Inventing Future

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Effect of Human Resources on the Competitiveness of African Companies

By Alpha Traore

Annotation- The interest of the study is to make companies more competitive, especially those in developing countries, on an international scale. The main objective is to study the link between the human resources of companies and their competitiveness in international markets. Using SPSS software for data processing, we arrive at the following results: African companies employ much more women (99.2%) than men (98.1%) in their subsidiaries in international markets, the results show that exports of goods and services of companies represent 98.1% of the Gross Domestic Product (GDP) of African countries, exports of goods and services and primary income represent only 98.5% of the GDP of African countries.

Keywords: *effect, human resources, companies, competitive, international markets.*

GJHSS-E Classification: *LCC: HD57.7*



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Effect of Human Resources on the Competitiveness of African Companies

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Keywords: effect, human resources, companies, competitive, international markets.

I. Introduction

The socio-professional integration of higher education graduates has been the subject of intense research in educational sciences. Most of the work notes that higher education graduates are increasingly confronted with the problem of unemployment. The contribution of neoclassicals in labor economics is focused on the microeconomic study of the labor market to adapt general representations of markets to this particular market of a service, a production factor, which is the "labor market". In labor economics, the perspectives developed share with the sociology of work an approach focused more on recruitment than on selection. They are made up of two approaches: the first is commercial and totally managerial which intends to get closer to Human Resources Management (HRM) by becoming prescriptive. While the second, is institutionalist, leans towards the sociology of work by focusing on the segmentation and quality of work, beyond its monetizable attributes. Today, young people are the social group immediately affected by the integration economy in the labor market. The integration or professional integration of young graduates is therefore a question of society, but also of research. Studied for more than thirty years in France, it is often described as a complex and multifaceted process whose measurement proves to be an arduous task and mobilizes an impressive battery of concepts and instruments, both theoretical and empirical. It is important to highlight the relationship between the unemployment rate and recruitment. A recent study by Grobon S, I. Ramajo and D. Roucher shows that companies have been facing increasing recruitment difficulties for about ten years [1, 2, 3].

Companies are faced with a number of constraints which are linked, among other things, to access to credit, corruption, the financial situation, insufficient human resources as well as the lack of qualified labor, the level of supervision and technical and financial support below expectations, difficulties in accessing energy (for certain developing countries) as well as information and communication technologies, constraints linked to legislation, etc.

Which leads us to ask the following research question: do companies' human resources influence their competitiveness?

Specifically:

- Does the gender of companies' employees influence their competitiveness?
- Are companies' exports of goods and services correlated with their competitiveness?
- Do exports of goods and services and primary income have a positive effect on the competitiveness of companies?

To answer these questions, we pose the following hypotheses:

The Main Hypothesis is: Companies are competitive in international markets.

H1: The gender of employees in companies positively influences their competitiveness, women have more opportunities than men in terms of employment in companies. Through marketing, they can offer the company a certain credibility in international markets.

H2: Exports of goods and services by companies are correlated with their competitiveness; the higher the production, the more it is possible to export the surplus to international markets.

H3: Exports of goods and services and primary income have a positive effect on the internationalization of companies; the higher these primary incomes, the more motivated the company is to access international markets.

The main objective of this study is to investigate the link between the human capital of companies and their access to international markets.

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Specific Objectives Include:

- Establishing a relationship between the gender of company employees and access to international markets.
- Analyze the link between companies' exports of goods and services and their competitiveness.
- To study the correlation between exports of goods and services and primary income of enterprises and their competitiveness.

The interest of this study is to make companies more competitive on an international scale and facilitate their access to foreign markets. Furthermore, this study is organized around: context of the study, literature review, methodology as well as the presentation and interpretation of the results.

Investment in human resources allows individuals to acquire the knowledge and skills needed to obtain present and future jobs. Employment is essential for the development of a country, the lack of quality employment is the real problem in developing countries, more precisely low-income countries with a population increase[1].

To make human resources more qualified, companies must develop a performance model based on know-how (work) where the worker (the human) would be the main variable. They must also take into account in the model other factors such as: the requested market, the size of the company, relations with other companies through competition, legislation, etc. As also highlighted, employee training is the most responsible practice due to multiple stakeholder expectations that it can reconcile [6].

The economic performance of all workers can be increased through formal education and on-the-job training. Within a company, diversity could on the one hand positively impact the company's performance through the differentiation of values, beliefs, attitudes of the group of workers or even creativity. On the other hand, some authors have based themselves on the direct influence of women within the company. They claim that a very large number of women could positively influence the reputation, the conquest of new markets, the profitability as well as the financial performance of the company. According to Cadet "despite the fact that the literature on human capital is abundant, the profusion is however inversely proportional to the clarification of the concept, which remains complex, whatever the disciplinary approach." [7, 8].

II. Research Methodology

The development of the conceptual framework is a decisive step in social science research. A conceptual framework is a construction, a representation, a diagram containing a series of propositions. The construction of a conceptual framework in this precise framework, allows to summarize and understand the mechanisms at the base of the human capital of Smoll and Medium Enterprises (SME) and access to international markets.

In this study, the dependent variable represents Foreign Direct Investment (FDI), i.e. the internationalization of companies. It is dichotomous. To distinguish between them, this variable has two modalities: Yes (1), if the company is competitive; No (2), if the company is competitive.

The gender variable, the name given to all or part of the genitals. It is about knowing the influence of men and women on the competitiveness of companies. The modalities of this variable are among others: Male (1); Female (2).

The variable export of goods and services, these are quantities of goods shipped abroad in order to access international markets. It is also dichotomous: Yes there are surpluses for export, No production is insufficient.

The variable exports of goods and services and primary income. It determines not only the productive capacity of the company but also its financial capacity. It also has two modalities: yes the company can invest abroad, no the company cannot invest abroad.

In our specific case we will use SPSS software for data analysis and processing. We will do a bivariate descriptive analysis. It consists of crossing the dependent variable (FDI) with each of the independent variables in order to assess the level of correlation that exists between them. To measure the association between two variables we use the Chi-square statistic to which a probability "p" is associated. In social science, a significance threshold is generally set. When the probability associated with the Chi-square is lower than the significance threshold retained, we conclude that the two variables are associated. Otherwise, they are said to be independent. In the context of our study, the threshold retained is 5%.

III. Presentation and Interpretation of Results

The relationship between gender and Foreign Direct Investment (FDI) is significant at the 5% level. We find that companies employ significantly more women (99.2%) than men (98.1%) in their subsidiaries in international markets. Therefore, hypothesis H1 is verified, women have more opportunities than men in terms of employment in terms of FDI. Which makes them more credible in international markets (Table 1).

[1] https://live.banquemondiale.org/fr/evenement/2023/assemblees-annuelles-2023-investing-in-le-capital-human-pour-booster-l-emploi

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Table 1: Relationship between FDI and Gender. (7)

Summary of Observation Processing						
	Observations					
	Valid from		Missing		Total	
	N	Percentage	N	Percentage	N	Percentage
Human capital, F * FDI net outflow 2020	264	99.2%	2	0.8%	266	100.0%
Human capital, H*FDI net outflow 2020	261	98.1%	5	1.9%	266	100.0%

Source: Author

The relationship between FDI and exports of goods and services is significant at the 5% threshold. The results show us that exports of goods and services of companies represent 98.1% of the Gross Domestic Product (GDP). This is significant for the conquest of international markets. Therefore hypothesis H2 is verified, exports of goods and services are sufficient to encourage companies to conquer international markets (Table 2).

Table 2: Relationship between FDI and Exports of Goods and Services (7).

Summary of Observation Processing						
	Observations					
	Valid		Missing		Total	
	N	Percentage	N	Percentage	N	Percentage
X of B/S * IDE net outflow 2020	261	98.1%	5	1.9%	266	100.0%

Source: Author.

The link between FDI and Exports of goods and services and primary income is significant at the 5% level. According to the results, exports of goods and services and primary income represent only 98.5% of GDP. This rate is very significant to enable companies to invest in international markets. Also hypothesis H3 is verified because exports of goods and services and income allow companies to invest in international markets (Table 3).

Table 3: Relationship between FDI and Exports of Goods and Services and Income (7).

Summary of Observation Processing						
	Observations					
	Valid		Missing		Total	
	N	Percentage	N	Percentage	N	Percentage
X of B/S and RP * IDE net outflow 2020	262	98.5%	4	1.5%	266	100.0%

Source: Author

IV. Conclusion

In light of all the above, let us deduce that companies have the capacity to conquer international markets over all those based in Africa. This performance is due not only to the fact that men take precedence in terms of employment, which allows companies to have a certain credibility on international markets, but also to the increase in the quantity produced in order to export the surplus to other markets as well as the existence of financing for Foreign Direct Investments (FDI).

Companies must work more for the professional training of employees in a constant and regular manner. Give more opportunities to women than to men so that they are more competitive internationally. Also, they must increase their productive capacity more in order to export the surplus to international markets. In addition, to compete in international markets, they must seek financing to not only increase their productive capacity through employee training but also for Foreign Direct Investments.

I would like to thank my consultant for her availability and commitment to supporting me in the quest for success. Also my family for their support as well as all the goodwill that contributes directly or indirectly to the success of these scientific works.

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From the Northeast to Minas: The Reterritorialization of Immigrants from Ceará in Governador Valadares-MG

By Dr. Renato Conrado

Abstract- This study seeks is a research on the migration of Cearenses to the municipality of Governador Valadares-MG, known for being an international emigration center. Bibliographical and documentary research and a field work are its methodology. The outcome of this research shows that the Ceará's community created spaces, reproducing its original culture and keeping its own identity alive. These migrants created a territory with hybrid characteristics, living in a constant multiterritoriality.

Keywords: *ceará, governador valadares-MG, migration.*

GJHSS-E Classification: *LCC: JV6201-6347*



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From the Northeast to Minas: The Reterritorialization of Immigrants from Ceará in Governador Valadares-MG

Do Nordeste Para Minas: A Reterritorialização de Imigrantes Cearenses em Governador Valadares-MG*

Dr. Renato Conrado

Resumo- **Este estudo busca compreender a migração de Cearenses para o município de Governador Valadares-MG, conhecido por ser um polo de emigração internacional. Como metodologia, foram utilizadas a pesquisa bibliográfica e documental, sendo também realizado um trabalho de campo. Constatou-se que a comunidade cearense criou espaços, reproduzindo nesses a sua cultura e mantendo viva a sua identidade. No processo de reterritorialização, criaram um território com características híbridas, vivendo uma constante multiterritorialidade.**

Palavras-chave: ceará, governador valadares-MG, migração.

Abstract- **This study seeks is a research on the migration of Cearenses to the municipality of Governador Valadares-MG, known for being an international emigration center. Bibliographical and documentary research and a field work are its methodology. The outcome of this research shows that the Ceará's community created spaces, reproducing its original culture and keeping its own identity alive. These migrants created a territory with hybrid characteristics, living in a constant multiterritoriality.**

Keywords: ceará, governador valadares-MG, migration.

Este trabalho foi realizado com apoio financeiro da Fundação de Amparo à Pesquisa do Estado de Minas Gerais – FAPEMIG

I. Introdução

O município brasileiro de Governador Valadares ficou amplamente conhecido como um polo de emigração internacional. Esse movimento emigratório foi favorecido pela rede que começou ser construída na década de 1960, quando vários jovens de classe média participaram de programas de intercâmbio ou viajaram no espírito de aventura, para viver um "tempo" na América. Esse movimento inicial, ao mesmo tempo, respondia à crescente influência do "american way of life" e à forte presença de cidadãos daquele país, em Governador Valadares, nos anos de 1950[1]. Nas duas décadas seguintes, num quadro regional de crise estrutural provocada pelo esgotamento da fronteira agrícola, esse fluxo migratório internacional se intensifica e adquire a relevância nacional e internacional, entre meados da década de 1980 e, a nas décadas de 1990 e 2000, se irradiando por toda região de influência de Governador Valadares e, ao mesmo tempo, incorpora outros destinos, tais como Portugal e Reino Unido[2] (SIQUEIRA, 2009; SIQUEIRA, ASSIS, 2010; SIQUEIRA, SANTOS, 2012).

A emigração internacional é o fenômeno mais conhecido, porém a Região Geográfica Intermediária de Governador Valadares também se particulariza pela perda expressiva de população para as outras regiões brasileiras, com o saldo migratório líquido negativo dos mais expressivos do Brasil, entre 1960 e 1991 (SOARES, 2002). Em proporção menor, essa tendência de perda de população persistiu nas décadas seguintes. Para a microrregião de Governador Valadares[3], considerando os dados do Censo Demográfico de 2010, o saldo migratório negativo era de 10.396[4] emigrantes. Ou seja, saíram mais pessoas

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[1] Essa presença de cidadãos dos EUA em Governador Valadares era decorrente dos Acordos de Washington que previram o programa de saneamento do Vale do Rio Doce, a reforma da Estrada de Ferro Vitória a Minas e a criação da Companhia Vale do Rio Doce, abrangendo os anos de 1940 e 1950.

[2] Para se avaliar o impacto da emigração em Governador Valadares, basta ressaltar que entre os dez municípios brasileiros com maior número de emigrantes internacionais, de acordo com os dados do Censo Demográfico de 2010, o município ocupava a sétima posição, dentro de um grupo no qual só figuraram capitais de estados (SIQUEIRA, SANTOS, 2012).

[3] Microrregião de Governador Valadares era composta por 25 municípios: Alpercata, Campanário, Capitão Andrade, Coroaci, Divino das Laranjeiras, Engenheiro Caldas, Fernandes Tourinho, Frei Inocêncio, Galiléia, Governador Valadares, Itambacuri, Itanhomi, Jampruca, Marilac, Nacip Raydan, Nova Módica, Pescador, São Geraldo da Piedade, São Geraldo do Baixio, São José da Safira, São José do Divino, Sobrália, Tumiritinga, Mathias Lobato e Virgolândia. A partir de 2017, o Instituto Brasileiro de Geografia e Estatística (IBGE) passou a utilizar uma nova divisão territorial brasileira na qual as antigas microrregiões foram substituídas pelas regiões geográficas imediatas, continuando Governador Valadares e ser um polo, mas perdeu cinco municípios para Teófilo Otoni e recebeu seis novos municípios

[4] Considerando o quesito de data fixa, ou seja, indivíduos que foram recenseados em 2010 em um município mas que, em 2005, residiam em outro.

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da microrregião do que entraram. Considerando que 26.676 pessoas emigraram de Governador Valadares e que 18.736 pessoas imigraram para o município, temos que o município apresentou um saldo migratório negativo de 7.940 migrantes, representando, sozinho, 76,4% da perda populacional da microrregião para outros estados do Brasil (CUNHA et al, 2016; CUNHA et al, 2017).

Ainda utilizando os dados do último censo, considerando ser Governador Valadares, o principal município dentro da microrregião que levava o seu nome, é possível perceber seu baixíssimo poder de atração dessa. Os dados apontam que 6.742 indivíduos estavam residindo em algum município dentro da microrregião em 2005 e foram recenseados em outro município, também pertencente a microrregião. Se considerarmos que a população total da microrregião era de 415.696 habitantes, que Governador Valadares possuía uma população de 263.689 habitantes – ou seja, 63,4% da população da micro – e que apenas os municípios de Itambacuri, Coroaci e Itanhomi possuíam uma população maior que dez mil habitantes, impressiona o fato de que Governador Valadares tenha atraído apenas 2.201 desses migrantes, algo próximo a um terço do total (CUNHA et al., 2016; CUNHA et al., 2017).

Dentro deste contexto de perda populacional e de fraco poder de atração que caracteriza Governador Valadares, este trabalho busca analisar um movimento populacional inverso, ou seja, de chegada de imigrantes ao município. O foco está em um grupo populacional que deixou seus locais de origem e optaram por aqui viver, especificamente os que possuem como origem o estado do Ceará e que passaram a residir, em sua maioria, em um determinado bairro da cidade de Governador Valadares (Santa Rita). A pesquisa busca identificar no bairro os lugares e elementos culturais/simbólicos que estão ligados ao processo de reterritorialização desses migrantes.

PALAZZOLO (1973), em sua história sobre o aldeamento de Itambacuri, menciona os retirantes do Ceará e Bahia que fugiam da fome e das doenças que se seguiram a grande seca de 1890, se estabelecendo na região, até Figueira (Governador Valadares). Com a construção da rodovia federal Rio-Bahia (BR 116), migrantes nordestinos que rumavam para São Paulo, ao passar por Governador Valadares, tomavam a decisão de "apear" do pau-de-arara, se estabelecendo na cidade conforme suas qualidades técnicas, muitos no ramo do couro (ESPINDOLA, 1998, p. 158-159). Entretanto, as alterações ambientais e a concentração da propriedade fundiária na região de Governador Valadares, bem como a rodovia federal, fizeram com que a cidade polarizasse na verdade a pobreza, conforme observa Brito et al. (1997).

> Governador Valadares, de fato, polarizava a pobreza da região, o que se tornaria ainda mais agudo com a inauguração da rodovia Rio-Bahia no início da década de 1950. Além de atrair os imigrantes que abandonavam o campo no próprio vale do Rio Doce, a cidade passou a funcionar como "corredor migratório" para baianos e nordestinos (BRITO et al., 1997, p. 65).

Portanto, a presença nordestina e, mais especificamente cearense, não se constitui uma novidade. Todavia, a presença de uma comunidade concentrada em um bairro em específico, é uma característica que justifica o presente estudo.

Como metodologia, além da pesquisa bibliográfica e documental, se utilizou o trabalho de campo com o objetivo de levantar os aspectos locais e as práticas cotidianas desse grupo, segundo as orientações de Certeau (1998). Como esse recomenda, buscou-se caminhar pelo bairro como um "andarilho-voyeur", observando as práticas cotidianas e não apenas estabelecendo um olhar de cima. As caminhadas permitiram um contato mais aprofundado com a área de estudo, principalmente com os territórios relacionados ao grupo pesquisado, possibilitando, por meio desse procedimento, sentir cheiros, ouvir sons e ver mais de perto esse território.

O artigo se divide em quatro seções, incluindo essa introdução. Na seção seguinte, são descritas as principais características das regiões de origem dos emigrantes, assim, como de Governador Valadares e, mais especificamente, do bairro Santa Rita. Na terceira seção é descrito o processo de reterritorialização dos cearenses e, por fim, temos as considerações finais.

II. Um Rápido Panorama da Origem e do Destino

O Ceará, devido à conjunção das características físicas do seu território e o seu posicionamento geográfico[5], possui uma distribuição irregular das chuvas, sofrendo com as secas periódicas – como os demais Estados dentro do semiárido. O Estado, segundo Queiroz (2013), tem apresentado, a partir da década de 1980, uma tendência à diminuição das suas taxas de mortalidade e fecundidade e dos seus saldos migratórios negativos. Queiroz ressalta que,

> Dado esse quadro [de secas], conjugado com o baixo desenvolvimento econômico e falta de oportunidades de trabalho, historicamente o Ceará tipifica como área de evasão populacional, alta taxa de mortalidade e de fecundidade, com impactos sobre o seu crescimento populacional (QUEIROZ, 2013, p. 43)

[5] O Estado possui uma área de 148.886,31 km², sendo composto por 184 municípios (MEDEIROS *et al.*, 2017), sendo que, a partir da resolução nº 115 do Conselho Deliberativo da Sudene, de 23 de novembro de 2017, passou a ter 175 (95,1%) desses municípios pertencendo a área de abrangência do Semiárido Brasileiro.

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Queiroz (2013, p. 102), analisando os dados dos Censos Demográficos de 1970, 1980, 1991, 2000 e 2010, ressalta que, nos últimos três censos, embora o estado não tenha revertido o processo histórico de perda populacional, esse não é tão intenso como nas décadas de 1960, 1970 e 1980. A autora aponta para a tendência a reversão das perdas populacionais, "caso a diminuição nas saídas se mantenha e o fluxo migratório interestadual de retorno permaneça".

Um dos destinos da migração de cearenses é o estado de Minas Gerais, no qual destacamos o município de Governador Valadares. De acordo com os dados do Censo Demográfico de 2010, havia 5.060 indivíduos nascidos no Nordeste e que estavam residindo no município, sendo o maior grupo composto pelos baianos (59,7%), com os cearenses representando o segundo maior grupo, com 571 indivíduos (11,3%) e os pernambucanos o terceiro, com 418 indivíduos (8,3%).

Governador Valadares é um município localizado no Leste do estado de Minas Gerais, dando nome à região geográfica intermediária (RGINT) e à região geográfica imediata(RGIME) a que pertence. O município está situado é um entroncamento rodoferroviário, ocupando uma posição central na bacia hidrográfica do rio Doce. Pelo Censo Demográfico de 2010 a população do município era de 263.689 habitantes – sendo que 96,1% residiam na área urbana – e sua população estimada em 2020 era de 281.046 habitantes[6]. Considerando essa estimativa, Governador Valadares era o nono município mais populoso de Minas Gerais, sendo também o mais extenso entre os 58 municípios da REGINT e totalizando 36,3% da população dessa (774.437 habitantes). Já considerando a RGIME, formada por 26 municípios, sua população representa 61,7% do total (455.614 habitantes)[7]. É o município polo, exercendo grande influência econômica em relação aos municípios próximos, respondendo também a boa parte da demanda desses em relação a saúde e educação.

O município possui uma localização privilegiada (veja Figura 01), sendo cortado por três rodovias federais, com destaque para a BR 116, conhecida como Rio-Bahia (neste trecho chama-se Santos Dumont), ficando a meio caminho entre Feira de Santana (Bahia) e a cidade de São Paulo, sendo um ponto de parada obrigatória de todas as rotas que partem do Nordeste em direção às cidades do Rio de Janeiro e São Paulo[8]. Além das rodovias, o município é ainda cortado pela Estrada de Ferro Vitória-Minas, pertencente à mineradora Vale, única ferrovia nacional com tráfico diário regular de passageiros, ligando a cidade à capital mineira (Belo Horizonte) à capital do Espírito Santo (Vitória).

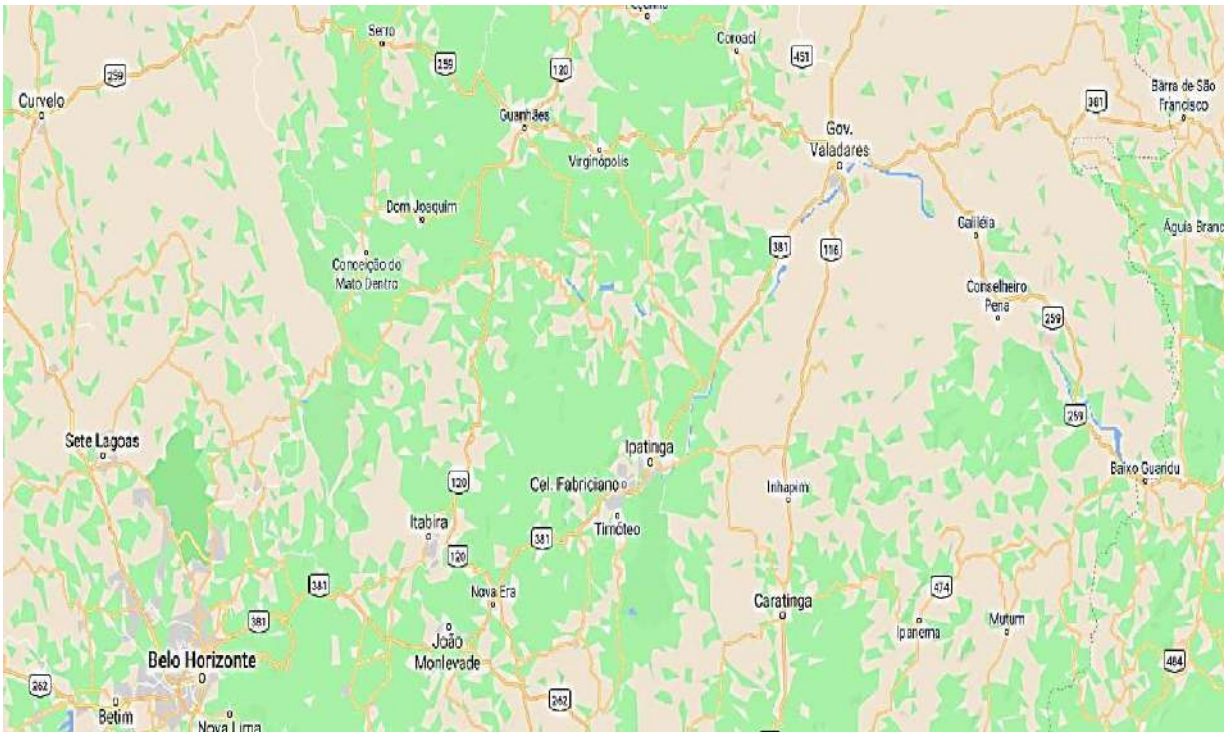
Fica claro na Figura 1, que a condição de entroncamento rodoferroviário que cortam Governador Valadares faz com que o município seja um local de passagem de muitas pessoas provenientes dos quatro pontos cardeais, particularmente do Nordeste para o Rio de Janeiro e São Paulo.

[6] Fonte: IBGE. Diretoria de Pesquisas (DPE) e Coordenação de População e Indicadores Sociais (COPIS). Estimativas da população residente no Brasil e unidades da federação com data de referência em 1º de julho de 2020.

[7] Os 26 municípios que compõem a região geográfica imediata de Governador Valadares são: Alpercata, Capitão Andrade, Conselheiro Pena, Coroaci, Divino das Laranjeiras, Engenheiro Caldas, Fernandes Tourinho, Frei Inocêncio, Galiléia, Goiabeira, Gonzaga, Governador Valadares, Itanhomi, Jampruca, Marilac, Mathias Lobato, Nacip Raydan, Santa Efigênia de Minas, São Geraldo da Piedade, São Geraldo do Baixio, São José da Safira; Sardoá, Sobrália, Tarumirim, Tumiritinga e Virgolândia. A região geográfica intermediária de Governador Valadares, com 58 municípios, é composta por, além dos municípios citados anteriormente, por mais 32 municípios divididos entre as regiões geográficas imediatas de Ganhães (20), Mantena (7) e Aimorés-Resplendor (5). Os municípios que compõem a região geográfica imediata de Ganhães são: Cantagalo, Coluna, Divinolândia de Minas, Dom Joaquim, Dores de Guanhães, Frei Lagonegro, Guanhães, José Raydan, Materlândia, Paulistas, Peçanha, Rio Vermelho, Sabinópolis, Santa Maria do Suaçuí, São João Evangelista, São José do Jacuri, São Pedro do Suaçuí, São Sebastião do Maranhão, Senhora do Porto e Virginópolis. Já a região geográfica imediata de Mantena é composta pelos municípios: Central de Minas, Itabirinha, Mantena, Mendes Pimentel, Nova Belém, São Félix de Minas e São João do Manteninha. Por fim, temos a região geográfica imediata de Aimorés-Resplendor, composta pelos municípios: Aimorés, Cuparaque, Itueta, Resplendor e Santa Rita do Itueta.

[8] Além da BR 116, a cidade de Governador Valadares é cortada pela BR 381, que liga o município a capital do estado, Belo Horizonte (distante 324 Km), e a cidade de São Paulo; no seu outro terminal com o norte capixaba. A cidade também é cortada pela BR 259, que liga a cidade ao Espírito Santo e ao centro do estado de Minas Gerais, até encontrar a BR 040, ao norte Belo Horizonte, ligando a cidade a Brasília.

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Fonte: Adaptado de imagem do Google Maps.

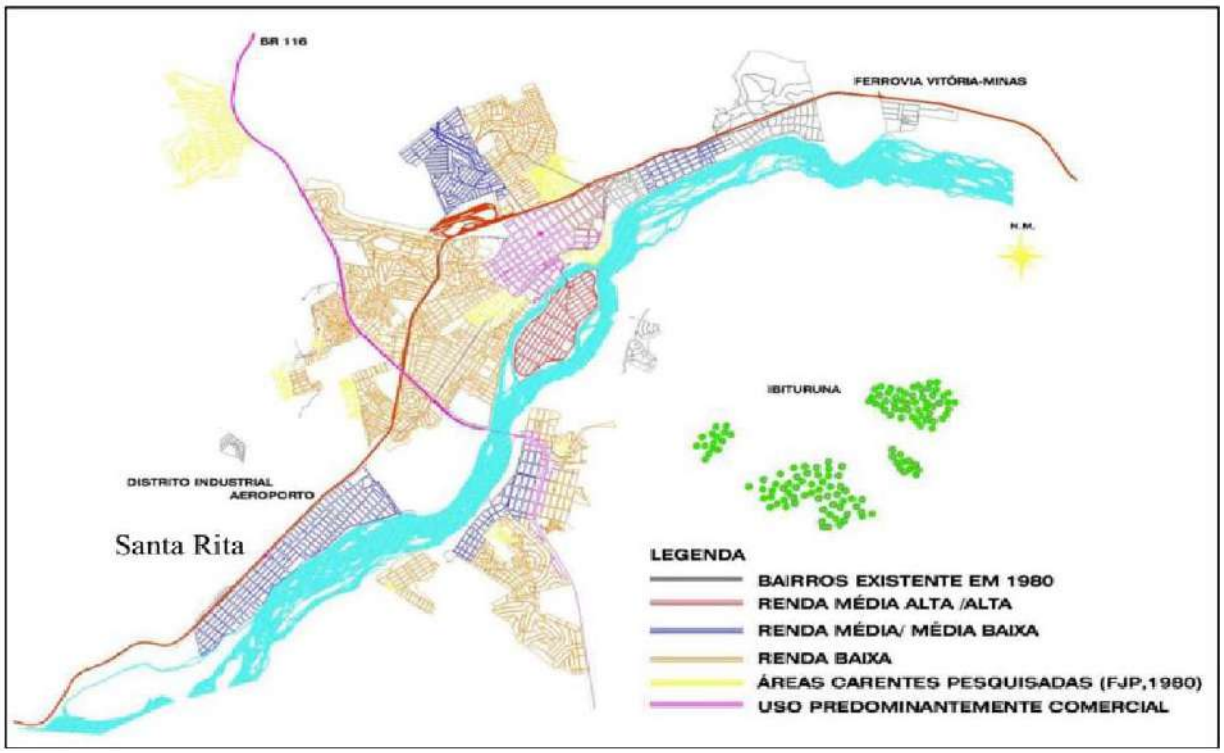
Figura 1: Governador Valadares e as Rodovias que cortam o Município

O produto interno bruto (PIB) do município de Governador Valadares, em 2017, foi de pouco mais de 5,2 bilhões de reais, sendo o 14º maior dentro do estado de Minas Gerais, representando 1,05% do PIB estadual, 49,6% do PIB da região geográfica intermediária e 76,1% do PIB da região geográfica imediata. Além do peso da economia valadarense em relação aos municípios do seu entorno, fica evidente o peso do setor de serviços na economia do município (64,8%)[9]. O IDH do município passou da faixa muito baixa, com 0,508 em 1991, para 0,635 em 2000, fincando incluído no grupo de municípios com médio grau de desenvolvimento humano, segundo a classificação do Programa das Nações Unidas para o Desenvolvimento (PNUD). Em 2010, o município alcançou um índice de 0,727, mostrando uma considerável melhora nos seus indicadores sociais, sendo classificado como possuindo um alto desenvolvimento humano.

Como indicado na introdução, o foco da pesquisa é o grupo de migrantes originário do estado do Ceará residente no bairro Santa Rita, na cidade de Governador Valadares. O bairro está localizado próximo ao distrito industrial e ao aeroporto municipal, sendo delimitado, de um lado, pela avenida Euzébio Cabral, que dá continuidade à BR 381, e do outro pelo rio Doce, apresentando, por esse fato, áreas aluviais sujeitas a alagamentos nos períodos chuvosos. Como pode ser observado na Figura 2, até a década de 1980, o bairro ainda se encontrava separado da malha urbana por remanescentes de áreas rurais (chácaras agrícolas). "Além da BR 116, o único bairro que apresentava alguns dos serviços de infraestrutura citados era o Santa Rita, identificado como moradia da classe média-baixa" (GUIMARÃES, 2009, p. 181-182). Exceto a áreas central e os bairros adjacentes de classe média, o bairro Santa Rita era um dos poucos que contava com coleta de lixo, ruas principais pavimentadas e serviço de água e rede de esgoto. Ele se diferenciava principalmente por possuir um comércio próprio, em um contexto em que o restante da cidade dependia praticamente do comércio da área central.

[9] O setor industrial foi responsável por 11,2% do valor adicionado bruto e o agropecuário por apenas 0,6%. O PIB per capita no ano do município foi de R$20.957,24, 23,2% menor que o de Minas Gerais (R$27.282,75), mas 25,7% maior que o da região geográfica imediata (R$16.666,30) e 41,8% maior que o da região geográfica intermediária (R$14.782,16).

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Fonte: Mapa da distribuição de renda, em 1980, no distrito-sede, Governador Valadares, elaborado com base no diagnóstico realizado pelo Fundação João Pinheiro, 1980 (GUIMARÃES, 2009, p. 181).

Figura 2: Bairro de Santa Rita, em Governador Valadares, 1980

O bairro Santa Rita é o maior da cidade de Governador Valadares, tanto em termos populacionais quanto em extensão territorial. De acordo com os dados do Censo Demográfico de 2010, sua população era de 19.687 habitantes, um pouco menos que a de Conselheiro Pena (22.242 habitantes), segunda maior população entre os municípios que compõe a região geográfica imediata de Governador Valadares. A instalação de migrantes cearenses no bairro Santa Rita teve início em meados dos anos de 1980, inicialmente se dedicando ao comércio ambulante, porém se estabelecendo posteriormente em estabelecimentos fixos. Pode-se afirmar, que o grupo aproveitou a fase de melhoria do IDH do município, como mostrado anteriormente, quando esse passou de muito baixa (0,508), em 1991, para um alto desenvolvimento humano (0,727), em 2010. Como o bairro Santa Rita apresentava uma tendência de autonomia em relação à área central da cidade, essa melhoria foi acompanhada do crescimento dos setores de comércio e serviços localizados no bairro.

Nesse contexto de melhoria do IDH e de crescimento dos setores de comércio e serviços, os migrantes cearenses se estabeleceram em pontos determinados do bairro com diferentes estabelecimentos. Assim, foi se estruturando uma rede social ligada a esses migrantes estabelecidos no bairro Santa Rita e os bons resultados obtidos por uns serviram de incentivo para que outros viessem do Ceará para as terras mineiras. Hoje há um número considerável de cearenses residindo no bairro, embora seja difícil de se estimar a quantidade exata. Entretanto, basta destacar que, apenas entre os membros da Associação da Comunidade Cearense de Governador Valadares – ACC-GV, eram 178 associados que, no ano de 2019, residiam no bairro.

As redes sociais possuem um papel essencial para a manutenção e perpetuação dos movimentos migratórios. Tratando sobre a migração internacional, Massey et al., (1993), afirmam que a existência dessas redes aumentaria a probabilidade de o movimento migratório acontecer – o que também pode ser aplicado as migrações internas. Segundo esses autores, as redes "reduzem os custos e riscos do movimento e aumentam a expectativa de retorno com a migração. As redes migratórias constituiriam uma forma de capital social que propiciaria às pessoas terem acesso ao mercado de trabalho no exterior" (MASSEY et al., 1993, p. 448).

Embora não tenha sido objetivo desse trabalho estudar as formas como essa rede atuou no sentido de servir de suporte a esses migrantes cearenses, pela organização do grupo, não é difícil levantar a hipótese que ela tem atuado no sentido de minimizar os riscos relativos a migração, principalmente no que diz respeito a informação sobre o local de destino e suporte no momento de chegada e durante o processo de adaptação, particularmente considerando a existência

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da Associação da Comunidade Cearense de Governador Valadares.

III. Um Rápido Panorama da Origem e do Destino

O ato de migrar é visto como um processo de desenraizamento do local de origem e um aventurar-se no local de destino. Marandola Jr. e Dal Gallo (2010) mostram que o migrar é sair de um território com o qual estamos familiarizados e no qual temos certa segurança e lançar-se no mundo, em lugares poucos conhecidos e, portanto, que se apresentam como pouco seguros.

> O processo de desenraizamento original iniciado pelo movimento migratório se dá, em termos existenciais, pela alteração da territorialidade consolidada, a modificação desta relação originária self-lugar, saindo do lugar-natal, o que implica deixar os lugares de infância, juventude ou idade adulta, responsáveis pela nossa formação enquanto pessoa e sobre os quais está edificada nossa identidade. Implica, portanto, sair dos territórios da segurança e lançar-se no mundo, em lugares de pouca ou nenhuma familiaridade, onde há pouco ou nenhum controle, uma das raízes da insegurança (MARANDOLA JR.; DAL GALLO, 2010, p. 410).

O migrante vive em múltiplos territórios no local de destino, buscando se reterritorializar nesse novo local que escolheu para viver. Haesbaert (1997), que estudou o processo de migração de gaúchos para às regiões do cerrado no Centro Oeste brasileiro, mostra como estes migrantes se reterritorializavam no local de destino, "colocando em questão acima de tudo a formação de "novos territórios", ou melhor, as novas formas de territorialização dos sulistas frente à desterritorialização dominante (mas não exclusiva) entre os nordestinos" (HAESBAERT, 1997, p. 28).

Os novos espaços criados ou, quando já existentes, escolhidos por esses migrantes, possibilitam que as suas práticas cotidianas continuem a ser realizadas. Para isso, "eles reproduzem os geossímbolos e a organização socioespacial de seu antigo território"

> Ao restabelecer os elos espaciais e identitários o grupo migrante é capaz de se enraizar e dar fundamento à sua identidade que, evidentemente, não será a mesma, pois agora são migrantes num outro lugar e não estão isentos das influências locais, incorporando-as mesmo que parcialmente (MARANDOLA JR; DAL GALLO, 2010, p. 415)

Um importante ponto de encontro e de vivência da comunidade de migrantes proveniente do estado do Ceará que se estabeleceu no bairro Santa Rita – e com certeza o mais importante – é a Associação da Comunidade Cearense de Governador Valadares (ACC-GV). O projeto foi idealizado por alguns cearenses durante uma confraternização no final do ano de 2001. A ideia inicial dos seus dezenove fundadores foi a de criação de um espaço que, além de se configurar como um local de lazer e de confraternização dos associados, fosse aberto a toda a população Valadarense no sentido mostrar a essa um pouco da cultura do estado do Ceará. O terreno onde a associação está instalada fica cerca de dois quilômetros da área comercial do bairro Santa Rita, no bairro Distrito Industrial, próximo ao aeroporto municipal.

A ACC-GV foi algo pensado e trabalhado durante alguns anos até a sua fundação. Os migrantes realizaram vários encontros até chegarem a um consenso sobre o objetivo e organização da associação, o que seria oferecido a seus sócios e quem assumiria a diretoria. Sua fundação se deu no dia 16 de março de 2008, contando com a presença de autoridades políticas da cidade. Em 2010, a partir da Lei nº 6.160, de dezembro de 2010, foi reconhecida pelo município de Governador Valadares como entidade de utilidade pública. A associação foi declarada de utilidade pública estadual, pela Assembleia Legislativa de Minas Gerais, por meio da Lei n. 23.080, de 9 agosto de 2018.

Em lista fornecida pela ACC-GV, em 26 de novembro de 2019, constavam inscritos 302 sócios, sendo que desses, 178 residiam no bairro Santa Rita (59%). Embora quase 95,0% dos associados residam em Governador Valadares, como pode ser observado na Tabela 1, que a ACC-GV também possui associados residentes em outros dez municípios mineiros próximos a sede da associação e em quatro municípios do estado do Espírito Santo.

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Tabela 1: Município de residência dos associados da ACC-GV em 2019

Local de residência		Freq.	%
Governador Valadares	Governador Valadares	286	94,70
	Bairro Santa Rita	178	58,94
	Outros bairros	108	35,76
Outros Municípios Minas Gerais (10)	Capitão Andrade-MG	1	0,33
	Ipaba-MG	1	0,33
	Teófilo Otoni-MG	1	0,33
	Nova Módica-MG	1	0,33
	Caratinga-MG	1	0,33
	Mantena-MG	1	0,33
	Resplendor-MG	1	0,33
	Coluna-MG	1	0,33
	Ipatinga-MG	1	0,33
	Coronel Fabriciano-MG	3	0,99
Outros Municípios Espírito Santo (4)	Nova Venécia-ES	1	0,33
	Ibatiba-ES	1	0,33
	Alto Rio Novo-ES	1	0,33
	Serra-ES	1	0,33
Total		302	100,00

Fonte: Elaboração dos autores a partir de dados fornecidos pela ACC-GV

A ideia dos fundadores era a de criar um espaço de encontro e de vivência para os migrantes, onde se pudesse ser servida a comida típica cearense, contando com uma loja onde seriam comercializados produtos típicos e artesanato, além do projeto futuro da construção de um museu relacionado a comunidade cearense e sua cultura, no geral. Atualmente o espaço conta com uma área coberta, com uma cozinha, banheiros e churrasqueiras, o que possibilita que ali sejam realizadas confraternizações. A ACC-GV também oferece cursos de confecção de tapetes, toalhas e outros assessórios de cama, mesa e banho. Os cursos são abertos para associados e para a comunidade externa.

No projeto da ACC-GV, está previsto a ampliação do espaço de lazer, com as seguintes melhorias: construção de um campo de futebol, de quadras e de uma piscina. No sentido de ser um espaço também aberto à população valadarense, há a previsão de se contar, além da loja em funcionamento com os produtos regionais do Ceará, com um espaço onde possam ser realizadas apresentações de artistas locais interpretando canções de músicos cearenses (Amelinha, Belchior, Fagner, Ednardo, entre outros) e de outros estados do Nordeste. Há também o projeto de que o espaço conte com uma biblioteca, onde estejam estivessem disponíveis obras literárias de escritores nordestinos. Enfim, o espaço foi pensado e está sendo construído visando que a cultura do Ceará e, de modo geral a nordestina, sejam expostas e vivenciadas pela comunidade cearense e por toda a população de Governador Valadares. A ACC-GV seria um pedaço do Ceará em Minas Gerais.

Fica claro a intensão de utilizar a associação como um instrumento de reterritorialização dos migrantes, como se pode ver e ler na página da ACC-GV[10], ao apresentar a bandeira da entidade, na qual se fundem as bandeiras do Ceará e de Minas Gerais, acompanhada do poema *Construindo um Ceará*, da associada e uma das fundadoras, Verônica Oliveira Lima. O poema é dividido em duas partes distintas. A primeira trata da saudade do Ceará, a exemplo de "Canção do Exílio", escrito pelo maranhense Gonçalves Dias, em 1843, quando era estudante de Direito na Universidade de Coimbra, Portugal. Verônica tem "saudade no coração" da terra que está distante e começa constando que se encontra "em terra estranha", porque está "longe" do seu sertão. Na segunda parte ela apresenta a solução para essa saudade, que é construir no destino sua terra de origem.

Sua terra é o Ceará e é nele que se encontra a felicidade, daí ela afirma "Feliz é o filho que sonha / Aos braços da mãe voltar / E os mares do Ceará / Hão de me banhar o peito". Isso porque somente pode ficar satisfeito aquele que retorna um dia para sua terra. É no Ceará "que tudo anima a gente". Aí a autora lista a

[10] Site da ACC-GV, https://sites.google.com/site/cearensesgv/, acesso em 07/02/2023.

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chuva quando cai, a fogueira junina, o cultivo da terra. A saudade é tanta, que ela diz "chega a ficar duído", pois a autora duvida que exista melhor lugar para se viver. Portanto, seu projeto, como o de Gonçalves Dias, é voltar para sua terra: "Volto antes deu morrer / Pois lá ficou meu umbigo".

Na segunda parte, ela propõe um projeto para os cearenses que vieram morar "Aqui nas Minas Gerais". Um projeto que deve ser realizado, enquanto não for possível voltar: "Em edificar aqui; Um pedacim do Ceará". Isso é possível porque "Cearense tem demais / Já tem forró e baião /Tem até associação / E o que faltar a gente faz. / É construindo um Ceará / Aqui nas Minas Gerais".

Como foi dito, a bandeira da ACC-GV também transmite a ideia de recriar um território cearense dentro do estado de Minas Gerais, porém também demonstra a adesão a nova terra, a reterritorialização realizada com sucesso, visto que se promove a hibridização das bandeiras dos dois estados. Esse mecanismo simbólico é significativo, pois indica que não é uma simples transposição ou um saudosismo superficial, mas um elaborado mecanismo de ressignificação na nova terra sem deixar as raízes da origem. Como pode ser visualizado na Figura 3, a bandeira é formada por uma composição na qual o brasão existente no centro da bandeira do Ceará, cujo fundo é verde, é colocado no centro do triângulo vermelho da bandeira de Minas Gerais. Em torno do triângulo vermelho, em vez dos dizeres que aparecem na bandeira mineira (*Libertas quae sera tamen*), temos o nome da associação.

Como já destacado anteriormente, Marandola Jr. e Dal Gallo (2010) apontam que a migração implicaria na desestabilização ser-lugar, com o migrante perdendo a segurança proporcionada pelo seu local de origem, que faz parte da sua própria existência enquanto ser, para se aventurar em lugares desconhecidos, o que gerará a sensação de insegurança. Segundo os autores,

> A necessidade por parte do migrante de preservar sua personalidade, sua identidade e voltar a ter a sensação do pertencimento leva a um gradual e contínuo processo de edificação de "lugares próprios", os quais permitem ao migrante enraizar-se. Estes lugares e suas articulações são, na verdade, o território dos migrantes. Esses lugares se configuram como base e fundamento das redes sociais estabelecidas por eles (MARANDOLA JR.; DAL GALLO, 2010, p. 412).



Fonte: Site da ACC-GV

Figura 3: Bandeira da Associação da Comunidade Cearense de Governador Valadares

Ao se estudar a experiência da comunidade cearense residente no bairro Santa Rita, na cidade de Governador Valadares, se constata que essa buscou construir esses lugares próprios. Ainda segundo Marandola Jr. e Dal Gallo (2010), o migrante irá construir uma nova rede de relacionamentos ligada a esses locais específicos, o que aumentará gradativamente a sensação de segurança, levando-o a enraizar-se no local de destino. Essa nova rede geralmente é constituída a partir da rede migratória que o trouxe para algum determinado lugar.

> O papel das redes no fenômeno migratório permite entender a dimensão estrutural das escolhas e motivos da migração. Por outro lado, a partir das redes sociais, é possível compreender também o capital simbólico e material a que o migrante tem acesso no local de destino. É neste sentido que pensamos o papel da rede social e suas relações com a territorialidade e os lugares migrantes: em que medida elas conseguem diminuir o impacto da ruptura com o lugar de origem, em termos familiares, culturais e existenciais? (MARANDOLA JR.; DAL GALLO, 2010. p. 412).

Também Haesbaert (1997, p. 92) destaca o papel fundamental das redes sociais como "malha

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cada vez mais globalizante dentro da qual os territórios podem se tornar meros pontos, ou seja, momentos ou parcelas elementares das redes".

Respondendo à questão formulada por Marandola Jr. e Dal Gallo, pelo até aqui apresentado, é fácil perceber entre a comunidade cearense de Governador Valadares a importância da ACC-GV como um desses lugares próprios no processo de reterritorialização desses migrantes e, ao visitarmos esse lugar é impossível não perceber a importância da rede social criada, no sentido de minimizar para o migrante os riscos inerentes a todo processo migratório, como também de, dentro do contexto traumático de ruptura com o lugar de origem, possibilitar a identificação desse no local de destino, não apenas pela presença de seus conterrâneos – gente que compartilha os mesmos hábitos e costumes –, mas também pela criação de lugares, onde esses hábitos e costumes deixados para trás, possam ser revividos. Voltando ao poema apresentado anteriormente: "E o que faltar a gente faz. É construindo um Ceará aqui nas Minas Gerais".

Vale ressaltar a intensa multiterritorialidade vivenciada por esses migrantes, que estão completamente reterritorializados no município que, longe de seus locais de origem, escolheram para viver, mas recriam no destino laços de identidade com a sua terra natal. Esses migrantes estão de forma material e simbólica ligados a ambas territorialidades: a do território que escolheram para viver, em Minas Gerais, e a do território que deixaram no Ceará.

IV. Considerações Finais

Migrar sempre se apresenta como uma oportunidade para a maioria dos seres humanos, quando não se trata de migração forçada por diferentes motivos (ambiental, econômico, político, conflito militar, desastres etc.). A oportunidade de migrar e a decisão de partir raramente é tomada de forma isolada, por um único indivíduo, a partir do uso de sua racionalidade. Normalmente envolve outras pessoas, sejam elas familiares ou amigos. Ao escolherem um novo local para residirem, o migrante imagina que esse oferece as condições almejadas. Eles carregam consigo as suas territorialidades – constituídas no seu local de origem – e, como ressaltam Espindola et al. (2018, p. 22), levam também "outros seres, alguns escolhidos para irem junto, outros que vão escondidos na sua bagagem".

A migração que ocorreu e que ainda ocorre entre o estado do Ceará e o município de Governador Valadares é, antes de tudo, movida pelo mercado de trabalho e pelas redes sociais que se formaram entre os migrantes que aqui chegaram. Alguns migrantes que aqui primeiro chegaram, e se consolidaram, acabaram por motivar outros a fazerem o mesmo processo, sendo que muitos escolheram o bairro Santa Rita como local para estabelecerem suas novas residências, comércio e atividades laborais. Desse movimento nasceu uma comunidade cearense que deu origem à ACC-GV. Os pioneiros não apenas incentivaram a migração, como apoiaram esses novos migrantes, oferecendo condições para trabalharem como vendedores ambulantes ou em outros tipos de atividades. Com o aumento da presença desses cearenses no bairro Santa Rita, esses passaram a construir pontos de referência culturais/simbólicas de sua comunidade dentro do bairro ou próximos desse, que foram identificados nas caminhadas.

A comunidade cearense criou espaços dentro do bairro e próximos a ele, reproduzindo nesses a sua cultura e mantendo viva a sua identidade. Essa nova configuração é percebida pela população do bairro onde a comunidade está inserida. Antes não tão conhecidos, hoje esses espaços estão presentes e são, antes de tudo, planejados para serem espaços de convivência não apenas para a comunidade cearense, mas também para todos aqueles que desejam conhecer, aprofundar e participar de projetos desenvolvidos pela comunidade de migrantes ou que simplesmente desejem conhecer um pouco da cultura dessa comunidade.

No processo de reterritorialização, o migrante acaba criando um território com características híbridas, vivendo uma constante multiterritorialidade. Ele mantém os vínculos identitários e a comunicação com o Ceará, seu local de origem, ao mesmo tempo que experimenta todas as territorialidades do local que escolheu para viver, no caso, Governador Valadares.

Aqui em Minas Gerais, eles buscaram criar ou se apropriar simbolicamente de espaços onde podem se encontrar, vivenciar a sua cultura e, de certa forma, se sentirem mais perto do Ceará. Nesses locais, até mesmo na forma de conversar com as pessoas, o sotaque parece mais carregado com palavras que muitas vezes somente os cearenses conhecem. Como no poema que se encontra no site da ACC-GV e que é mencionado anteriormente nesse trabalho, os indivíduos dessa ativa comunidade se sentem "construindo um Ceará aqui nas Minas Gerais".

Obviamente este trabalho não tem a pretensão de esgotar o tema por ele abordado. A identificação dos lugares e os elementos culturais e simbólicos que estão ligados ao processo de reterritorialização dos migrantes cearenses, representa uma primeira e modesta contribuição no estudo das características, particularidades e história desse grupo, que somados aos outros migrantes vindos de outros estados do Nordeste, representam uma parcela significativa da população do município. Novas pesquisas se fazem necessárias para melhor caracterizar esses migrantes e o processo de reterritorialização deles em Governador Valadares. Entretanto, como não se deve medir a relevância de um trabalho apenas pela quantidade de

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respostas por ele alcançadas, mas também pelas novas questões por ele suscitadas, espera-se que este estudo contribua para aumentar o interesse de outros pesquisadores por este objeto de estudo tão rico e interessante.

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Understanding Mobile Internet Access and Data Plan Choice in Brazil: A Machine Learning Approach

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Abstract- This paper applies the Elastic Net Machine Learning technique to choose the variables that best represent the characteristics of mobile internet use in Brazil. We use regularized models to estimate the importance of a large number of variables, including socioeconomic attributes, internet and device utilization patterns, and digital skills to explain (a) access to the internet through mobile devices and (b) choice of mobile data plan. After identifying the most important variables, we estimate their marginal effects on the two dependent variables with nonlinear econometric models. The results suggest that socioeconomic characteristics and user skills have significant explanatory power in both estimations. Specifically, barriers such as age, income, and skill gaps persist, hindering inclusive mobile internet adoption. Conditional on mobile internet use, these characteristics are more common among postpaid internet data plan subscribers. Moreover, communication skills like messaging and social media use stand out regarding internet access, whereas internet utilization patterns (on the move and at work) have high explanatory power in the data plan choice.

Keywords: internet adoption, information and communication technology, digital education, mobile phone usage, ICT access, digital skills.

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Understanding Mobile Internet Access and Data Plan Choice in Brazil: A Machine Learning Approach

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Abstract- This paper applies the Elastic Net Machine Learning technique to choose the variables that best represent the characteristics of mobile internet use in Brazil. We use regularized models to estimate the importance of a large number of variables, including socioeconomic attributes, internet and device utilization patterns, and digital skills to explain (a) access to the internet through mobile devices and (b) choice of mobile data plan. After identifying the most important variables, we estimate their marginal effects on the two dependent variables with nonlinear econometric models. The results suggest that socioeconomic characteristics and user skills have significant explanatory power in both estimations. Specifically, barriers such as age, income, and skill gaps persist, hindering inclusive mobile internet adoption. Conditional on mobile internet use, these characteristics are more common among postpaid internet data plan subscribers. Moreover, communication skills like messaging and social media use stand out regarding internet access, whereas internet utilization patterns (on the move and at work) have high explanatory power in the data plan choice.

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I. Introduction

Mobile broadband internet and the liberalization of telecommunications markets have played a significant role in the growth of access to information and communication technologies (ICTs) since the 1990s. This technological development changed the patterns of internet usage and communication, both in the private and business domain. Governments worldwide seek to increase internet adoption among the population because it contributes to economic (Olumekor *et al.* 2024), social, educational (Chen *et al.* 2024), and environmental sustainability (Aljebreen *et al.* 2023). In particular, mobile internet use is highly popular in developing countries as it is easier and less expensive compared to a landline and a personal computer (Wu *et al.* 2023). Sustainable ICT use is really a key to development because permeates all sectors of the economy. In this context, digital skills are important for employment and daily life, as well as for an increasingly digital future, where individuals need to be able to use ICTs (International Telecommunication Union 2018). Thus, connectivity can be seen as a driver of economic development and a tool to empower people and communities in a sustainable way.

The number of internet users worldwide has been growing at a rapid pace. While in 2003, only 12% of the world's population was using the internet, this share rose to 53.6%, or 4.1 billion people, in 2019 according to data from the World Telecommunications / ICT Indicators Report. The same source reports that mobile phone subscriptions reached approximately 8.3 billion in 2019. Most countries in Latin America are above the global average in terms of ICT usage. Table 1 shows that 88% of people in Brazil use mobile phones, followed by Colombia (85.2%) and Paraguay (84.3%). Regarding internet and computer usage by the population during the same period, Brazil ranks third (70.4%) and fourth (38.6%) respectively. These numbers indicate that progress has been made, but there is still clearly room to increase internet adoption in Brazil and many other developing countries.

Table 1: Percentage of Individuals using Cell Phones, Internet and Computers

	Brazil	Colombia	Paraguay	Argentina	Peru	Uruguay	Bolivia
Cell phone	88.0	85.2	84.3	81.2	80.7	76.7	69.7
Internet	70.4	64.1	65.0	74.3	52.5	74.8	44.3
Computer	38.6	44.9	23.4	44.8	31.6	54.4	29.7

Notes: The numbers refer to the year 2018, with exception of Argentina (2017).
Source: ITU World Telecommunication /ICT Indicators database (2020)

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A key question for businesses and policymakers is how to sustain the growth of internet access and the expansion of an increasingly inclusive information society. Although there are several studies on the determinants of (mobile) internet adoption, most of them highlight socio-economic factors such as income, education, age, or gender (Martínez-Domínguez and Mora-Rivera 2020; Vimalkumar *et al.* 2021).

This research investigates in how far internet access has progressed in Brazil and what factors most hinder a continued and inclusive mobile internet adoption. The present study stands out from the previous literature because we take a more holistic approach and include a large number of socio-economic variables (67), as well as a large set of indicators for internet and device utilization patterns, and digital skills. We rely on the Elastic Net Machine Learning technique to identify which variables have the highest explanatory power regarding individuals' internet use via cell phone. After identifying the most important attributes, we use econometric techniques to quantify the marginal effect of the selected variables on mobile internet access using nonlinear models. These results reveal which factors still hinder the expansion of mobile internet access.

Since the type of mobile phone contract determines whether internet is used and if so how, we also study the variables that indicate who opts for the prepaid modality. We use rich micro data before the COVID-19 Pandemic (2014 to 2018) from Brazil called the Household ICT Survey which measures the ownership and use of Information and Communication Technologies by Brazilian citizens. Based on this nationally representative survey, we apply Machine Learning (ML) such as the Elastic Net regularization techniques to select the variables and estimate the significance of each attribute in explaining mobile internet access and mobile data plan choice. In the present context, a Machine Learning approach is particularly suited to deal with the large amount of microdata and the high dimensionality of explanatory variables (Athey 2019). ML also has significant advantages in using data to select functional forms flexibly, as well to estimate and compare alternative models. Finally, the process of repeated cross validation is useful to reduce overfitting and increase consistency. To the best of our knowledge, no other study has applied the proposed ML methods to the context of mobile internet adoption and mobile plan choice.

The data suggest that the socio-economic characteristics of internet users are decisive in their mobile internet access. For example, older individuals are more likely to not access the internet through mobile phones and do not have prepaid phone services. The differences across population groups also seem to be related to digital illiteracy as well as personal income. The skills with the highest explanatory power for having mobile internet access are sending text messages, searching information, and using social media. Stimulating and facilitating the access to these services is thus likely to increase mobile internet adoption among the groups of the population which are not well-inserted in the digital world thus far. Skills, however, are less relevant regarding the choice of mobile data plan type. Socioeconomic characteristics like age and income as well the pattern of use (on the move and at work) are closely related to having a postpaid mobile internet plan.

Our findings are in line with Riggins and Dewan (2005) who argue that the existence of a 'digital divide' among countries, i.e. the gap between those who have widespread access to ICTs (such as personal computers and the internet) and those who do not, may primarily be attributed to differences in income and educational levels. Although, policy makers are well aware of the pronounced regional disparities that are highly persistent (Ehrl and Monasterio 2019, 2024) and specific programs seem to have some effect but are still rather slow to reach income conversion, if ever (de Almeida *et al.* 2021; Ehrl *et al.* 2022). These findings are also observed in the context of mobile internet and in a variety of different countries Chen (2021); Demoussis and Giannakopoulos (2006); Martínez-Domínguez and Mora-Rivera (2020); Vicente and López (2011). Yet, controlling for these attributes and many others, we find that gender and race are not among the most influential drivers of mobile internet adoption, as argued by Wong *et al.* (2020), Chen (2021) and many others. Ochoa *et al.* (2022) adds that employment, location, and housing characteristics are also important drivers of mobile internet adoption in West Africa.

Van Deursen and van Dijk (2018) note that with internet connectivity rates reaching high levels in recent years, research attention on the digital divide has shifted from indicators related to internet access (referred to as the first-level digital divide) to indicators of the second-level digital divide, which includes skills and internet use. Within this context, several empirical studies highlight the relationship between the internet use pattern and the socio-demographic characteristics explored in first-level digital divide studies (Araujo and Reinhard 2019; Martínez-Domínguez and MoraRivera 2020). Chen (2021) includes the interesting aspect of social network effects and finds that having more connections in social media platforms increases mobile internet usage, which is in line with our observations. The digital divide and the unequal access of mobile internet adoption is relatively little researched, see the recent survey by Lythreatis *et al.* (2022). Digital skills, however, were analyzed in related contexts such as of adoption of mobile financial services (Kiconco *et al.* 2019) and mobile learning Mac Callum and Jeffrey (2013).

Our paper complements findings from Brazil by Nishijima *et al.* (2017), Araujo and Reinhard (2019), and

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Silva *et al.* (2020) who also use microdata and estimate logistic models to explain internet and cell phone usage. Silva *et al.* (2020) highlight that during economic crises families attempt to replace home internet access with more economical alternatives. Additionally, especially families with low income and education levels experience a negative impact on internet access rates due to the economic crisis. Nishijima *et al.* (2017) focus on internet access and mobile phone property and observe that income and education have a much larger explanatory power than personal attributes such as age or ethnicity. Araujo and Reinhard (2019) and Martínez-Domínguez and Mora-Rivera (2020) is among the few studies that relate digital skills to age and gender, however, without estimating their specific for mobile internet adoption.

Overall, the various approaches to studying sustainable internet access by families reveal an empirical challenge that is overcome in the present paper: selecting which variables to consider in applied works that best represent the characteristics of internet users. Most papers make a pre-selection of a few variables, although having more information available in the data set. This selection is usually based on a gap in the literature but without discussing the influence of alternative (similar) options. By using ML techniques we avoid much of the pre-selection of variables and let the data indicate which attributes are most relevant for explaining the access of internet though the mobile phone and the choice of mobile data plan.

Apart from this introduction, this paper is divided into four more sections. In the second section, we discuss related literature. Section three presents the data and methodology used in this research. The fourth section contains the results, and the fifth section provides conclusions and possibilities for future research.

II. Related Literature

The use of the internet became widespread just over 20 years ago. Although the price of internet usage plans and the necessary devices have been decreasing sharply, the access to internet is still far from universal. The existence of a 'digital divide' that varies across countries and population groups is well documented by a variety of papers.

Regarding barriers to digital access, Dutton *et al.* (2005), LaRose *et al.* (2012), Chen (2021) show that people are less likely to use the internet if they are older, belong to an ethnic minority, are female, do not have children, or are from disadvantaged areas. Other studies that reinforce the relationship between inequalities in ICT access and income and education which hinder a sustainable growth of internet adoption include Demoussis and Giannakopoulos (2006), Nishijima *et al.* (2017), and Silva *et al.* (2020). This study follows these papers by adopting personal income, education, and other individual characteristics such as ethnicity and age to the list of potential determinants of ICT access.

Affordability can be considered a first-level divide that still requires careful attention of researchers. van Deursen and van Dijk (2018) indicate that is problem continues even in the wealthiest and technologically advanced countries in the world. Moreover, the authors stress that ongoing expenses such as maintenance, software, and subscriptions also should not be neglected. The use of internet via cellphone offers poor families affordable access, and it is unsurprisingly very popular in developing countries (Marler 2018). Although, connected low income groups have a less pleasant experiences and obtain worse outcomes using the internet according to Gonzales (2015). Our research adopts these insights by considering that the type of internet plan (prepaid vs more expensive options) is an important aspect of internet usage.

Skills can be considered a second-level divide that pose even more subtle difficulties to exploit the benefits of ICT (Adamczyk *et al.* 2024; Ehrl and Monasterio 2024; Gonzales 2015). A variety of different measures can be found in the literature. Van Deursen and Van Dijk (2014) even include skills as one of the four stages of internet access: motivation, physical access, digital skills, and use. These authors consider digital skills to be divided into six types: operational, formal, informational, communication, content creation, and strategic skills. According to these authors, digital skills are essential for living in the information society, which includes economic, educational, political, social, cultural, and institutional participation. Technical skills are obviously required to use the internet and the skill proficiency varies by the type devices people are using (Araujo and Reinhard 2019; Martínez-Domínguez and Mora-Rivera 2020). The former paper observes that Brazilians who access the internet using both computers and mobile devices exhibit the highest level of digital skills. Interestingly, Martínez-Domínguez and Mora-Rivera (2020) find that entertainment and communication services are used more intensively by people aged 65 years and older. Education seems to have little impact on the type of internet utilization. Similar to these papers, we exploit self-reported activities by internet users as a proxy for digital skills.

Van Deursen and Van Dijk (2011) suspected that the unequal distribution of digital skills in the Dutch population may be one of the causes for the disparities in internet access. Part of the reasoning behind that conclusion is that although computers, mobile phones, and internet access itself has become gradually more affordable, part of the population, especially the elderly and very young remain unconnected. Eynon and

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Geniets (2016) exploit interviews with a small group of youth and find that limited experience and support networks contribute to the lack of skill acquisition. Chohan and Hu (2022) show that government-sponsored digital competency training programs can reduce the digital divide. One of the few examples that directly link digital skills to ICT (including internet adoption) is Yu *et al.* (2017) who find evidence in favor of a relevant connection, as in the present case.

Dutton and Reisdorf (2017) highlight that attitudes and values of internet users and non-users have been added more recently as key variables shaping internet engagement. Similarly, Eynon (2009) specifically investigates the digital divide in terms of education and learning, and finds that 91% of people with a positive attitude towards ICT are internet users. Dasgupta *et al.* (2005), Vicente and López (2011), and Zhang (2013) show that cultural and geographic characteristics are also related to opportunities for ICT access and use among individuals in different EU countries. Such differences may be responsible for the large variations in mobile phone usage across countries observed by Vimalkumar *et al.* (2021).

III. Methodology

a) Data

This research uses microdata from 2014 to 2018 that stems from the TIC Survey, which is an annual survey conducted by the Regional Center for the Study of Information Society Development (Cetic), operating under the sponsorship of UNESCO. Cetic is the executive branch of the Internet Management Committee in Brazil (CGI), responsible for coordinating and integrating internet services and is composed of members from the government, the business sector, and the academic community. The TIC Household Survey uses concepts and definitions contained in the Manual for Measuring ICT Access and Use by Households and Individuals published by the International Telecommunication Union (ITU). Data is collected through structured questionnaires with closed-ended questions and predefined responses (single or multiple answers). This database does not track a fixed set of individuals over time, which prevents the use of panel techniques.

The TIC Survey is subdivided into two main groups: households and individuals. For this research, we use individual-level microdata. We consider individual characteristics such as personal income, education, gender, age group, and race. We also consider the use of mobile phones and users' internet skills. We analyze the type of payment plan for individuals who have a mobile phone (prepaid or postpaid), taking into account the equipment used for internet access, the location where internet was used, users' communication-related skills, information-seeking skills, operational skills, as well as users' skills when accessing the internet via mobile phones. Skills are measured based on a set of binary proxies representing online activities performed by internet users in the last three months.

Table 2 presents summarized statistics of the dependent and independent variables used in the study, including the number of observations (N), the frequency of occurrence. This table provides a description of the entire set of variables studied.

The two dependent variables of interest are internet access via mobile phones and the type of payment plan for individuals who have a mobile phone (prepaid or postpaid). Variables related to devices used (3.3), location of use (3.4), and internet usage skills (3.5; 3.6; and 3.7) are questions from the TIC Survey related to internet use, while variables related to operational skills with mobile phones (3.8) refer only to mobile phone use.

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Table 2: Summary Statistics of Analyzed Variables

Variable / Categories	obs.	share (%)
DEPENDENT VARIABLES		
Used the internet on a cell phone?	86,682	
Yes	57,650	66.51%
Prepaid plan?	80,695	
Yes	62,479	77.43%
DEMOGRAPHIC CHARACTERISTICS		
Age Groups:	101,364	
10 to 15 years	6,892	6.80%
16 to 24 years	15,127	14.92%
25 to 34 years	18,809	18.56%
35 to 44 years	14,830	14.63%
45 to 59 years	22,322	22.02%
60 years or older	23,384	23.07%
Personal Income:	95,700	
No income	18,687	19.53%
Up to 1 minimum wage	37,957	39.66%
Between 1 and 2 minimum wages	24,056	25.14%
Between 2 and 3 minimum wages	8,157	8.52%
Between 3 and 5 minimum wages	4,235	4.43%
Between 5 and 10 minimum wages	1,964	2.05%
Over 10 minimum wages	644	0.67%
Educational Level:	101,364	
Illiteracy/Early Education	12,241	12.08%
Elementary School	42,861	42.28%
High School	38,559	38.04%
Higher Education	7,703	7.60%
Gender:	101,364	
Female	54,950	54.21%

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Table 2: Summary Statistics of Analyzed Variables

Variable / Categories	obs.	share (%)
Male	46,414	45.79%
Ethnicity skin color:	98,832	
White	37,148	37.59%
Black	14,403	14.57%
Brown	26,431	26.74%
Yellow	19,074	19.30%
Indigenous	1,776	1.80%
DEVICE WITH INTERNET USE		
Computer:	56,574	
Yes	19,124	33.80%
Notebook:	56,585	
Yes	19,482	34.43%
Tablet:	56,560	
Yes	8,464	14.96%
Video game:	58,412	
Yes	3,710	6.35%
TV:	58,386	
Yes	9,596	16.44%
LOCATION OF INTERNET USE		
Home:	58,508	
Yes	53,288	91.08%
Work:	58,508	
Yes	23,575	40.29%
School:	58,508	
Yes	9,677	16.54%

Tables continues on the next page

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Table 2: Summary Statistics of Analyzed Variables

Variable / Categories	obs.	share (%)
Someone else's home:	58.508	
Yes	32,483	55.52%
Public free access center:	58,508	
Yes	8,284	14.16%
Private access center:	58,508	
Yes	6,502	11.11%
While in transit (street, bus, subway)	58,508	
Yes	25,771	44.05%
Other location	58,742	
Yes	283	0.48%
COMMUNICATION SKILLS		
Sending or receiving e-mails:	58,409	
Yes	34,470	59.01%
Sending instant messages:	58,475	
Yes	51,837	88.65%
Talking by voice or video:	58,437	
Yes	33,546	57.41%
Participating in social networks:	58,455	
Yes	44,208	75.63%
Participating in lists or discussion forums:	58,308	
Yes	5,945	10.20%
Using microblogs (Twitter):	58,221	
Yes	5,100	8.76%

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Table 2: Summary Statistics of Analyzed Variables

Variable / Categories	obs.	share (%)
INFORMATION SEEKING SKILLS		
Product or services:	58,450	
Yes	33,816	57.85%
Health or services:	58,450	
Yes	24,274	41.53%
Travel or accommodation:	58,458	
Yes	16,542	28.30%
Employment or sending resumes:	58,456	
Yes	12,274	21.00%
Virtual encyclopedia:	58,401	
Yes	16,277	27.87%
Government websites:	58,392	
Yes	14,634	25.06%
OPERATIONAL SKILLS		
Downloading movies:	58,446	
Yes	13,819	23.64%
Downloading music:	58,440	
Yes	26,190	44.82%
Downloading games:	58,449	
Yes	14,768	25.27%
Downloading software or apps:	58,398	
Yes	14,497	24.82%

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Table 2: Summary Statistics of Analyzed Variables

Variable / Categories	obs.	share (%)
CELL PHONE OPERATIONAL SKILLS		
Used cell phone to make or receive calls:	86,714	
Yes	82,759	95.44%
Used cell phone to send or receive text messages (SMS):	86,618	
Yes	44,310	51.16%
Used cell phone to listen to music:	86,662	
Yes	52,162	60.19%
Used cell phone to watch videos:	86,647	
Yes	47,311	54.60%
Used cell phone to play games:	86,640	
Yes	30,152	34.80%
Used cell phone to take photos:	86,683	
Yes	57,416	66.24%
Used cell phone to use maps:	86,579	
Yes	27,643	31.93%
Used cell phone to access email:	86,595	
Yes	34,169	39.46%
Used cell phone for social networks:	86,628	
Yes	45,249	52.23%
Used cell phone to access websites:	86,580	
Yes	38,523	44.49%
Used cell phone to download apps:	86,564	
Yes	38,636	44.63%
Used cell phone to search for information on Google:	86,574	
Yes	42,911	49.57%
Used cell phone to share photos, videos, or texts:	86,616	
Yes	46,420	53.59%
Used cell phone to send text messages (WhatsApp, Skype):	86,630	
Yes	52,422	60.51%

Notes: The category "no" is omitted in case of binary variables. The non-missing observations refer to the entire TIC sample covering the surveys from 2014 to 2018.

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b) Regularization ML methods

To select the variables with the highest explanatory power among the attributes listed in table 2, we used ML regression techniques, where the dependent variable is either the binary indicator for 'internet use on the cell phone during the last three months', or 'having a prepaid mobile data plan'.

An appropriate choice among the diverse ML methods to advance the present research question is binary classification using penalized logistic regression. For this purpose, we employed the Elastic Net regularization technique, which comprises Lasso and Ridge models. The two latter techniques are also known as shrinkage methods used to address the issue of high relative variance in predictions. Our Elastic Net regularization model is set to minimize the following cross-entropy function for binary dependent variables

$$-\left[\frac{1}{N}\sum_{i}\sum_{t} y_{it}(\beta_0 + X'_{it}\beta) - \log(1 + e^{\beta_0 + X'_{it}\beta})\right] + \lambda\left[(1-\alpha)||\beta||_2^2/2 + \alpha||\beta||_1\right] \quad (1)$$

where ι represents one of the N individuals in the sample in year t. β is the vector with the parameters to be estimated of the explanatory variables X, as defined further below. λ can take values between 0 and ∞, so that it is the regularization parameter penalizing the model's complexity. When $\lambda = 0$ the regularization is turned off and the estimation of β is as in ordinary logistic models. α controls the combination of two basic regularization methods. When $\alpha = 0$ the equation takes the form of the Ridge model, and when $\alpha = 1$, the Elastic Net collapses to the pure Lasso model. Both α and λ are known as the tuning parameters. The parameter estimates of α, λ, and β, i.e. the minimization of eq. (1), is obtained through Maximum Likelihood estimation.

Zakharov and Dupont (2011) highlight the following advantages of the Elastic Net estimation over the common binary logistic regression. (1) It avoids overfitting in the sense that outliers can cause some attributes to have relatively large weights, so that small changes in the values of these attributes lead to significant changes in the model's prediction. (2) The Lasso penalty forces coefficients of relatively irrelevant variables to become exactly zero, thus producing sparse models. Given the large number of attributes considered in our estimation, a selection of important variables reduces the complexity of the model's interpretation. (3) The combination of Lasso and Ridge regularization reduces instability problems regarding Lassos' variable selection.

The explanatory variables are combined linearly but differ between the two dependent variables, as follows. For the indicator 'internet use on the cell phone during the last three months', three types of explanatory variables are used such that X can be represented as:

$$X'_{it}\beta = \beta_1 T_t + \beta_2 SEC_{it} + \beta_3 CPO_{it} \quad (2)$$

The vector T_t represents a temporal trend that captures how the dependent variable evolves over time. The vector SEC_{it} represents individuals' socio-economic characteristics: personal income, education level, gender, age group, and skin color/ethnicity. CPO_{it} represents individuals' cell phone operational skills.

To predict the indicator variable 'having a prepaid mobile data plan', the linear part can be represented as:

$$X'_{it}\beta = \beta_1 T_t + \beta_2 SEC_{it} + \beta_3 CPO_{it} + \beta_4 C_{it} + \beta_5 I_{it} + \beta_6 O_{it} + \beta_7 H_{it} + \beta_8 P_{it} \quad (3)$$

where T_t, SEC_{it}, and $CPO_{it}$are defined as in eq. (2). The variables in C_{it}, I_{it}, and O_{it} represent the communication, information seeking, and operational skills of individuals, respectively, see table 2. The variable H_{it} represents the devices used to access the internet in the last three months, P_{it} refers to the location of internet use.

c) Estimation Procedure for Tuning Parameters

To estimate the models, we used the statistical program R. Following common practice in the application of the Elastic Net regularization method, we randomly divided the sample into a training set (70% of total observations) and a test data set (30%) (Mehta *et al.* 2019).

The Elastic Net pre-model is estimated with the training data set using the *cv.glmnet* algorithm to firstly select λ for given values of $\alpha = 0.5$, as is standard in the literature. In this process we used the repeated cross-validation method K-fold^{+1}. The K-fold cross-validation randomly divides the data into k blocks of approximately equal size. To train the model k-1 blocks are used, and one is left out. This separate block is used for predictions that are summarized in performance measures (for example, accuracy measures). The resulting k performance estimates are averaged to obtain the overall resampled estimate (Kuhn *et al.* 2013). The repeated cross validation method K-fold^{+1} performs the same procedure as K-fold, but more than once. In the case of five repetitions and ten cross-validations, this would result in 50 total resamplings. The λ with the best precision results in 0.00013 for the dependent

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variable "used internet on cell phone" and is equal to 0.00035 for "prepaid type data plan.

Based on these initial values for λ, we use the *expand.grid* command and vary both α and λ in sequential steps of 0.1 for the range [0,1] and 0.0001 in the range [0,0.001], respectively, to find the model estimates with the highest accuracy overall. Again the repeated cross validation method K-fold[+1] is applied with $k = 10$ folds, with repetitions of five times for each process. The performance of the regularization model is also evaluated using the AIC (Akaike Criterion) and the area above the ROC (Receiver Operating Characteristic) curve. The summary of the results from this evaluation presented in table 3 indicates that the estimations are fairly accurate.

Table 3: Estimated Tuning Parameters and Performance

dependent var.:	Mobile Data on Cell Phone	Prepaid Plan
# of β coefficients	33	62
λ	0.0006	0.0009
α	1	0.4
accuracy	0.961	0.748
precision	0.511	0.513
AIC	12,506	43,186
ROC	0.990	0.714

IV. Results

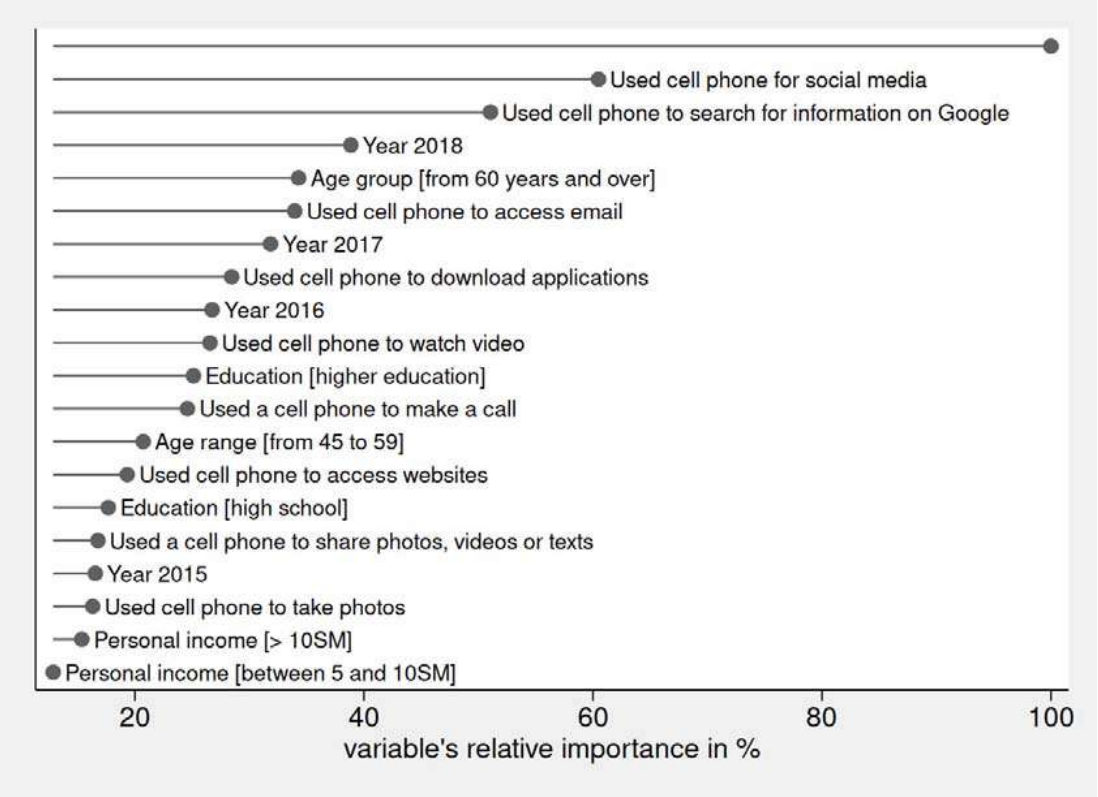
a) Variable Selection

Figures 1 and 2 show the estimated coefficients of the 20 variables with the highest explanatory power relative to the highest coefficient estimate in each model for the two dependent variables, respectively, according to the Elastic Net technique described in the previous section. Note that in the present case the coefficients of a model are directly comparable among each other because all of the explanatory variables are created as binary indicators. We will (arbitrarily) focus on the 20 most important variables in order to keep the interpretations traceable.

The attribute "used cell phone to send text messages" is the most important predictor for "internet access via cell phone", followed by "used cell phone for social networks" and "used cell phone to search for information on Google". The dominance of skill based measures is striking given that large parts of the literature highlighted the importance of socio-economic characteristics. Notwithstanding, age and education also appear among the list of the 15 most important characteristics for internet access via cell phone. The general effects of internet access in specific years are also among this list, confirming results from Silva *et al.* (2020) regarding the impact of business cycles on individual internet connections and affordability. Finally, the two highest income level groups rank at the bottom of our 20 selected variables in figure 1.

Figure 2 shows that the attribute "age group [60 years and above]" is the variable with the highest explanatory power regarding the decision between a prepaid or more flexible and expensive postpaid mobile data plan. Other age groups, income groups, year indicators are among the top 10 most important variables from this model. The remaining selected variables in figure 2 comprise indicators for the location of internet use, race/ethnicity, education, and information seeking and cell phone operating skills. Given the dominance of the latter in the previous model, it is rather surprising to see that the various skill measures under analysis seem to affect the mobile plan choice much less that the use of internet on the cell phone in general.

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Note: The figure displays the coefficient estimates relative to the highest coefficient estimate from equations 1 and 2 using the Elastic Net model where the dependent variable is the indicator for "internet access via cell phone". The variable with the highest explanatory power, which is represented by the first horizontal bar in the chart, is "used cell phone to send text messages".

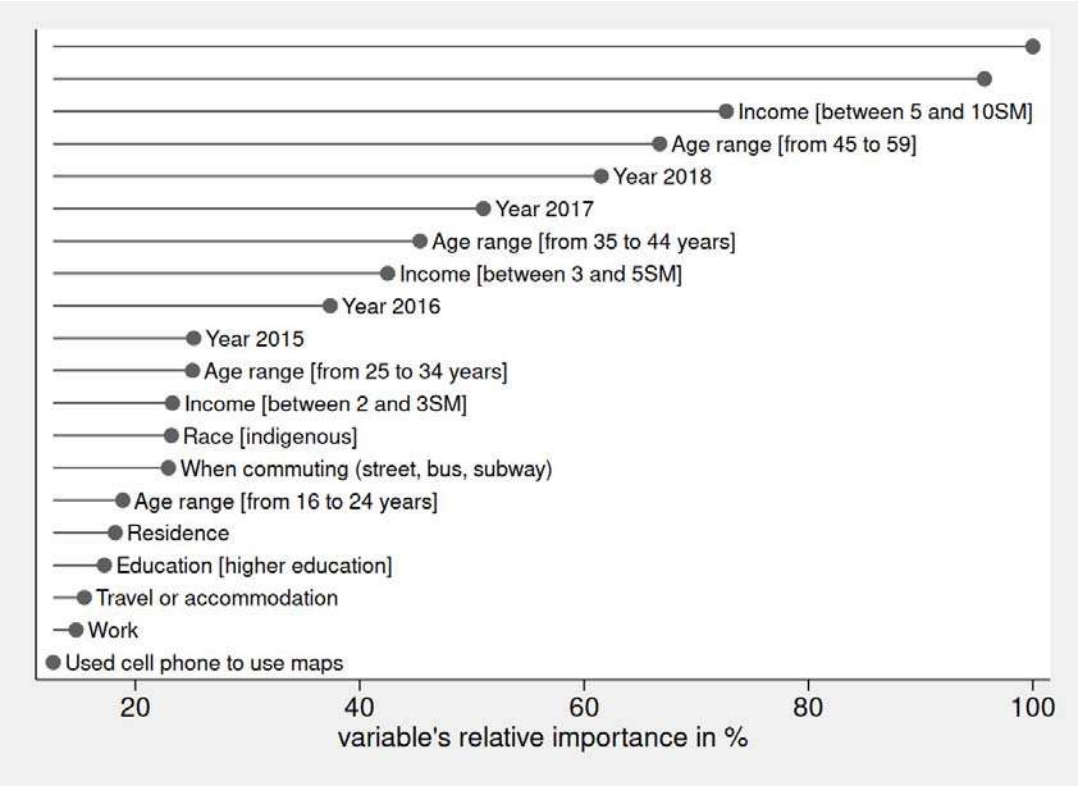
Figure 1: The 20 Most Relevant Variables for "internet access via cell phone"

b) Marginal Effects of Selected Variables

Based on the 20 variables with the highest explanatory power presented in figures 1 and 2, we select these variables and add the remaining categories for age, income, education, race/ethnicity and year. The estimated coefficients from the logistic model can be transformed into marginal effects to facilitate interpretations. As neither the logistic nor the Elastic Net model account for the potential endogeneity of the explicatory variables, the marginal effects do not have a causal interpretation.

Table 4 shows that, compared to the year 2014 (the omitted base variable), the probability of using the internet via cell phone increases over the years, with the exception of 2015. This observation is reasonable given that the Brazilian economy was formally in recession between 2014 and 2016, with growth rates below -4% (Silva *et al.* 2020). In times of crisis, there tends to be a decrease in employment and, consequently, in family consumption levels, which may provoke a reduction in telecommunications services expenses. Furthermore, the data suggests that the probability of internet access via cell phone decreases with age. The estimated coefficient for the group of individuals aged 60 and above is equal to -2.031, which corresponds to a marginal effect of -6.4 percentage points. Communication technology has the potential to benefit older adults by promoting their independence and increasing their ability, but still, older adults are less likely to adopt new technologies (Heinz *et al.* 2013). Silva *et al.* (2020) highlight that elder Brazilians are frequently characterized by low digital literacy. Along the same lines, Riggins and Dewan (2005) and Scheerder*et al.* (2017) and Litt (2013) also find a negative relationship between internet usage and age.

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Note: The figure displays the coefficient estimates relative to the highest coefficient estimate from equations 1 and 3 using the Elastic Net model where the dependent variable is the indicator for "prepaid mobile data plan". The variables with the highest explanatory power, which are represented by the first and second horizontal bars in the chart, are "age group [60 years and above]" and "income above 10SM", respectively, where SM is the Brazilian acronym for the official minimum wage.

Figure 2: The 20 Most Relevant Variables for "prepaid mobile data plan"

Table 4 indicates that individuals with no income or up to two time the minimum wage (SM) have roughly the same probability ot access internet via cell phone, which is significantly higher among individuals with large income levels. For individuals with personal income between 2 and 3 minimum wages, the estimated coefficient is equal to 0.259, which corresponds to a marginal effect of 0.8 percentage points (p.p.).

Table 4: Logit Estimation – "internet access via cell phone"

Year 2015	-0.548***	(0.069)
Year 2016	1.196***	(0.063)
Year 2017	1.389***	(0.066)
Year 2018	1.683***	(0.068)
Age range [from 16 to 24 years]	-0.652***	(0.109)
Age range [from 25 to 34 years]	-0.959***	(0.105)
Age range [from 35 to 44 years]	-1.177***	(0.105)
Age range [from 45 to 59]	-1.510***	(0.101)
Age group [from 60 years and over]	-2.031***	(0.106)
Personal income [up to 1SM]	-0.036	(0.061)
Personal income [between 1 and 2SM]	0.120*	(0.068)
Personal income [between 2 and 3SM]	0.259***	(0.093)
Personal income [between 3 and 5SM]	0.548***	(0.124)
Personal income [between 5 and 10SM]	0.728***	(0.188)

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Personal income [> 10SM]	0.726**	(0.286)
Education [elementary education]	0.370***	(0.070)
Education [high school]	0.905***	(0.077)
Education [higher education]	1.246***	(0.126)
Used cell phone to send text message	3.718***	(0.056)
Used cell phone to search for information on Google	1.935***	(0.090)
Used cell phone to access email	1.332***	(0.092)
Used cell phone to watch video	0.971***	(0.055)
Used a cell phone to make a call	-0.857***	(0.071)
Used cell phone to access websites	0.913***	(0.110)
Used a cell phone to share photos. videos or texts	0.608***	(0.065)
Used cell phone to take photos	0.638***	(0.045)
Used cell phone for social media	2.395***	(0.078)
Used cell phone to download applications	1.065***	(0.088)
Observations	79,669	
Log Likelihood	-8,930.565	
AIC	17,919.13	

*Notes: The table reports the estimated coefficients from a logistic regression model where the dependent variable is an indicator whether the individual has accessed internet via cell phone during the last three months. Robust standard errors are in parenthesis. *** p-value <0.01, ** p-value <0.05, * p-value <0.10.*

This relationship increases with income and for those with ten or more minimum wages the average marginal effect is equal to 2.29 percentage points. On the one hand, higher income provides people with more consumption opportunities. On the other hand, the observed effect may be partly explained by the fact that higher income is related to the professional obligation to use ICTs on the cell phone. This may be related to the fact that higher income means more likely individuals to have access to higher education and, in turn, have access to consumer goods in the area of information and communication technology. Higher socioeconomic status is also positively related with digital competence (Araujo and Reinhard 2019). Nishijima *et al.* (2017), Coelho *et al.* (2019), and Silva *et al.* (2020) previously reported that that income is one of the main determinants of access to ICTs. The lowest level of education (0 to four years of schooling) is used as the reference category so that the positive estimated coefficients of the remaining three education categories indicate that internet access via cell phone becomes more likely with the years of schooling. For individuals with secondary education and higher education the marginal effect is equal to 2.85 p.p. and 3.92 p.p., respectively.

The remaining variables in table 4 represent digital skills. Having operational and communication skills is positively related to the probability of internet access via cell phone. It is interesting to note that the only negative coefficient is observed for the ability to actually make a 'call' so that the use of this elementary function does not really represent an abnormality. For example, those who exchange instant messages, use social networks, search for information on Google, access their email, and download applications have a ceteris paribus 11.72, 7.55, 6.10, 4.19, and 3.35, percent higher probability of accessing the internet via cell phone, respectively. Sharing photos, however, has a relatively low marginal effect (1.91 p.p.).

Table 5 presents the estimated coefficients of the logistic model, considering the dependent variable "type of payment plan to access the internet via cell phone" where the value 1 corresponds to a prepaid plan and 0 to a postpaid one. Prepaid plans are characterized by a limited amount of data allowance, lower probability of having zero-rating applications included, and they are more affordable. It is coherent that prepaid plans are much more frequent in Brazilian federal states in the North and Northeast regions where per capita income and wage levels are lower (Caldeira *et al.* 2023; Ehrl and Monasterio 2021; Schiavon and Moreira 2022). This type of payment plan, is still predominant in Brazil, according to data from the responsible national regulatory agency ANATEL.

Table 5 shows that having a prepaid mobile data plan steadily became less frequent over time. The marginal effect for the year 2018 indicates that, compared to the base year 2014, prepaid internet plans

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decreased by 13.45 p.p. In fact, the National Telecommunications Agency reports a similar number of 11.6 million (+13.3%) new postpaid lines in 2018. The number of accesses per billing modality, compared to 2017, reduced by 12.73 p.p. for prepaid, while in the postpaid modality it increased by 11.46 p.p.[1]. These observations point to the growing importance that people attribute to internet services and potent data packages.

Table 5: Logit Estimation – "prepaid mobile data plan"

Year 2015	-0.325***	(0.041)
Year 2016	-0.499***	(0.043)
Year 2017	-0.684***	(0.042)
Year 2018	-0.800***	(0.042)
Age range [from 16 to 24 years]	-0.416***	(0.068)
Age range [from 25 to 34 years]	-0.534***	(0.069)
Age range [from 35 to 44 years]	-0.832***	(0.070)
Age range [from 45 to 59]	-1.121***	(0.069)
Age group [from 60 years and over]	-1.548***	(0.077)
Personal income [up to 1SM]	0.085**	(0.039)
Personal income [between 1 and 2SM]	-0.087**	(0.040)
Personal income [between 2 and 3SM]	-0.414***	(0.047)
Personal income [between 3 and 5SM]	-0.677***	(0.053)
Personal income [between 5 and 10SM]	-1.082***	(0.067)
Personal income [> 10SM]	-1.347***	(0.108)
Education [elementary education]	0.148	(0.103)
Education [high school]	0.138	(0.103)
Education [higher education]	-0.225**	(0.107)
Race [black]	0.138***	(0.036)
Race [brown]	0.159***	(0.029)
Race [yellow]	0.155***	(0.038)
Race [indigenous]	0.281***	(0.105)
Use internet @Residence	-0.261***	(0.049)
Use internet @Work	-0.233***	(0.027)
Use internet on the move	-0.287***	(0.024)
Book travel or accommodation	-0.203***	(0.026)
Used cell phone to use maps	-0.206***	(0.026)
Observations	47,858	
Log Likelihood	-24,505.42	
AIC	49,066.84	

*Notes: The table reports the estimated coefficients from a logistic regression model where the dependent variable is an indicator whether the individual has a prepaid mobile data plan. Robust standard errors are in parenthesis. *** p-value <0.01, ** p-value <0.05, * p-value <0.10.*

Young individuals aged 10 to 15 years are the age group with the highest probability to have a prepaid mobile data plan. The estimated marginal effect for the group of people aged 60 years and above indicates a 26.03 p.p. lower probability of having a prepaid plan. A similar pattern is observed with respect to income and

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education. People in the upper and middle class are more likely to posses a postpaid mobile data plan. Individuals with a personal income level of more than 10 minimum wages have a 22.66 p.p. lower probability of having a prepaid plan. Education is a less powerful explanatory variable compared to income. The second and third educational category show no statistically significant difference with respect to the reference group and individuals with higher education 'only' present a marginal effect of 3.78 p.p. Similar observations for these variables regarding internet access are made with Brazilian data by Nishijima *et al.* (2017) and Coelho *et al.* (2019).

Brazil is among the most unequal countries in the world and social mobility is relatively low. Women and Non-white citizens have worse salaries, even after controlling for other socio-economic characteristics (Mariano *et al.* 2018). We thus expect skin color / race to be related to mobile data plan selection, too. The data show that non-white individuals have comparable but significantly (2.5 p.p.) higher probability of choosing a prepaid plan. For indigenous citizens the marginal probability is even as high as 4.7 p.p.

In relation to the location where the individual used to access the internet, table 5 shows that usage at home, at work and 'on the move' is associated with a 4-5 p.p. lower probability of having a prepaid plan. The omitted categories comprise 'other locations' and free access public and private alternatives. This finding is reasonable given that postpaid data plans provide a larger amount of data allowance and usually include some zero-rating applications such as media content and chat apps which allows users to access the internet in a larger variety of places. Finally, the two digital skills variables that made it the top 20 variable selection are 'book travel or accommodation' and 'use maps'. Using the internet for these services is associated with a 3.4 p.p. lower probability of using a prepaid mobile data plan. Again, the intuition behind this observations seems to be that heavy internet users with advanced skills and needs opt for the potent postpaid plans.

V. Conclusion

This research used microdata from the Brazilian ICT Household Survey in 2014– 2018 and applied Machine Learning techniques to identify the variables with the highest explanatory power among a pool of 67 variables to explain how to increase internet access via mobile devices and how to predict the type of mobile data plans individuals chose. The variables compass frequently studies socio-economic characteristics, year fixed effects, location and device of internet access, as well as operational, communication, and information seeking skills. Having selected the most important variables via Elastic Net regularization method, we estimate their marginal effects and differences in predicted probabilities regarding each of the two dependent variables.

We find that age, income, and education have predictive power for access to internet via cell phone and particularly for the type of mobile plan. Some of individuals' skills/ICT activities are also among the variables with high predictive power, especially for mobile internet access. Finally, effects that are specific for a year, such as the business cycle or technological progress are also highly important predictors for individual's mobile internet usage patterns.

The differences between the two models lead to some interesting insights and implications. The fact that socio-economic status, and personal income above all, are much better predictors for having a cheaper, more limited prepaid mobile data plan but nor for mobile internet access in general, indicates that the digital divide with respect to these characteristics is becoming more narrow. However, age still seems to be the predominant dimension that prevents a sustainable reduction in the digital divide. The cohort aged 60 years or older, specifically, is estimated to have a 6.4 p.p. lower probability of accessing internet via mobile phone as compared to 10 to 15 year old children, which are the most likely users.

Another encouraging observation is the increasing trend both regarding the use mobile internet and postpaid data plans, even after controlling for other variables such as income. However, we also perceive that the recession during the years 2014–2016 temporary hindered the expansion of internet access via cell phones. State-sponsored access to internet and the necessary devices for socially disadvantages families or school children may help to bridge the digital divide such that further economic and social sustainability can be reached.

The relatively low predictive power of specific skills and activities is rather surprising. Hence, an insight from our research may be that operational skills, and the lack thereof, do not seem to constitute major barriers for people to adopt a cell phone with internet access. Future studies, however, should investigate this question more in depth. Among the few variables that turned out to be relevant for internet access via cell phone are sending text messages using social media. These skills/ activities seem to be predominant on this type of device whereas regarding other activities, the phone seems to have closer substitutes.

We hope that the present results will serve as a foundation for supporting public policies in the telecommunication sector. This area lacks well-designed evaluations and implementation of public policies. A prominent example is the Universalization Fund for Telecommunications Services (Fust). The fund was created in 2000 with the mission of reducing regional and social inequality, i.e. accelerating the universali-

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zation of telecommunication services in Brazil. During the Fust's 22 years of existence it has collected several billions, but not a single Brazilian Real was actually spent (Reis and Ehrl 2023). Our research shows which groups should be targeted by policies that intend to promote sustainable, universal internet access and equal opportunities in the digital society.

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Federal Economic Measures to Combat the Pandemic Crisis and the Federative Pact

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Abstract- This article seeks to explain the economic measures adopted by the Federal Government in response to the pandemic caused by the novel Coronavirus (COVID-19). Constitutional Amendment No. 106 and Complementary Law No. 173 will be used as a reference basis, with the aim of demonstrating how the fiscal regime was changed, within the constitutional possibilities, to maintain the country's economic health and how the states were impacted by the actions of the Federal Government. This study will analyze the changes in budgetary and fiscal rules and the distribution of resources among the states as a way of compensating for the loss of tax revenue. From another perspective, spending containment assumes an important role in combating the crisis and economic recovery is now being discussed in actions such as the suspension of states' debts with the Union. Ultimately, the distribution of resources allocated for this purpose from the perspective of the federative pact and how balance should be maintained on its basis should be determined. The theoretical framework is provided through specialized doctrines, scientific articles, specific legislation and the qualitative and descriptive approach.

Keywords: financial assistance, health crisis, revenue sharing, federative pact.

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Federal Economic Measures to Combat the Pandemic Crisis and the Federative Pact

Audic Cavalcante Mota Dias [α] & Roberta Araújo de Sousa [σ]

Abstract- This article seeks to explain the economic measures adopted by the Federal Government in response to the pandemic caused by the novel Coronavirus (COVID-19). Constitutional Amendment No. 106 and Complementary Law No. 173 will be used as a reference basis, with the aim of demonstrating how the fiscal regime was changed, within the constitutional possibilities, to maintain the country's economic health and how the states were impacted by the actions of the Federal Government. This study will analyze the changes in budgetary and fiscal rules and the distribution of resources among the states as a way of compensating for the loss of tax revenue. From another perspective, spending containment assumes an important role in combating the crisis and economic recovery is now being discussed in actions such as the suspension of states' debts with the Union. Ultimately, the distribution of resources allocated for this purpose from the perspective of the federative pact and how balance should be maintained on its basis should be determined. The theoretical framework is provided through specialized doctrines, scientific articles, specific legislation and the qualitative and descriptive approach.

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Introduction

Since its enactment, the Federal Constitution has identified the federated entities as indivisible parts of a whole, despite being endowed with the autonomy due to each one, observing their competences. Thus, the Brazilian tax system establishes rules common to all entities and to each one individually. Thus, by the constitutional rules, tax competences are determined and revenues are distributed in order to guarantee fair and equitable federative harmony.

The article seeks to analyze the behavior of federated entities in situations where emergency measures are necessary. In this case, the basis of study will be the 2020 pandemic caused by the new coronavirus (COVID 19) and both economic and tax actions that were taken with the aim of remedying the negative effects of the crisis. In a brief analysis, the two main legal measures of a reparative and contingent nature will be analyzed.

In the first section, the approach discuss the point of view of the legal action of a tax nature issued by the Federal Government whose purpose was to provide conditions for rapid recovery after the crisis. Determinations for the purchase and sale of financial assets and simplified processes for hiring personnel and acquiring inputs and equipment are the measures focused on in the proposed constitutional amendment analyzed in this section.

In the second section, the focus will be on the analysis of Complementary Law No. 173 and the establishment of the Federal Program to Combat Coronavirus, as the second measure at the federal level to help address the difficult situation faced by Brazilian states, mainly with regard to the suspension of the states' debt with the Federal Union.

In the third and final section, the approach discuss the relationship between federal measures under the aspect of the federative pact and how the distribution of revenues constitutes an indicative basis for determining the legislation that is the object of this study. The fiscal and tax sustainability of the states and the need to allocate resources to combat the 2020 pandemic complement the aforementioned analysis.

I. Constitutional Amendment No. 106 – "War Budget PEC"

In 2020, the world experienced one of the biggest health crises in history. The new Coronavirus, which causes the infectious disease COVID-19, has left countless people dead and a growing number of infected people every day. Its rapid contagious capacity has challenged doctors and researchers in the search for a cure or vaccine to prevent its rapid spread, which has led laboratories around the world to race against time.

In the face of the pandemic, society demanded social and health protection measures from the state. The urge to isolation, in addition to businesses closure, caused a disruption of the way to work of an entire society, which led the government to intervene to maintain social well-being. Urgent measures were

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needed to contain the spread of the epidemic while guaranteeing the population's primary means of subsistence.

Actions aimed at changing the rules of the tax regime in Brazil were also put on the agenda. The main need was to make rules imposed by the Federal Constitution more flexible, which limit the actions of federated entities and provide general rules for hiring personnel, works, services and supplies, in addition to the extraordinary fiscal and financial regime, used on an exceptional basis, whenever the regular regime cannot meet the requirement, separating them from the Union budget.

The establishment of such rules was determined by Constitutional Amendment No. 106, of May 7, 2020. It began processing through constitutional amendment proposal No. 10/20, starting in the Chamber of Deputies, counting, in this Legislative House, 395 favorable votes and 63 in the Federal Senate, returning to the Chamber for approval of the modifications made to its text, having been promulgated by the National Congress, on May 7.

Its voters were Senator Antônio Anastasia and Federal Deputy Hugo Mota, resulting in Constitutional Amendment No. 106. The proposal, despite being constitutional, is not part of the body of the constitutional text, but consists of separate content, with a start and end date. In this discussion, it will be in force while the state of public calamity recognized by the National Congress continues, not affecting acts that occurred before the start of the exceptional state decreed by Decree-Law No. 06, on March 19, 2020.

As for its content, its rules deal with the possibility of special hiring of personnel, works and services. As for hiring personnel, its importance is due to the need to add to the staff of professionals in the Brazilian health system, the increase in the workforce in combating the pandemic. This emergency hiring will be carried out on a temporary basis, without a budget forecast, that is, the admission of personnel beyond the budget allocations is authorized, and may exceed the spending ceiling for this purpose.

Specifically regarding the contracting of works and services, in addition to purchases[1], on an exceptional basis, its justification is quite similar to that of admissions. The emergency need induces that the acquisitions must be rapid so that they can fulfill their objective. The purchases mainly concern health supplies, such as personal protective equipment, expansion of the health network and other materials to support the fight against the pandemic, although this is not explicit in the text.

The reason for the divergence between deputies and senators in the votes on the Constitutional Amendment Proposal (CAP) in both Houses of the National Congress was the measure authorizing the Central Bank of Brazil to buy and sell securities issued by the National Treasury as well as assets[2]. These actions were aimed at increasing market liquidity, a demand from the sector in view of the economic effects of the pandemic crisis.

The purchase and sale of National Treasury bonds, another determination established by the CAP, but acquired from other markets, is beneficial both for the forecasts that the Central Bank can make regarding the yield curve of the bonds issued, and for the control of the currency in circulation. And in compliance with the principle of transparency, the Central Bank must make public all information regarding the transactions carried out, reporting to the National Congress.

Regarding the purchase innovation private market assets sale by the Central Bank, these must be carried out in accordance with the positive assessments of at least one of the three largest risk agencies. This determination aims to avoid the purchase of invalid securities or securities with a high default rate, which is why they can only be acquired through negotiations with the secondary market, that is, assets that are already in circulation, preferably from micro, medium and small companies.

It should be noted that fiscal actions such as those explained in this section, aimed at mitigating the economic impact of the 2020 pandemic on the Brazilian financial system, are not innovations introduced by the current Government. Similar methods of fiscal actions of state intervention were used to combat the effects of the 2008 economic crisis that shook the world market.

[1] Art. 2. For the exclusive purpose of dealing with the context of the calamity and its social and economic effects, during its duration, the federal Executive Branch, within the scope of its powers, may adopt simplified processes for hiring personnel, on a temporary and emergency basis, and for works, services and purchases that ensure, when possible, competition and equal conditions for all competitors, waiving compliance with § 1 of art. 169 of the Federal Constitution in the contracting referred to in item IX of the caput of art. 37 of the Federal Constitution, limited to the situations dealt with in said item, without prejudice to the protection of the control bodies.
Sole paragraph. In cases of distribution of health equipment and supplies essential to dealing with the disaster, the Union shall adopt objective criteria, duly published, for their respective allocation to States and Municipalities.

[2] Art. 7º The Central Bank of Brazil, limited to dealing with the national public calamity referred to in art. 1º of this Constitutional Amendment, and with validity and effects restricted to the period of its duration, is authorized to buy and sell:
I - securities issued by the National Treasury, in the local and international secondary markets; and
II - assets , in national secondary markets within the scope of financial, capital and payment markets, provided that, at the time of purchase, they have a credit risk category rating in the local market equivalent to BB- or higher, granted by at least 1 (one) of the 3 (three) largest international risk rating agencies, and a reference price published by a financial market entity accredited by the Central Bank of Brazil.

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It is important to emphasize that exceptional breaches of legal rules that deal with budgetary security are authorized for specific purposes, such as extraordinary application in health. In other words, the rule of not carrying out credit operations to finance current expenses should not be trivialized nor should its use become commonplace. The non-application of a limit on hiring personnel or expenditures that exceed the definitions established in the Fiscal Responsibility Law are unprecedented in the current situation.

Thus, the so-called "golden rule" of public accounts must be observed when making exorbitant investments so that the use of special credit operations does not create future deficits that are difficult to solve . The issue of public debt will be addressed later. As can be seen from the text below:

> Dieter W. Benecke asserts in this vein that public credit should be used for profitable production purposes, opening up new prospects, generating jobs (or at least maintaining existing ones), introducing innovations and allowing for an increase in income, in order to put the country in a better position to pay the principal and debt services. The use of public credit for non-profit purposes, for consumption purposes or to alleviate past debts, as a rule does not create new income and tends to aggravate the problem in the future, even though it may temporarily provide a respite for the public accounts. (ANDRADE *apud* BENECKE , 2012, P. 113)

II. Complementary Law Nº 173, of May 27, 2020

Initiated by Complementary Bill No. 39/2020, in the Federal Senate, authored by Deputy Antônio Anastasia, and approved with amendments and partial presidential veto of its text, the matter deals with the intention of parliamentarians to establish a large program in the areas of health and social assistance to aid states and municipalities, aiming to face the crisis caused by the new Coronavirus, and the balance of federated entities in maintaining their economic health.

The first measure concerns the suspension of payment of debts owed by states and municipalities to the federal government[3]. The debts agreed upon can hardly be called recent. They were agreed upon decades ago and did not exclude any state from participating; all of them owe the federal government. Given that the provisions defining criteria for payment of debts are very old, there was a need for new measures to update the criteria for refinancing obligations agreed upon between the entities.

The legal decision included in the Complementary Law analyzed here follows the understanding given in the precautionary measure issued by the Supreme Federal Court, whose rapporteur was Justice Alexandre de Moraes, which suspended, for a period of 180 (one hundred and eighty) days, the debt of the State of São Paulo with the Federal Union, during the crisis. The installments totaled R$ 1.2 billion reais and should be fully applied to actions aimed at health.

Obviously, decisions regarding the reallocation of resources during the new Coronavirus pandemic are guided by the defense of the greatest constitutionally protected asset, which is health. This even guided the vote on the Precautionary Measure mentioned in the previous section, as seen below:

> The claim of the State of São Paulo that it is unable to fulfill its obligation to the Union due to the "current extraordinary and unpredictable moment related to the COVID-19 pandemic and all the circumstances involved" is absolutely plausible; therefore, in the case, there is a need for strict observance of the principle of reasonableness, since, observing the necessary proportionality, justice and adequacy of the requested measure and the current situation of the COVID-19 pandemic, which demonstrates the imperativeness of allocating public resources to mitigate the serious risks to health in general, leading to the need for its concession, since the action of the Public Authority will only be legitimate if rationality, prudence, proportion and, mainly, at this moment, real and effective protection of the fundamental right to health are present (MORAES, 2020, P. 4-5)

Refinanced by Law 9,496 of September 11, 1997, the new debt negotiation was based on the debtors' reality in the face of the economic and financial context they were experiencing. With this law, not only was it possible to refinance debts arising from loans or those already refinanced by the Union, authorized by the Federal Senate, but also to consolidate the total amounts and assume part of the debts, payable for the period established by law, by the Federal Union.

The negotiation reported above was important to maintain the economic balance of the debtor entities and to allow fiscal and financial stability. However, the determination instituted by Complementary Law 173 guarantees states and municipalities the use of amounts that would be used to pay amounts arising from installments that would go directly to the accounts of the Federal Government, preventing the latter from executing the refinancing contracts until December 2020.

The control of public debt, since it indirectly affects the entire financial system and economic

[3] The Federative Program to Combat the SARS-CoV-2 Coronavirus (Covid-19) is hereby established, pursuant to art. 65 of Complementary Law No. 101, of May 4, 2000, exclusively for the financial year 2020.
§ 1º The Program referred to in the caput is composed of the following initiatives:
I - suspension of payments of debts contracted between:
a) on one side, the Union, and, on the other, the States and the Federal District, supported by Law No. 9,496, of September 11, 1997, and Provisional Measure No. 2,192-70, of August 24, 2001;
b) on one side, the Union, and, on the other, the Municipalities, based on Provisional Measure No. 2,185-35, of August 24, 2001, and Law No. 13,485, of October 2, 2017;

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stability, can and should be controlled by the Federal Senate, in accordance with constitutional precepts, which determines its limits but not the details of credit operations. In fact, failure to comply with the debt within the two-year period established in the constitutional text constitutes grounds for federal intervention in debtor entities. In this sense, it is important to maintain financial austerity for the benefit of the entire system:

> The lack of control over public accounts creates distrust in the market regarding the solvency of entities, scaring away foreign investors. Often, the debts of subnational entities end up being assumed by the federal entity – as has already occurred in Brazil on three occasions – which harms fiscal policy and its austerity efforts . (ANDRADE, 2012, p. 62)

However, these are specific situations that do not fall within the scope of the legal exemptions provided for in the supplementary law. The use of this portion of the budget that would be allocated to the payment of the internal debt with the Union, those arising from credit operations and social security, as referred to in Law No. 13,485, of October 2, 2017, due to the renegotiation, may be reallocated to actions to combat the pandemic. In this period of high costs of maintaining health and social assistance, all resources are welcome. Thus, the amounts for payment of the debt may be allocated to these operations to support health and maintain the well-being of the population.

In order to ensure maximum effectiveness of the provisions of the law, the measures took effect immediately, regardless the contractual situation in force at the time of the law's enactment, whose effects are retroactive to the beginning of the pandemic period. Furthermore, no debtor entity will be included in a default registry during this period. All performance, however, must be publicized in accordance with the assumptions of the principle of transparency.

The waiver of conditions for waiving tax credits, such as compensation measures through increased revenues, provided for in the Fiscal Responsibility Law and other laws that impose criteria for receiving voluntary transfers. These waivers can only be applied with a view to the effectiveness of the Federal Program to Combat Coronavirus. An important provision to ensure that the receipt of amounts and transfers of resources are not compromised.

The loss of tax revenue by the states and the need to intensify the allocation of resources to combat the new Coronavirus (COVID 19) have placed the federated entities in a precarious financial situation. In view of this situation, the complementary law in question subsidized aid [4]of a considerable sum to be distributed in four monthly installments, of equal value, totaling R$ 60,000,000,000.00 (sixty billion reais) under the terms of art. 5 and subparagraphs.

Of these amounts, a specific portion (10 billion) should be allocated to the health sector and payment of professionals working in the health system, and the annex to the law provides for the amount to be distributed among the states, which will be in accordance with population data from the Brazilian Institute of Geography and Statistics (BIGS), with the exception of the Federal District. Furthermore, the remaining amount will be allocated to the states and municipalities, with the distribution taking into account the most recent population data.

Finally, it should be noted that, in return, States, Municipalities and the Federal District are prohibited from promoting any salary adjustments for their public servants, holding public competitions, creating positions and granting benefits. In other words, no increase in personnel expenses will be permitted, except in cases of benefits to be paid to professionals in the health and social assistance areas who are directly involved in combating the cause of the state of emergency.

III. The Tax System and The Federal Pact

The Brazilian republican division into federated entities is responsible for decentralizing the government and providing the entities with administrative and financial autonomy, balancing and maintaining their independence among themselves. In this way, powers are divided in a way that grants equitable federative divisions. Such as the function and legal power, tax powers and revenue distributions are also defined by the Federal Constitution, regulated by scattered legislation.

Taxation is an essential activity carried out by the state, from which comes the main sources of revenue responsible for funding the functioning of the public sector, maintaining essential activities and investments, in addition to implementing public policies of a positive nature for social well-being. These expenses are organized by budget laws: Multi-Year Plans, Budget Guidelines Laws and Annual Budget Laws, drawn up at the three levels.

The idea of a fiscal state may even impose certain restrictions on taxpayers' assets due to the compulsory nature of taxes; however, it is the form of

[4] Art. 5º The Union will deliver, in the form of financial aid, to the States, the Federal District and the Municipalities, in 4 (four) equal monthly installments, in the fiscal year 2020, the amount of R$ 60,000,000,000.00 (sixty billion reais) for application, by the local Executive Branches, in actions to combat Covid-19 and to mitigate its financial effects, as follows:

I - R$10,000,000,000.00 (ten billion reais) for health and social assistance actions, being:

a) R$7,000,000,000.00 (seven billion reais) to the States and the Federal District; and

b) R$3,000,000,000.00 (three billion reais) to Municipalities;

II - R$50,000,000,000.00 (fifty billion reais), as follows:

a) R$30,000,000,000.00 (thirty billion reais to the States and the Federal District;

b) R$ 20,000,000,000.00 (twenty billion reais to the Municipalities

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funding used by the Brazilian economic system. Therefore, the price paid by taxpayers must be fair for the maintenance of public services and the set of assets corresponding to the classic functions of the state, while preserving the minimum freedom of citizens with due observance of their tax capacity. (NABAIS, 2018).

With the forecast of tax collection and the preparation of the public budget, it is clear how expansive social rights and their maintenance can be, especially in a system where the presence of the state is fundamental, whether to ensure basic rights or to remedy the harmful effects of crises that alter social well-being.

> In effect, the costs of social rights are materialized in public expenditure with immediate expression in the sphere of each of their holders, a sphere that thus expands to the exact extent of these expenditures. An individualization that makes such costs particularly visible both from the point of view of those who bear them, that is, from the point of view of the state, or rather, of the taxpayers, and from the point of view of those who benefit from them, that is, from the point of view of the holders of social rights. (NABAIS, P. 20)

The taxes under the jurisdiction of the Federal Government, States, Federal District and Municipalities are those provided for in art. 153 of the Federal Constitution and following. However, of a different nature, the revenue sharing refers to the sharing of resources resulting from tax collection provided for in the provisions cited above. These are provided for in article 157 and following of the Federal Constitution, and provide for the percentages shared of Federal Taxes to States and Municipalities and from States to Municipalities.

Although the above distributions are made directly, the constitutional provisions also provide for the possibility of reallocating fund resources. The two most relevant funds for the allocation discussed here are the State Participation Funds (SPF) and the Municipal Participation Fund (MPF). The coefficient is calculated using population data provided by the BIGS, i.e, states with a larger population receiving a larger volume of fund resources.

Such issues involving tax jurisdictions have brought into vogue ideas about tax reform and how the possibility of its implementation would affect the incidence of state and municipal tax collection. The discussions involve grouping together several taxes, including those between different entities, into one and dividing them proportionally among those responsible for collecting them. This determination is clearly contrary to the current rules already established in the Constitution.

Taxation based on sources other than those already determined in the legal text, whose sources will be variable, possibly aggregated, not observing the provisions of the federative pact, nor respecting the jurisdictions of States and Municipalities, violates the precepts of federative autonomy. The tax-paying capacity of these and their collection continues to be part of the origin of the inviolability of the federative pact. Therefore, any attempt to the contrary must be viewed with caution by the system operators.

In line with the idea of equitable federal division, criticism is made regarding the suspension of installments of debts owed by states and municipalities to the Union. The exemption from payment during the pandemic period did not meet the equitable criteria for revenue distribution, by exempting the payment of installments proportionally. Instead of strengthening the federal pact, it directly benefited defaulting states that did not comply with the obligations agreed upon to fully settle their debts.

In other words, states and municipalities that had honored their obligations ended up receiving, proportionally, smaller amounts than states with larger debts. All because the intention of the legal provision is to reduce the debt so that it can be reallocated for use in measures to combat the new Coronavirus (Covid 19). Therefore, if the criteria for reducing and distributing the debt were different, the amount used would have been considerably higher for those in good standing.

IV. Conclusion

The conclusions drawn in this article came from the technical analysis of the two federal measures to combat the current pandemic. The relations between the Federal Union and the States, Municipalities and Federal District were strengthened with the distribution of revenues aimed at granting the aforementioned entities the necessary conditions to combat the health crisis.

The measures mentioned, which included the suspension of payments resulting from debts with the Union, public and private loans, social security debts and spending contingency such as the non-superlative change in their payrolls, were justified based on the greater good of health. Thus, their tax losses were offset by the non-payment of the debts described. In this way, the resources would be used for measures such as special hiring and acquisitions.

Although efficient and necessary to support States and Municipalities in combating the Coronavirus, situations could have been legally arranged to better adapt to the reality of the entities, such as the situation of debt suspension, which would have been better used if it had been proposed by analyzing the payers' compliance and, based on this basis, redistributing the amounts, after considering a fixed-value payment exemption. Despite this slight observation, the payment exemption still remained as a relief to the debtors.

In general terms, the inviolability of the federative pact, despite constant attempts to reform its structure, must be maintained in strict compliance with

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the provisions of the Federal Constitution, both regarding the administrative and financial autonomy of the federated entities and their tax collection capacity, with strict observance of the balance and harmony that should govern the relations between the Union, States and Municipalities. Actions such as those analyzed in this article are a demonstration of this premise.

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The Digital Renminbi and its Impacts on the Structural Power of the Dollar

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Abstract- This paper analyzes how the digital renminbi (e-CNY) may impact the structural power of the U.S. dollar and discusses its primary limitations. We adopt the framework of the dollar's structural power within US hegemony, highlighting the political consequences of its central role. Next, we examine China's digitalization from two perspectives: monetary and operational, and within the context of the Digital Silk Road, whose four pillars – infrastructure, technology, e-commerce, and governance – support the e-CNY's dissemination. This paper argues that the e-CNY's launch might provide a new impetus for the renminbi's internationalization, particularly in regional payments and e-commerce. However, this does not challenge the dollar's structural dominance in the short term, as the limits to the expansion of the e-CNY in the international monetary hierarchy remain quite significant.

Keywords: central bank digital currency, chinese digital currency, e-CNY, digital renminbi, digital yuan, china, structural power of the dollar, international monetary hierarchy, digital silk road.

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The Digital Renminbi and its Impacts on the Structural Power of the Dollar

Alba Boaventura [α] & Isabela Nogueira [σ]

Abstract- **This paper analyzes how the digital renminbi (e-CNY) may impact the structural power of the U.S. dollar and discusses its primary limitations. We adopt the framework of the dollar's structural power within US hegemony, highlighting the political consequences of its central role. Next, we examine China's digitalization from two perspectives: monetary and operational, and within the context of the Digital Silk Road, whose four pillars – infrastructure, technology, e-commerce, and governance – support the e-CNY's dissemination. This paper argues that the e-CNY's launch might provide a new impetus for the renminbi's internationalization, particularly in regional payments and e-commerce. However, this does not challenge the dollar's structural dominance in the short term, as the limits to the expansion of the e-CNY in the international monetary hierarchy remain quite significant.**

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Introduction

The introduction of Central Bank Digital Currencies (CBDCs) has sparked significant international debate due to their potential to be a turning point in monetary transactions. CBDCs may not only accelerate international settlements but also provide alternatives to the U.S.-led global payment system (Raghuveera, 2020). This could impact security and defense by creating blind spots for the U.S. in tracking international financial flows, potentially undermining its economic coercion and provoking broader geopolitical consequences (Economic Diplomacy Initiative, 2020; Raghuveera, 2020). Following Russia's removal from the Society for Worldwide Interbank Financial Telecommunication (SWIFT) after its February 2022 invasion of Ukraine, the urgency to explore alternatives to dollar reliance has grown.

The e-CNY – the Chinese digital renminbi – is at the forefront of the CBDC race to strategically leverage digitalization and strengthen China's autonomy in its technological competition with the U.S. As of June 2023, China boasts the world's most advanced digital ecosystem, with around 943 million people using mobile payment platforms daily (Daxue Consulting, 2024). The Chinese expansive investment project, the Belt and Road Initiative (BRI), also encompasses a digital extension known as the Digital Silk Road (DSR). In summary, it aims "to create 'a global information highway with China at its core' […] through technology 'bundles' comprised of smart cities, smart ports, e-commerce and digital currency, communications networks, and satellite networks" (Hemmings, 2020, p. 7).

Yet, any monetary actions face significant obstacles because of the structural power of the U.S. dollar. Unlike relational power, i.e., coercing or influencing B's behavior regardless of B's preferences, structural power emphasizes how social processes shape outcomes. It "confers the power to decide how things shall be done, the power to shape frameworks within which states relate to each other, relate to people, or relate to corporate enterprises" (Strange, 1995, p. 50). In the monetary realm, this power enables the hegemon to control global credit supply and currency convertibility, as well as to impose financial sanctions that restrict access to the SWIFT system (Guzzini, 2000; Strange, 1989; 1994; Cohen, 2015; Torres, 2019).

Based on this debate, the objective of this paper is to analyze how the e-CNY may challenge the structural power of the U.S. dollar in the international system and to assess its main limitations. This discussion is essential for two reasons. First, China's leading role in the CBDC race raises concerns in American literature about the e-CNY's potential to weaken the "dollar bomb," the ability to constrain access to the reserve currency global market (Torres, 2019). Second, despite extensive research on 5G and the BRI, few studies focus on the DSR and its role in China's strategy to lead the Fourth Industrial Revolution.

This paper is structured into three sections, in addition to this introduction. The first section outlines the theoretical framework of structural power and its impacts on the International Monetary Hierarchy (IMH), along with the current status of the Chinese renminbi (RMB). The second section examines the two digital strategies pursued by China – the e-CNY and the

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DSR –, detailing their characteristics and potential points of convergence. Finally, the third section reflects on the implications of a successful e-CNY from a critical perspective. The article concludes with a summary of key findings.

I. Structural Power of the Dollar and the International Monetary Hierarchy

In the 1970s, a hypothesis emerged suggesting that the relative decline of U.S. power was behind global economic instabilities, including currency and interest rate volatility, stagflation, and rising commodity prices. Proponents of "declinist" theories linked this decline to a dispersal of political power and the lack of economic cooperation, especially after the breakdown of the gold-dollar standard in 1971 and the U.S. defeat in Vietnam in 1975 (Strange, 1987). However, Strange (1994) challenged the narrative of lost hegemony, arguing that it stemmed from a narrow view of power that focuses on exploiting advantages within the structure, known as relational power or the first face of power. Instead, she proposed a second face that is more diffuse and centered on social necessity, which shapes the system's foundations and redefines the rules to extract benefits (Cohen, 2015; 2016).

Structural power refers to a nation's ability to establish and influence four interconnected structures: security, production, finance, and knowledge. In particular, the financial sphere relates to control over credit and currency convertibility (Strange, 1994; Torres, 2018). This dominance over essential inputs – such as weapons, capital, credit, and technology – determines a country's position in the global hierarchy (Guzzini, 2000). Therefore, those who possess structural power can decide who has access to these resources and under what conditions (Strange, 1989). While indirect and less visible, this power enables A to expand or limit, either implicitly or explicitly, the range of choices available to B, thereby facilitating or constraining decisions and influencing behavior (Strange, 1994). According to Guzzini, this manipulation can occur in two ways: deliberately (indirect institutional power) or unintentionally (unintentional power) (Helleiner, 2005).

Strange (1989) contends that this theory demonstrates how the U.S. was not in decline but rather leveraging its hegemonic power unilaterally to prioritize its own interests. The resurgence of U.S. power after the Interest Rate Shock of 1979 occurred through "strong dollar diplomacy" and external pressures for both financial and trade liberalization during the 1980s and 1990s (Tavares; Melin, 1997). This process secured the dollar's centrality as the global reference currency, allowing the U.S. to: 1) appropriate wealth through seigniorage; 2) project its macroeconomic preferences; 3) define international financial regulations as the lender of last resort; 4) influence economic geography; and 5) gain symbolic power from global interest in its stability (Helleiner, 2005). Thus, the dollar's status became self-reinforcing, as the large size of the U.S. market boosted demand, which in turn increased its attractiveness and liquidity (Eichengreen, 2011).

This framework significantly affects the IMH. As Kirshner (1995) notes, currency acts as a coercive tool in three ways: 1) monetary manipulation to destabilize rival currencies; 2) dependence exploitation via threats or selective coordination of resources; and 3) systemic disruption to exploit advantages. Owing to its central position in the IMH, the U.S. exerts its influence through economic sanctions and exclusions from the SWIFT system, as evidenced by the cases of Iran (Torres, 2019) and Russia since 2022 amid the Ukraine War. While a few other central currencies represent global wealth to a lesser extent, peripheral currencies are often viewed as mere financial assets (Carneiro & De Conti, 2022). Despite the inertia within the IMH, De Conti et al. (2013) suggest that long-term changes are possible as a consequence of geopolitical shifts or if the currency issuer holds political power, a willingness to internationalize, and a larger integrated economy.

Given these criteria, China's monetary initiatives offer considerable potential. Since the 2008 Global Financial Crisis, the country has intensified efforts to internationalize the RMB, launching key projects like the Cross-Border Interbank Payment System (CIPS). Established in 2015, CIPS had expanded to include 153 direct participants and over 1.413 indirect participants worldwide by October 2024 (CIPS, 2024). Yet, China's capital control policies continue to restrict the RMB's external use, with the currency ranking fourth in global payments (SWIFT, 2024) and seventh in reserves (IMF, 2024) as of September 2024. The Chinese government's strategy to integrate the e-CNY with the DSR is expected to strengthen its competitiveness and provide China with greater economic autonomy, as discussed in the following sections.

II. Construction and Proliferation of Chinese Digital Currency and Infrastructure

a) Chinese Digital Currency: e-Cny or Digital Renminbi

A CBDC is a digital form of fiat currency issued by a central bank and denominated in the national unit of account. It functions as both a medium of exchange for payments and a store of value to preserve purchasing power. Unlike credit cards and bank transfers, CBDCs are legal tender and carry no solvency risk since they are direct liabilities of the central bank. They also differ from cryptocurrencies and stablecoins as they are issued, regulated, and priced by the

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monetary authority rather than the market, which reduces volatility (Bank of England, 2020). The global discussion around CBDCs gained momentum in 2018 when Facebook announced plans for a private currency, raising concerns about its economic impact due to the company's massive user base. Based on data up to March 2024 from the *CBDC Tracker*, 134 nations or monetary unions are exploring designs for implementing CBDCs in their jurisdictions, representing 98% of global gross domestic product (Atlantic Council, 2024).

In China, the CBDC debate began in 2014 when the government set up a task force to explore digital currency issuance and technology. By 2016, the Digital Currency Research Institute was established and the first prototype was developed, supported by partnerships among state banks, national firms, and private companies in the communications sector. The current pilot encompasses 26 cities and 17 provinces, including tests in Shenzhen, Suzhou, Xiong'an, Chengdu, Shanghai, Hainan, Changsha, Xi'an, Qingdao, Dalian, the Yangtze River Delta, the Pearl River Delta, and the Beijing-Tianjin-Hebei corridor (People's Bank of China, 2021; Bansal & Singh, 2021; Fullerton & Morgan, 2022; Gou, 2024).

In 2021, China joined Hong Kong, Thailand, and the United Arab Emirates for the Multiple CBDC Bridge (mBridge), a project exploring Distributed Ledger Technology (DLT) for cross-border applications. A digital wallet app was launched in pilot areas during the Winter Olympics in February 2022. Its overseas version also supports more than 210 countries and regions, as well as Visa and Mastercard cards. Hong Kong is the first international test, and 17 local banks registered 14.375 million e-CNY wallets through the Foreign Payment System by April 2024 (Fullerton & Morgan, 2022; Murray, 2022; Gou, 2024).

The People's Bank of China (PBoC) has emphasized that the initiative primarily focuses on reclaiming control of data and money from the private sector domestically (People's Bank of China, 2021). By the second quarter of 2020, Alipay (55.6%) from Ant Group and WeChat (38.8%) from Tencent dominated 94% of the Chinese mobile payments market (Fullerton & Morgan, 2022). With such a large market share, any disruption to one system could overwhelm the other. Massive withdrawals of bank deposits could also reduce liquidity and tighten credit. Nevertheless, the primary concern lies in the amount of data these companies possess, which enhances the products appeal and stifles competition. Therefore, the Chinese government argues that the e-CNY will strengthen financial stability, lower transaction costs, and simplify international payments, among other benefits (Bansal & Singh, 2021; Murray, 2020).

The e-CNY operates on two levels. First, the PBoC issues e-CNY and distributes it to state banks, commercial banks, and mobile app conglomerates. Second, these authorized entities distribute it to businesses and individuals. The PBoC centrally manages the system, overseeing transactions, balance management, and a real-time ledger. Three data centers authenticate users and record e-CNY issuance, transfers, and withdrawals, as well as conduct big data analysis for risk management. The e-CNY aims to provide a safer, faster, and cheaper alternative to the current system, offering controllable anonymity based on transaction value (small amounts remain anonymous, while larger amounts are traceable). However, critics argue that this anonymity may ultimately depend on the Chinese government's interests, which could use e-CNY as a tool to monitor political opponents more easily (Fullerton & Morgan, 2022; Kumar & Rosenbach, 2020; Murray, 2020).

Elston (2023) points out that by January 2022, 261 million people had created e-CNY wallets, representing a relatively low 28.89% adoption rate compared to China's 903.6 million mobile payment users. Moreover, many of these wallets may be inactive, as several users signed up merely to benefit from the 340 million RMB (US$ 50.47 million) distributed in 2022 through discounts, promotions, and red envelopes[1] by the PBoC to promote the initiative. In December 2022, a former PBoC Research director acknowledged that "the results are not ideal… Usage has been low, highly inactive" (Elston, 2023, online). Although it has low domestic adoption rates, the e-CNY remains the largest CBDC pilot globally (Kumar, 2023). By June 2023, the e-CNY had 120 million wallets, 16.5 billion RMB in circulation (0.16% of the total M0 money supply), and 950 million transactions, amounting to 1.8 trillion RMB (US$ 249.9 billion) in cumulative annual volume (Wee, 2023).

China has also been making significant multilateral efforts to promote the adoption of the e-CNY, as interoperability is essential to the success of the alternative financial system (Greene, 2021). In 2021, the PBoC helped establish the Finance Gateway Information Services Co. – a joint venture between SWIFT and CIPS –, a move seen by many experts as a strategic step towards broader e-CNY use (Greenwald, 2021; Bansal & Singh, 2021). Additionally, the mBridge project has shown promising results: by 2022, it had completed 164 transactions over six weeks using CBDCs and settled $22 million with the involvement of 20 commercial banks (BIS Innovation Hub, 2022). Estimates suggest that mBridge could cut cross-border invoicing costs by up to 50% and reduce payment times from days to seconds,

[1] Red envelopes (红包) contain banknotes and are traditional gifts given on holidays and special occasions to family and friends for good luck.

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with no dependency on time zones (Greene, 2021). As highlighted by Murray (2022, online),

> the mBridge's benefits may sound like minor incremental changes. They are not. The current system of international exchange is outdated. It requires numerous manual touches and is vulnerable to fraud and even large-scale theft. Think of China's approach as the high finance and international commerce version of Venmo. In comparison, the reigning U.S.-led system is akin to mailing a check. If the mBridge is scaled as planned, it would dramatically facilitate and accelerate the cross-border movement of money.

In 2020, the Chinese government launched the Blockchain Service Network (BSN), a platform aimed at standardizing global blockchain protocols to reduce costs and improve accessibility. The BSN operates both within China and abroad. Domestically, it is supported by China Mobile, China Telecom, and Baidu AI Cloud. Internationally, it collaborates with Google Cloud and Amazon Web Services to harmonize financial services. Notwithstanding these advances, the e-CNY does not currently use blockchain technology because of its centralized structure, identification requirements, and transaction volume. Yet, Yaya Fanusie, a former CIA analyst and researcher at the Center for a New American Security, predicts that these projects will eventually converge. Once the BSN is fully operational, he argues it will play a key role in advancing China's broader goal of creating a Universal Digital Payments Network (Raud, 2021; Raud & MacKinnon, 2022).

China's leadership in CBDCs is also partly attributed to the U.S.'s lack of decisive action. Despite anticipation regarding the Federal Reserve's (FED) stance, the January 2022 report *Money and Payments: The U.S. Dollar in the Age of Digital Transformation* is still considering whether the U.S. should join the CBDC race and invites public feedback on the issue. While the U.S. possesses the technology to create a digital dollar, there is no consensus on how it would function or its relevance to the structural power of the dollar. In February 2021, the chairman of the FED stated, "We don't need to be first. We need to get it right" (Li, 2021, online), suggesting that the gains from China's pioneering efforts may not be substantial. This has sparked debate in the U.S., with some analysts warning that China needs neither to internationalize the RMB nor to liberalize its current account to export its CBDC technology and regulate emerging financial technologies globally (Hoffman, 2021).

In fact, there is also a critical strategic dimension: providing a competitive alternative to U.S. channels for processing cross-border payments. To downplay the global implications of the e-CNY, Chinese authorities have employed rhetorical strategies. In April 2021, Li Bo, then Deputy Governor of the PBoC, stated that e-CNY enables the market to determine which currencies are used in cross-border trade and investment, rather than to replace the dollar as the world's predominant currency (Greene, 2021). In light of these "market selection" declarations, Cheng and Gao (2022, p. 220, our translation) indicate that the advent of CBDCs may transform the competition within the IMH for China:

> The technological progress represented by CBDCs will become a major force in breaking the inertia of international reserve currencies. CBDCs have unparalleled advantages over traditional fiat currencies in areas such as cross-border payments and payment versus payment (PvP) transactions, and are expected to be a game-changer in reshaping the landscape. Since 1920, the US dollar's status as a reserve currency in the international system has continuously strengthened, creating a strong inertia in its use. Within this existing competitive system, it has indeed been difficult for the RMB to achieve significant breakthroughs. However, in the new global reshuffling of digital currencies, all nations' digital currencies will effectively return to the same starting line, and the digital RMB is expected to stand out thanks to its first-mover technological edge and its competitiveness in the digital economy[2].

To put it bluntly, the dissemination of the e-CNY endeavors to elevate its position within the IMH, mitigate the side effects of the structural power of the dollar discussed earlier, and bolster China's financial autonomy. In other words, investing in the digital version intends to increase both the attractiveness and competitiveness of the RMB relative to other central currencies, promote its international spread, and consequently minimize the impact of the "dollar bomb." This is not solely a monetary strategy but part of a broader effort to expand China's digital infrastructure and technological capabilities, as addressed in the following subsection.

b) Digital Silk Road

The first mention of the DSR appeared in 2015 in a precursor white paper titled *Vision and Actions on Jointly Building the Silk Road Economic Belt and the 21st-Century Maritime Silk Road*. Initially referred to as the "Information Silk Road," its goal was to enhance international connectivity by constructing digital infrastructure, primarily through expanding cross-border optical cables and satellite-based communication (NDRC, 2015). Approximately 137 countries have undertaken or planned projects (Nouwens, 2021),

[2] Original: 以央行数字货币为代表的科技进步将成为国际储备货币快速挣脱惯性的重要力量。央行数字货币在跨境支付和券款对付领域具有传统法币无法比拟的优势，料将成为重要破局者。1920年以来，美元在国际储备货币体系中的地位不断巩固，形成了强大的货币使用惯性，人民币在旧有的竞争体系中确实难以取得突破性进展。然而，在新一轮的数字货币全球大洗牌中，所有国家的数字货币都将重回同一起跑线，而数字人民币则有望凭借先发技术优势与数字经济竞争力脱颖而出。

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resulting in global investments of around $79 billion (Triolo et al., 2020). In short, the DSR aims to help Chinese state-owned companies and private firms penetrate BRI member countries to obtain benefits in the race for both emerging markets (Triolo et al., 2020) and international standards.

From Cheney's (2019) perspective, the DSR encompasses four interrelated areas, which we propose to support the dissemination of the e-CNY: infrastructure, technological development, e-commerce, and cyberspace governance. The first area involves substantial investments in digital infrastructure, such as 5G networks to increase internet speeds, submarine and terrestrial fiber optic cables, and data centers (Cheney, 2019; Mochinaga, 2021). The second area covers domestic investments in artificial intelligence (AI) for data filtering and cybersecurity, satellite navigation systems via BeiDou, and quantum computing, a promising technology for intelligence and encryption (Cheney, 2019).

These elements contribute to the e-CNY by enhancing the sophistication of China's digital ecosystem in terms of infrastructure and security. By promoting a network for data transmission linked to the e-CNY, China would not only increase its ability to monitor information but also improve its defense against external interference. As Fanusie (2021, p. 2) states, "China's digital currency is as much about data as it is about money." Furthermore, the Chinese government announced nearly $1.4 trillion in investments between 2020 and 2025 to expand data centers and digital infrastructure, particularly in 5G and AI (USCC, 2021). Hence, the synergy between the e-CNY and the DSR builds a robust digital infrastructure and develops mechanisms to leverage it, thereby expanding Chinese influence and power (Hemmings, 2020).

The third area relates to e-commerce, specifically digital free trade zones and mobile payment networks. On one hand, these zones reduce international shipping costs in East Asia, with Malaysia's partnership with Alibaba as a notable example. Established in July 2017, this zone was "serving as an international logistics hub, providing auxiliary services such as training and finance, and providing online service platforms, including electronic customs clearing and commercial inspections." (Naughton, 2020, p. 35). As outlined by Naughton (2020), such partnerships create a digital common market with unified standards, likely strengthening China's position due to the volume of participants and transactions. If China tests its CBDC in these zones and improves trade efficiency, the e-CNY's appeal, credibility, and market acceptance could potentially rise, despite privacy concerns.

On the other hand, Beijing's subsidies and incentives to promote its mobile payment companies (Alipay and WeChat) through the DSR could further benefit the e-CNY. While Alipay envisions expanding into Europe, Australia, and Asia through Chinese tourists traveling abroad, WeChat aspires to surpass local rivals and capture markets in Russia, India, and emerging economies in Southeast Asia (Triolo, 2020). The internationalization of these platforms might create a network of acceptance and infrastructure that Beijing could later utilize to promote the e-CNY, regardless of its status as a new payment method (Bansal & Singh, 2021). In other words, the forays of Chinese mobile payment players into the DSR may lay the groundwork for the PBoC's future dominance with the e-CNY.

Finally, the fourth emphasizes the establishment of international norms for cyberspace. China advocates for *cyber sovereignty*, i.e., the right of nations to determine their own development, regulations, and policies in the digital domain. This view contrasts with Western liberal rhetoric since it sets precedents for government intervention (Cheney, 2019). Nevertheless, China's leadership in the global CBDC debate may enable it to promote international regulatory frameworks and standards that align with its interests. Taking into account the possible repercussions for the dollar's centrality, this prospect has raised concerns among U.S. policymakers. Some analysts argue that the country is "missing in action" and must ensure its historical guiding role in coordinating standards for financial technology innovations (Raghuveera, 2020, online).

III. Consequences of Chinese Digitalization

Kumar and Rosenbach (2020) describe three key benefits that China could gain from the e-CNY, especially in light of our hypothesis regarding its connection to the DSR. First, it would allow China to circumvent U.S. sanctions by utilizing an alternative settlement system via CIPS. Second, it could enhance China's influence by attracting foreign users to its technology, offering exclusive interoperability, and fostering dependency on its network. Third, China's access to vast amounts of data could provide it with an informational advantage, which critics argue might be used for political forecasting or to manipulate public opinion and electoral processes (Cheney, 2019; Hemmings, 2020; Mochinaga, 2021). Through the e-CNY and DSR, China is consequently perceived as exporting a system of digital surveillance characterized by real-time monitoring and censorship (Hemmings, 2020).

First and foremost, these speculations are largely exaggerated. Surveillance and the strategic use of data in the fourth industrial revolution are not exclusive to China, even though its *modus operandi* may have distinct characteristics. In the context of surveillance capitalism, Western countries also deploy

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advanced infrastructures for social control, relying on companies to monitor behavior on social media, in financial transactions, and through mobile devices (Zuboff, 2019). The main difference in China is that much of this surveillance is openly conducted by the state, with the public well aware of the monitoring – and often supportive owing to the perceived security benefits. In fact, U.S. critiques of Chinese surveillance display a degree of cynicism, as they tend to overlook scandals such as the Snowden leaks, which exposed espionage and sabotage by the U.S. government for political and economic advantages.

In addition, our analysis indicates that the launch of the e-CNY does not alter the nature of the RMB per se in a way that justifies surpassing the dollar in the short term. Instead, it is likely to lead to a brief repositioning of the RMB within the IMH. Some argue that the e-CNY has no impact on dollar supremacy due to China's capital controls (USCC, 2021; Fullerton & Morgan, 2022), while others propose that its programmable nature could introduce new forms of liberalization, such as in Hong Kong's CNH market (Ekberg & Ho, 2021). However, the e-CNY merely digitizes the RMB and faces the same challenges (Aysan & Kayani, 2022; Paulson, 2020) in competing with the structural power of the dollar. Although CBDCs may transform cross-border payments by reducing intermediaries and liquidity issues (Bansal & Singh, 2021), there is no evidence suggesting a shift in global financial dominance toward the e-CNY.

According to a BIS report (2021), more fundamental factors for monetary internationalization – geopolitics, institutional credibility, financial openness, and the rule of law – are slow to undergo significant transformations.

> Thus, the advent of CBDCs may accelerate changes to the configuration of reserve currencies, but may not change it dramatically over a short period. Regional patterns, where trade connections are tighter, and political pressures stronger, may instead evolve more rapidly. These tendencies already exist today, but a new CBDC issued in the region and with more attractive features compared with present versions of the national currency, could tip the balance towards the establishment of a new regional reserve currency (BIS, 2021, p. 18).

In line with this, we also believe that the connection between the e-CNY and DSR contributes to facilitating regional trade payments and accelerating Chinese e-commerce. Eichengreen et al. (2022) reveal that China was the largest supplier of imports for 70% of Asian countries and the main destination for 50% of them by 2022. In spite of the percentage of trade invoiced in RMB remaining stable since 2017, its absolute value has risen, particularly with Asian countries such as Cambodia, South Korea, Taiwan, and India. If integrated into regional trade programs, the e-CNY could streamline RMB settlements and mitigate both transaction costs and the currency risks associated with using the dollar as an intermediary (Knoerich, 2021).

Hence, the spread of the e-CNY through the DSR is likely to significantly promote the RMB's internationalization, enhancing its status within the IMH and granting China greater independence. Trade invoicing has been the main driver of RMB internationalization, helping central banks accumulate reserves for last-resort liquidity (Gopinath & Stein, 2018; Eichengreen et al., 2022). This trajectory closely mirrors the approach taken by the U.S. in the 20th century to internationalize the dollar. Initially, the U.S. leveraged the dollar's use in foreign trade, followed by its adoption in private financial transactions, and ultimately for central bank reserves (Eichengreen, 2010). In light of Gopinath and Stein (2018), this widespread use of a currency creates a self-reinforcing cycle, which "begins with wanting to hold the currency in which one is paid, thus requiring safe assets in that currency, decreasing interest on these assets, incentivizing issuance, and thus pricing in that currency to hedge." (BIS, 2021, p. 17).

In the context of the BRI and DSR, the adoption of the e-CNY could further accelerate the recent surge in cross-border e-commerce. Qi (2023) observes that 30 BRI e-commerce partner countries accounted for 31.5% of China's cross-border e-commerce volume in 2022. By the end of that year, China's pilot digital trade zones had expanded to 165 zones across 31 provinces, representing 90% of the country's RMB 2.11 billion (US$305.67 billion) e-commerce revenue (State Council, 2023). To promote the spread of the e-CNY within the BRI, China could offer commercial incentives, lower interest rates, and reduced transaction costs in regions where it has significant geopolitical influence, notably in the Asia-Pacific (Bansal & Singh, 2021).

IV. Concluding Remarks

The structural power of the dollar is essential for exercising American influence through economic sanctions. However, its overuse can lead to distortions and encourage nations to seek alternatives to this dominance. Since 2008, China has accelerated its efforts to internationalize the RMB and has recently turned to digitalization to attain more flexibility vis-à-vis the dollar's power. Although Chinese authorities claim that the e-CNY aims to restore state control over payments and ensure monetary stability, it also promises greater efficiency in cross-border payments at a lower cost. Given the CBDC's potential to revolutionize international settlements, some experts have raised concerns about whether e-CNY could threaten the supremacy of the U.S. dollar.

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The e-CNY project should be seen as part of China's broader digital strategy within the DSR rather than in isolation. The four pillars of the DSR – infrastructure, technology, e-commerce, and governance – facilitate e-CNY adoption by strengthening China's digital ecosystem. Moreover, multilateral initiatives such as the Finance Gateway Information Services Co., mBridge, and the BSN improve interoperability and technical support for e-CNY. As a result, Kumar and Rosenbach (2020) identify three key advantages China derives from the e-CNY: 1) the ability to create a dependency network through CIPS, akin to the U.S.'s role with SWIFT; 2) the potential to expand political and economic influence, particularly in cyberspace; and 3) access to vast amounts of data for potential geopolitical purposes.

Yet the initiative faces significant structural challenges. Domestically, strict Chinese capital controls continue inhibiting the RMB's global reach. On the one hand, this policy has been critical in channeling the so-called "financialization with Chinese characteristics" toward an investment-driven growth model and preserving the country's autonomy (Nogueira, Guimarães, & Braga, 2019). On the other hand, it is counterproductive to the international use of the RMB since it restricts liquidity and limits the development of its financial system. Externally, the structural power of the dollar and its self-reinforcing position remain obstacles, albeit the relative delay of the U.S. in the CBDC race. While losses of relative power on a competitive frontier may occur, they do not necessarily imply a decline in the structural power of the dollar over the economy.

Thus, the self-reinforcing cycle of the dominant currency, the resistance to changes in the IMH, and the limit of its external use still constrain the RMB's internalization, either in the physical or digital version. As long as e-CNY builds trust and credibility in the international community, its association along the BRI and DSR corridor may boost the RMB's internationalization in the short term through regional gains, particularly in e-commerce. This approach aligns with China's internationalization strategy of following the historical lessons of the dollar but will face strong external resistance. From the perspective of the U.S. establishment, any rival innovations that could potentially impact the dollar's preeminence must be neutralized.

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Central Bank Autonomy and Price Stability in Sub-Saharan Africa: Implications for the Bank of Central African States (BEAC)

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Abstract- The purpose of this paper is to validate the link between the autonomy of the Central Bank and inflation. An econometric modeling of the relationship between inflation, the autonomy of the Central Bank and economic performance variables will allow to answer to the problem that the reduction of the inflationary bias passes by the autonomy of the Central Bank. Indeed, by adopting a legal and real measure of autonomy Cukierman et al. (1992) for ten (10) Central Banks in Sub-Saharan Africa over the period 1980-2017, the static panel regression partially confirms the expected relationship. Result which proves that the condition of the autonomy of the Central Bank can only be necessary (and not sufficient) to price stability.

Keywords: *central bank autonomy, price stability, static panel data, sub-saharan africa (SSA).*

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Central Bank Autonomy and Price Stability in Sub-Saharan Africa: Implications for the Bank of Central African States (BEAC)

Autonomie des Banques Centrales et Stabilité des Prix en Afrique Subsaharienne: Implications Pour la Banque des Etats de l'Afrique Centrale (BEAC)

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Résumé- **L'objectif de ce papier est de valider le lien entre l'autonomie de la Banque Centrale et l'inflation. Une modélisation économétrique de la relation entre l'inflation, l'autonomie de la Banque Centrale et des variables de performance économique permettra a permis de répondre à la problématique selon laquelle la réduction du biais inflationniste passe par l'autonomie de la Banque Centrale. En effet, en adoptant une mesure légale et réelle de l'autonomie Cukierman et al. (1992) pour dix (10) Banques Centrales en Afrique Subsaharienne sur la période 1980-2017, la régression en panel statique confirme partiellement la relation attendue. Résultat qui prouve que la condition de l'autonomie de la Banque Centrale ne peut être que nécessaire (et non suffisante) à la stabilité des prix.**

Motsclés: autonomie de la banque centrale, stabilité des prix, données de panel statique, afrique subsaharienne (ASS).

Abstract- **The purpose of this paper is to validate the link between the autonomy of the Central Bank and inflation. An econometric modeling of the relationship between inflation, the autonomy of the Central Bank and economic performance variables will allow to answer to the problem that the reduction of the inflationary bias passes by the autonomy of the Central Bank. Indeed, by adopting a legal and real measure of autonomy Cukierman et al. (1992) for ten (10) Central Banks in Sub-Saharan Africa over the period 1980-2017, the static panel regression partially confirms the expected relationship. Result which proves that the condition of the autonomy of the Central Bank can only be necessary (and not sufficient) to price stability.**

Keywords: central bank autonomy, price stability, static panel data, sub-saharan africa (SSA).

Introduction

L'autonomie de la Banque Centrale peut se définir comme sa capacité à prendre des décisions dans le domaine qui la concerne, de manière indépendante et sans recevoir des instructions du gouvernement (Eyzaguirre et Vergara (1993), Avom et Bobbo (2013)). Suivant Bade et Parkin (1982) et Grilli et al. (1991), l'autonomie de la Banque Centrale peut prendre deux (02) formes: l'autonomie politique ou d'objectifs, et l'autonomie économique ou d'instruments. Dans le premier cas, la Banque Centrale a autorité pour déterminer les objectifs de la politique monétaire, par exemple la cible d'inflation. Dans le deuxième cas, la Banque Centrale peut définir la politique pour arriver aux objectifs.

L'autonomie de la Banque Centrale est essentielle pour assurer l'efficacité des opérations de cette dernière. Elle correspond à la posture institutionnelle la plus efficace pour assoir les objectifs assignés. Pour assurer plus efficacement la stabilité des prix, l'autonomie de la Banque Centrale doit orienter non seulement la formulation de la politique monétaire, mais aussi les attentes des agents économiques quant à l'efficacité de cette politique (Mishra et al., 2010).

En Afrique Subsaharienne (ASS), le contexte de la politique monétaire évolue peu à peu. Beaucoup plus que dans les pays en développement, la question de l'autonomie au sein des Banques Centrales africaines a suscité très peu d'intérêt en raison du rôle confié à ces institutions, qui dans les années 1980, étaient principalement chargées de financer les déficits chroniques des Etats à travers l'utilisation des instruments directs de politique monétaire (Masson et Pattillo (2005), Bobbo (2018)). Dans les années 2000 cependant, grâce à la mise en œuvre des Programmes d'Ajustement Structurel (PAS) préconisés par le Fonds Monétaire International (FMI), plusieurs de ces Banques Centrales ont modifié leurs statuts dans le but: d'accorder la priorité à l'objectif de stabilité des prix, - d'adopter les instruments indirects de politique monétaire - de limiter les crédits octroyés aux gouvernements et d'accorder à ces institutions une plus grande autonomie par rapport aux pressions politiques (Khan, 2011).

Dans cette analyse relative à l'économie politique des Banques Centrales, il s'agit principalement

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de répondre à la question suivante : *quel est l'effet de l'autonomie des Banques Centrales sur la stabilité des prix en ASS ?* Pour ce faire, notre objectif est dans un premier temps *d'évaluer les efforts entrepris par les Banques Centrales d'ASS (la BEAC particulièrement) en matière d'autonomie,* puis dans un second temps de *vérifier empiriquement si l'autonomie des Banques Centrales est une condition suffisante pour garantir la stabilité des prix en ASS.* Un tel objectif situe notre étude à la charnière des thématiques sur les déterminants de l'inflation. Compte tenu de cela, nous formulons l'hypothèse centrale selon laquelle : *l'autonomie de la Banque Centrale est un dispositif qui favorise la stabilité des prix en ASS.* Plusieurs travaux ont confirmé l'hypothèse du lien qui existerait entre inflation et autonomie de la Banque Centrale. Parmi les plus populaires, on peut citer ceux de: Grilli et al. (1991), Cukierman et al. (1992), Alesina et Summers (1993)... Tous ces travaux concluent en substance que les Banques Centrales autonomes produisent moins d'inflation que celles qui sont sous les ordres du pouvoir politique.

L'originalité de cette étude vient du fait qu'elle ambitionne de stimuler les débats en apportant des résultats plus actuels sur la relation entre l'autonomie des Banques Centrales et l'inflation en Afrique Subsaharienne. Elle a également pour objectif d'être un outil de référence profonde et plus large dans l'analyse empirique dans ce domaine, en complétant l'analyse existante et en comblant les lacunes empiriques et méthodologiques des études antérieures. Ce travail entend aussi approfondir la littérature empirique sur les déterminants de l'inflation en se concentrant prioritairement sur le cadre institutionnel (autonomie de la Banque Centrale comme un déterminant de l'inflation).

A l'issue de nos estimations, les résultats démontrent que la condition d'une Banque Centrale autonome ne peut-être que nécessaire (et pas nécessairement suffisante) à la stabilité des prix; dans la mesure ou certaines Banques Centrales restent confrontées à des difficultés dans l'atteinte de leurs objectifs officielles. Le reste de l'article est organisé comme suit : la section 1 est dédiée à une revue de la littérature. Les faits stylisés en ASS sont examinés dans la section 2. La spécification du modèle et la méthodologie pour nos estimations sont présentées dans la section 3. Dans la section 4, nous tirons des implications et recommandations de politiques monétaires de nos résultats.

I. Considérations Théoriques

a) *Problème de L'incohérence Temporelle Induit par les Autorités Publiques*

L'idée centrale dans la théorie de la Banque Centrale autonome est qu'une Banque Centrale coupée du pouvoir politique serait la garante de la stabilité des prix et ce, sans influencer d'autres variables macroéconomiques comme la croissance ou le chômage. Cette théorie est née autour de la problématique de « *l'incohérence temporelle* » entre les objectifs fixés par le gouvernement et les objectifs réellement atteints par ce dernier en matière monétaire (Kydland et Prescott, 1977).

Cette incohérence pose la question de l'optimalisation du bien-être social en usant de manière discrétionnaire des instruments de politique économique. Kydland et Prescott résument cette incohérence en une maxime « *la règle contre la discrétion* », et en un axiome, la règle peut permettre au gouvernement d'optimaliser le bien-être social, jamais l'utilisation discrétionnaire.

Par ailleurs, un resserrement de la politique monétaire suite à une plus grande autonomie peut refléter une volonté explicite de la Banque Centrale d'affirmer son attachement à la stabilité des prix, et ce plus particulièrement lorsque la situation budgétaire est relativement dégradée. En d'autres termes, une telle attitude de la Banque Centrale dans la conduite de sa politique monétaire vise à conforter sa position stratégique vis-à-vis du gouvernement, c'est-à-dire à démontrer à l'autorité budgétaire sa volonté ne pas se retrouver la « *poule mouillée* » du jeu au sens de Sargent et Wallace (1981) (Lucotte, 2012).

En s'appuyant sur une courbe d'offre de Phillips augmentée des anticipations rationnelles à la Lucas, Barro et Gordon (1983) déduisent que l'utilisation discrétionnaire de la politique monétaire, ou le non-respect de la règle comme par exemple une cible d'inflation, serait indubitablement contrecarrée par les agents économiques et produirait l'effet contraire escompté à savoir, dans le cas de la politique monétaire, par une augmentation de l'inflation.

En effet, la négociation collective aboutie, le gouvernement a tout intérêt, en régime discrétionnaire, d'user de l'arme monétaire et ce, malgré la règle fixée auparavant. Dès lors, la question est de savoir pourquoi ce gouvernement adopte un comportement discrétionnaire ? A ce sujet, Alesina (1989) puis Alesina et Roubini (1994), complète les travaux de Barro et Gordon (1983) par l'apport de Nordhaus (1975) sur le cycle politico-économique. Selon ces travaux, l'opportunisme des gouvernants les conduit, peu avant une élection, à user de manière discrétionnaire de l'arme monétaire afin d'augmenter leurs chances de réélection, sans tenir toutefois compte des effets néfastes d'une telle politique sur la stabilité des prix.

b) *Solution au Problème de L'incohérence Temporelle*

La solution au problème posé par le comportement discrétionnaire des autorités politiques proposé dans la littérature consiste à « *lier* » les mains du gouvernement en matière de politique monétaire.

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Plusieurs mesures ont été proposées pour atteindre cet objectif. Kydland et Prescott (1977) ont prôné l'établissement d'une règle de conduite monétaire. Barro et Gordon (1983) rétorquent qu'une règle seule, comme une cible de croissance de la masse monétaire par exemple ne suffit pas. Il faut y adjoindre l'idée de « *réputation* ». Pour eux, plus un gouvernement respecte la règle monétaire précédemment fixée, plus sa réputation augmente auprès des acteurs privés, plus sa crédibilité en matière de politique monétaire se renforce.

Pour Rogoff (1985), la réputation et la crédibilité finissent tôt ou tard par céder le pas face aux velléités des gouvernants à appliquer une politique discrétionnaire. Sa solution réside dans la nomination d'un gouverneur « *conservateur* » à la tête de la Banque Centrale, ce qui signifie que l'autorité monétaire suit une fonction objective qui donne plus d'importance à la lutte contre l'inflation qu'au soutien à la croissance ou à la lutte contre le chômage.

Walsh (1995) critique cette dernière idée sur un point de logique. Il avance qu'un gouvernement peut certes déléguer le respect de la règle monétaire à un banquier central conservateur mais, sans moyens pratiques pour y parvenir cette délégation de compétence reste vaine. S'inspirant de la théorie du principal-agent (le gouvernement et la société sont le principal et le banquier est l'agent), Walsh montre qu'un « *un contrat* » peut-être passe entre les deux agents, avec un objectif en termes d'inflation. En cas de non-respect du contrat, le principal peut punir l'agent (le meilleur moyen selon Walsh, est d'indexer le salaire du banquier central en fonction des résultats obtenus en matière d'inflation pour l'inciter à respecter ses engagements et ainsi atteindre l'équilibre socialement optimal et le risque de limogeage).

c) Critique Sur la Théorie de la Banque Centrale Autonome

La théorie économique de la Banque Centrale autonome n'est pas exempte de critiques. Le premier paradoxe qui traverse la théorie économique de la Banque Centrale autonome renvoie au texte fondateur de Kydland et Prescott en 1977. Le modèle proposé par ces deux économistes se basait essentiellement sur un modèle d'économie nationale fermée. La place des phénomènes économiques internationaux et autres chocs externes était réduite à sa portion congrue, alors que le système économique international connaissait alors de fortes turbulences (fin du système monétaire de Bretton Woods et chocs pétroliers) (Steiner, 2003).

Comme deuxième paradoxe, alors que les premiers modèles intégraient d'autres déterminants de l'inflation au plan conceptuel du moins, les travaux les plus actuels semblent désormais limiter la source première de l'inflation à la politique monétaire. Ce point est d'autant plus paradoxal que les travaux de Barro et Gordon qui ont ouvert la voie à l'application du modèle de Kydland et Prescott à la politique monétaire se basaient à l'époque sur une courbe de Phillips. Cela signifiait que l'impact de l'emploi, et par extension le résultat de la négociation collective influait également sur le niveau des prix.

Enfin, certains résultats empiriques des études sur le lien entre l'autonomie des Banques Centrales et le niveau d'inflation sont remis en cause par une recherche reprenant les mêmes données et méthodes qu'Alesina et Summers (1993) mais, ne trouvant pas de corrélation (Klomp et De Haan 2010). Les critiques les plus sévères viennent d'ailleurs des premiers théoriciens de l'autonomie comme Barro (1995) qui, en reprenant les données de Cukierman et al. (1992), n'arrive pas à trouver de corrélation statistique signifiante avec le niveau d'inflation en neutralisant les autres déterminants éventuels de l'inflation.

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d) Quelques évidences Empiriques

La littérature empirique est résumée par le *tableau 1* ci-dessous.

Tableau 1: Quelques Etudes Empiriques Récentes sur la Relation Entre L'autonomie de la Banque Centrale et L'inflation

Auteurs et Années	Pays ou Groupe de Pays	Période d'étude	Indice d'autonomie de la Banque Centrale	Résultats de la Relation Entre Autonomie et Inflation
Jacome et Vasquez (2008)	24 pays d'Amérique Latine	1985-2012	Indice d'autonomie Légale (CWN) et taux de rotation du gouverneur (TOR)	Relation positive et significative pour l'ensemble des pays
Klomp et De Haan (2010)	100 pays de l'OCDE	1980 - 2005	Indice d'autonomie légale (CWN) et taux de rotation du gouverneur (TOR)	Relation négative et significative pour l'indice Légal ; mais non significative pour l'indice TOR.
Kasseeah et al. (2011)	20 pays d'Afrique	1988 - 2007	Taux de rotation du gouverneur (TOR)	Relation positive et significative pour l'ensemble des pays.
Bogoev et al. (2012)	28 pays socialistes en transition	1990 - 2010	Indice d'autonomie Légale (CWN)	Relation négative mais faible degré de significativité.
Aguir (2013)	54 pays en développement classés par niveau de revenu	1991 - 2011	Taux de rotation du gouverneur (TOR)	Relation négative et significative pour les pays qui connaissent un taux d'inflation élevé.
Dincer et Eichengreen (2014)	100 Banques Centrales dans le monde	1998 - 2010	Indice d'autonomie Légale (CWN)	Relation négative et significative pour la plupart des Banques Centrales.
Romelli (2015)	10 pays industrialisés (les plus avancés)	1972 - 2014	Deux indicateurs d'autonomie Légale (GMT et CWN)	Relation négative et significative sur la dynamique de l'inflation.
Garriga et Rodriguez (2017)	149 pays en dans le monde	1980 - 2012	Indice d'Autonomie Légale (CWN)	Relation négative et significative pour l'ensemble des pays.
Qureshi Irfan (2017)	21 pays en de développement (PED) et 21 pays industrialisés	1972 - 2006	Taux de rotation du gouverneur (TOR)	Relation négative et significative à 25% dans les PED et 15% dans les pays industrialisés.
Agoba et al. (2017)	48 pays d'Afrique Subsaharienne	1970-2012	Indice d'Autonomie Légale (CWN)	Relation négative et significative / Autonomie pas une condition suffisante

Avec: Indice-GMT : Indice d'autonomie légale de Grilli et al. (1991); Indice-CWN: Indice d'autonomie légale de Cukierman et al. (1992); TOR: Indice d'autonomie réelle de Cukierman et al. (1992) / taux de rotation des gouverneurs.
Source: Construction des auteurs.

II. Autonomie des Banques Centrales en Afrique Subsaharienne : Une Analyse des Statuts

Le caractère qualitatif de la notion d'autonomie fait qu'il n'existe pas une référence unique par rapport à laquelle on pourrait apprécier le degré de liberté d'une Banque Centrale.

a) Appréciation de l'autonomie des Banques Centrales dans la littérature

Grilli et al. (1991) vont proposer une méthode d'appréciation de l'autonomie des Banques Centrales

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qui repose sur la construction de trois (03) indices: l'indice d'autonomie politique, l'indice d'autonomie économique et l'indice global obtenu par l'addition des (02) deux indices précédent. A l'inverse, la méthode proposée par Cukierman et al. (1992) considère pour leur part, deux (02) principaux indicateurs: l'indice d'autonomie légale et l'indice d'autonomie réelle (le taux de renouvellement des gouverneurs). Le premier indice vise à mesurer l'autonomie de droit (autonomie légale), qui est le degré d'autonomie que le législateur a voulu conférer à la Banque Centrale. Il est basé sur 16 caractéristiques d'autonomie, construit à partir des chartes des Banques Centrales des pays considérés, chacune établie sur une échelle de *0 point* (niveau le plus faible d'autonomie légale) et *1 point* (niveau le plus élevé d'autonomie légale), qu'ils ont ensuite regroupés dans 4 catégories (voir Cukierman et al. 1992). Quant à l'indice d'autonomie réelle, il désigne est le taux de renouvellement des gouverneurs. Selon Cukierman et al. (1992), au-dessus d'un certain seuil *(0.2 à 0.25 point)* un taux de renouvellement élevé des gouverneurs de Banques Centrales tendrait à indiquer un niveau faible d'autonomie réelle de la Banque Centrale. (voir Cukierman et al. 1992).

b) Cas Particulier de la BEAC

En Afrique Centrale dans le cadre de la réforme, une nouvelle organisation de la BEAC et une révision de ses statuts ont été adoptées en Septembre 2007, Octobre 2010 et Juin 2017. L'objectif et les missions de la BEAC sont clairement définis dans *l'article 1* de ses statuts. La poursuite d'un objectif quantifié de stabilité des prix à *3%* a été décidée par la Communauté Economique et Monétaire d'Afrique Centrale (CEMAC) dans le cadre du pacte de convergence régional par les autorités monétaires et politiques, ainsi que par les bailleurs de fonds et d'autres organismes internationaux. Les *articles 2* à *7* présentent avec clarté la personnalité juridique de la BEAC ainsi que ses privilèges et immunités. La formulation des *articles 8* à *26,* relatif à l'activité de la Banque Centrale doit être précisée, notamment en ce qui concerne les obligations de la BEAC. Le rôle de la Banque Centrale agissant en qualité d'agent pour le compte des Etats est abordé aux *articles 9, 10, 12, 19* et *21*. Massoud (2013) considère que les conditions relatives aux objectifs, aux limites de financement de l'Etat ainsi que le rôle de la BEAC, agissant en tant qu'intermédiaire pour le compte de l'Etat sont compatibles avec les spécifications du code de bonnes pratiques. La composition, les responsabilités et les modalités de fonctionnement des organes de décision de la Banque Centrale (*articles 28* à *37*) sont clairement formulées, sauf en ce qui concerne l'intervention du comité ministériel. La composition, les responsabilités et les modalités de fonctionnement du Comité de Politique Monétaire (CPM) sont définies et précisées aux *articles 38* à *45*. A ce sujet, la littérature relative à l'autonomie des Banques Centrales préconise de confier la responsabilité de l'élaboration et de la mise en œuvre de la politique monétaire à un Comité de Politique Monétaire. Cette évolution se justifie par le fait que compte tenu du nombre et de la diversité des membres qui composent un Comité, il y a mise en commun d'informations, ainsi qu'une variabilité moindre dans les décisions adoptées (Blinder et Morgan, 2005). Il serait donc préférable de confier la décision de politique monétaire à un groupe plutôt qu'à un individu (Bobbo, 2018). Dans la pratique, pour 79 Banques Centrales sur un total de 88 étudiées par Fry et al. (2000), la prise de décision relève d'un comité.

En effet, les *articles 38.1* et *38.2* des statuts de la BEAC disent que c'est au CPM, qui est l'organe de décision de la BEAC en matière de politique monétaire et de réserves de change, que revient de définir la stratégie et les objectifs de la politique monétaire et de la politique de gestion des réserves de change, ainsi que les modalités de leur mise en œuvre. De par sa composition, le CPM de la BEAC apparaît comme un organe technique susceptible de faire diluer les préférences nationales. Dans le processus de nomination de ses membres, le gouverneur qui préside le CPM (*articles 39* et *49*) est nommé par la Conférence des Chefs d'Etat de la CEMAC pour une durée de sept (07) ans non renouvelable *(article 50).* Il ne peut être révoqué de ses fonctions par la Conférence des Chefs d'Etat que s'il ne remplit plus les conditions nécessaires à l'exercice de ses fonctions ou s'il a commis une faute grave *(article 53).* En effet, le CPM est composé de *15 membres* délibérants, dont le gouverneur qui assure la présidence, deux représentants de chaque Etat membre (dont le directeur national de la BEAC), et deux représentants de la France *(article 39).* En outre, dans la mesure où les statuts ne prévoient aucune responsabilité individuelle des membres qui la composent par défaut, le caractère supranational de la BEAC est de nature à garantir la collégialité au sein du CPM (Avom et Bobbo, 2013). Cependant, en conférant un pouvoir assez étendu à son gouverneur, les dispositions des statuts de la BEAC fragilisent la collégialité des décisions du CPM, pourtant indispensable pour conférer une grande autonomie à cet organe. En ce qui concerne le pouvoir de gestion monétaire, les statuts de 2010 et 2017 accordent au gouverneur le privilège et la primauté de la définition des taux d'intérêt applicables sur les avances de la BEAC aux établissements de crédit et aux Trésors nationaux (depuis le 18 Novembre 1998 avec l'uniformisation de tous les taux d'avances). Par ailleurs, *l'article 43* indique que dans le processus de prise de décisions, « en cas de partage des voix, celle du Président est prépondérante ». Selon la classification de Blinder et al. (2001), ces éléments montrent que dans le cadre de la

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BEAC, prévaut plutôt un CPM dont la décision finale appartiendrait officiellement au seul gouverneur. Dans de telles circonstances, les dispositions des statuts de la BEAC vont à l'encontre des résultats de Blinder et Morgan (2005) pour qui, un groupe prend en moyenne de meilleures décisions qu'un individu. Il serait donc souhaitable d'instaurer une véritable collégialité au sein du CPM afin d'accroître l'autonomie de la BEAC (Bobbo, 2018). Guillaumont (2006) fait observer que : *«Le pouvoir monétaire ne peut être légitimement indépendant que s'il est exercé collégialement par des personnes qui ont été choisies en fonction de leur compétence »*.

Les limites du financement budgétaire des Etats par la Banque Centrale sont prévues à *l'article 18.* D'après *l'article 17* des statuts de la BEAC, le CPM peut accorder aux Trésors des Etats membres, pour une année budgétaire donnée et à son principal taux de refinancement des établissements de crédit, des découverts en compte courant pour une période ne pouvant pas dépasser une année. Par ailleurs, *l'article 18* stipule que le montant total des concours accordés à un Etat membre de la CEMAC ne peut excéder un montant égal à *20%* des recettes budgétaires ordinaires fongibles d'origine nationale constatées au cours de l'année écoulée[1].

Concernant le degré d'autonomie de la BEAC, *l'article 5.2* des nouveaux statuts de 2017 précise que : « *la BEAC dans la poursuite de ses objectifs, de ses missions et de sa fonction est indépendante. Les Etats et organes de la CEMAC s'engagent à respecter cela* ». Or, comme l'ont fait remarquer Cukierman et al. (1992): *« Même lorsque la loi est explicite, la pratique réelle peut s'en écarter »*. Ces auteurs soulignent également que les divergences entre la pratique et la loi sont plus nombreuses dans les pays en développement que dans les pays industrialisés. En outre, le fait que la durée de la fonction des directeurs nationaux soit à la discrétion du gouverneur et de l'autorité monétaire du pays signifie que *le taux de rotation* des directeurs pourrait être faible. Or cela n'est nullement une garantie de l'autonomie réelle des *directeurs* puisque si ceux-ci sont soumis, ils auront tendance à rester en fonction plus longtemps (Bokino, 2014).

Malgré les remarques faites précédemment, force est de constater que les réformes institutionnelles entreprises au sein de la BEAC montrent clairement l'évolution générale vers le renforcement d'une plus grande autonomie de cette Institution, ainsi que de ses organes de décisions. De plus, bien que cette Banque soit une multinationale, ce qui la met de *facto* à l'abri de décisions unilatérales des gouvernements, elle avait été conçue comme demeurant d'une certaine façon *« dans la main des gouvernements »* puisque les membres du Conseil d'Administration de la BEAC chargés de mettre en œuvre la politique monétaire, en fonction des directives du Conseil des Ministres de chaque Union, étaient nommés par les gouvernements. Par ailleurs, la position extrêmement minoritaire des représentants de la France dans les Comités de Politique Monétaire leur confère un rôle d'observateurs et de conseillers. Même s'ils reçoivent des instructions de leur gouvernement, leur présence n'est pas incompatible avec le statut d'autonomie des Banques Centrales comme le serait à l'inverse une position dominante (en aucun cas la France possèderait un pouvoir de *véto* et il est arrivé que certaines décisions soient prises contrairement aux avis des représentants français (Guillaumont, 2017)). Les *tableaux 2* et *3* ci-dessous présentent l'évolution des indices d'autonomie de la BEAC et de quelques des Banques Centrales en Afrique Subsaharienne entre 1980 et 2017.

[1] Récemment, le Gouvernement de la BEAC à conclure un accord avec chaque pays membre sur un calendrier de réduction progressive des plafonds d'avances statutaires et de remboursement correspondant des montants avancés, à partir de 2018 ou plus tard, jusqu'à l'élimination complète des avances de la BEAC d'ici 2027. Les avances exceptionnelles, qui ont été consolidées en crédits à long terme, seront remboursées puis éliminées durant la même période.

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Tableau 2: Indice d'autonomie Légale (*de jure*) Calculé Selon la Méthodologie de Cukierman et al. (1992) entre 1980 et 2017 pour Notre Echantillon.

Pays/Zone	Cukierman (1980 – 1989)	Crowe et Meade – (1990 -2008)	Garriga (2009-2017) et Auteurs (2009–2017)	Années de réformes et amendements statutaires affectants le degré d'autonomie de la Banque Centrale (Garriga (2016) et Auteurs (2017))
1. CEMAC (BEAC)	0.34	0.6	0.5657	2007, 2010, 2017.
2. UEMOA (BCEAO)	0.34	0.49	0.8015	2003, 2010.
3. Nigeria	0.37	0.53	0.6262	1991, 1999, 2007, 2008, 2011, 2012,2014.
4. Afrique du SUD	0.25	0.48	0.3651	1989, 1991, 1993,1997, 2000, 2002, 2003, 2007, 2010, 2012 ,2014.
5. Ghana	0.31	0.56	0.5606	1993,2002, 2004, 2007, 2008,2011, 2012.
6. Angola	0.47	0.47	0.47	1991, 1992, 1997, 2004, 2010, 2011, 2012.
7. Tanzanie	0.44	0.53	0.5872	1995, 2006, 2012, 2014.
8. Ethiopie	0.40	0.43	0.4287	1994, 2011.
9. Kenya	0.44	0.48	0.5096	1985, 2002, 2008, 2011, 2012, 2015.
10. RDC	0.43	0.59	0.5608	2002, 2013.

Source: Base de données de Cukierman et al. (1992), de Crowe et Meade (2008), de Garriga (2016) et calculs des auteurs.

Tableau 3: Indice d'autonomie Réelle (*de facto*) Calculé Selon la Méthodologie de Cukierman et al. (1992) entre 1980 et 2017 pour Notre Echantillon.

Pays /Zone	Cukierman (1980 – 1989)	Crowe et Meade (1990 -2008)	Auteurs (2009 – 2017)
1. CEMAC (BEAC)	0.07	0.10	0.33
2. UEMOA (BCEAO)	0.14	0.10	0.33
3. Nigeria	0.10	0.20	0.44
4. Afrique du SUD	0.20	0.20	0.33
5. Ghana	0.20	0.25	0.66
6. Angola	0.40	0.40	0.11
7. Tanzanie	0.10	0.10	0.22
8. Ethiopie	0.10	0.20	0.11
9. Kenya	0.20	0.25	0.22
10. RDC	0.20	0.20	0.22

Source: Base de données de Cukierman et al. (1992), de Crowe et Meade (2008) et calculs des auteurs à partir des sites internet des Banques Centrales.

III. Cadre Méthodologique

a) Modèle de base

Le modèle économétrique de base utilisé pour l'analyse de la relation entre l'autonomie de la Banque Centrale et l'inflation prend sa source dans les travaux de Cukierman et al. (1992), dont le modèle de régression simple est formulé de la manière suivante: $D = P/(P+1)$ (1); avec : P : taux d'inflation mesuré par l'indice de prix à la consommation ; D : taux d'inflation mesuré par l'indice de prix de consommation transformée. Nous utilisons le taux d'inflation transformé dans le but de réduire l'hétéroscédasticité du terme de l'erreur, éliminer le poids des points aberrants sans engendrer de perte des observations et surtout, augmenter l'efficacité des estimations dans notre régression (Cukierman et al. (1992), Sturm et De Haan (2001), Aguir (2013)).

b) Modèle empirique et variables

L'équation de l'inflation transformé retenue dans la présente étude qui s'inspire du modèle de base de Cukierman et al. (1992), fut récemment utilisé dans les démarches empiriques d'Umoru et Tizhe (2014) et

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de Romelli (2015) afin de déterminer l'impact de l'autonomie de la Banque Centrale sur l'inflation au Nigéria et dans 10 pays industrialisés de l'OCDE respectivement. Comme Campillo et Miron (1997), Cottarelli et al. (1998), nous allons introduire d'autres variables à l'équation initiale de l'inflation transformée, afin d'obtenir notre modèle spécifique de régression. Notre modèle qui correspond à une équation de l'inflation en relation avec l'autonomie légale et réelle de la Banque Centrale se présente comme suit:

$$TRANSINFL_{i,t} = \alpha_0 + \alpha_1 LIBC_{i,t} + \alpha_2 TOR_{i,t} + \alpha_3 OUV_{i,t} + \alpha_4 MAMO_{i,t} + \alpha_5 PIB_{i,t} + \alpha_6 DEBU_{i,t} + \alpha_7 TCHA_{i,t} + \alpha_8 DEVFI_{i,t} + \alpha_9 QIPR_{i,t} + U_i + V_t + W_{it} \quad (2)$$

Avec: $TRANSINFL_{i,t}$: le taux d'inflation (indice de prix à la consommation) transformé dans le pays i au cours de l'année t; $LIBC_{i,t}$: l'indice d'autonomie légale de la Banque Centrale selon Cukierman et al. (1992) (dont la valeurs est comprise entre 0 et 1) dans le pays i au cours de l'année t; $TOR_{i,t}$: l'indice d'autonomie réelle de la Banque Centrale (taux de rotation des gouverneurs de la Banque Centrale) selon Cukierman et al. (1992) (dont la valeur est comprise entre 0 et 1) dans le pays i au cours de l'année t; $OUV_{i,t}$: l'ouverture commerciale (somme des exportations et des importations rapporté au PIB) dans le pays i au cours de l'année t; $MAMO_{i,t}$: la monnaie et quasi monnaie (M2) en pourcentage de PIB dans le pays i au cours de l'année t; $PIB_{i,t}$: le taux de croissance réelle du Produit Intérieur Brut par habitant dans le pays i au cours de l'année t; $DEBU_{i,t}$: le solde budgétaire rapporté au PIB dans le pays i au cours de l'année t; $TCHA_{i,t}$: le taux de change réel dans le pays i au cours de l'année t; $DEVFI_{i,t}$: le développement financier dans le pays i au cours de l'année t; $QIPR_{i,}$: la qualité des institutions (démocratie) dans le pays i au cours de l'année t; U_i : l'effet individu; V_t: l'effet temps; W_{it} : l'effet croisé; i : nombre de pays allant de 1 à 10; t: la période allant de 1980 à 2017; α_0: la constante ; α_1 à α_9: les coefficients de régression relatifs aux niveaux d'inflation. Notre équation comporte des variables explicatives numérotées de 1 à 9[2].

Tableau 4: Récapitulatif des Signes Attendus des Coefficients des Différentes Variables.

Variables Explicatives et Abréviations	Variable Expliquée
	$TRANSINFL_{i,t}$ (Romelli, 2015)
	Signes attendus et justifications
$LIBC_{i,t}$	– Négatif (Garriga et Rodriguez, 2017)
$TOR_{i,t}$	– Négatif (Aguir, 2013)
$OUV_{i,t}$	– Négatif (Romer, 1993)
$MAMO_{i,t}$	+/- incertain (Mba et al., 2014)
$PIB_{i,t}$	+/- incertain (Combey et Nubukpo , 2010)
$DEBU_{i,t}$	+ positif (Mishkin et Schmidt-Hebbel, 2001)
$TCHA_{i,t}$	+/- incertain (Chhibber et Shafik, 1990)
$DEVFI_{i,t}$	– Négatif (Krause et Roija, 2006)
$QIPR_{i,t}$	+/- incertain (Campillo et Miron, 1997)

Source: Construction des auteurs à partir d'une revue exhaustive de la littérature.

c) *Nature et Sources des Données*

Les données recueillies pour cette étude sont de sources secondaires. Les variables macro-économiques proviennent de diverses sources telles que: les bases statistiques de la Banque Mondiale dans le « *World Development Indicators* (*WDI*, 2018) », du Fonds Monétaire International dans « *l'International Financial Statistics* (*IFS*, 2018) », de *Freedom House Database* (2018) et de la Conférence des Nations Unies sur le Commerce et le Développement (CNUCED, 2018). Les données institutionnelles telles que le degré d'autonomie légale et réelle ont été extraites des bases de données de Cukierman et al. (1992), de Crowe et Meade (2008), du FMI-*Central Bank Laws Database* et *Morgan Stanley's Central Bank Directory* (1994-2008) et de Garriga (2016) issues du *Centro de Investigación y Docencia Económicas* (CIDE). Certaines données récentes de l'autonomie des Banques Centrales ont été calculées par nos propres soins le tout suivant la méthodologie de Cukierman et al. (1992). Nos données sont de nature quantitative et qualitative, et portent sur dix (10) Banques Centrales des pays d'Afrique Subsaharienne à savoir : la BEAC, la BCEAO, la Banque

[2] Pour savoir si l'autonomie de la Banque Centrale a un impact sur l'inflation, on étudie les coefficients suivants pour notre équation : Si $\alpha_1 > 0$ et $\alpha_2 > 0$, alors l'autonomie légale de la Banque Centrale (LIBC) *encourage* l'inflation, et l'autonomie réelle (TOR) *aggrave* cet impact. Si $\alpha_1 > 0$ et $\alpha_2 < 0$, alors l'autonomie légale de la Banque Centrale (LIBC) *encourage* l'inflation, mais l'autonomie réelle (TOR) *atténue* cet effet. Si $\alpha_1 < 0$ et $\alpha_2 < 0$, alors l'autonomie légale de la Banque Centrale (LIBC) *décourage* l'inflation, et l'autonomie réelle (TOR) *accentue* cet impact. Enfin, si $\alpha_1 < 0$ et $\alpha_2 > 0$, alors l'autonomie légale de la Banque Centrale (LIBC) *décourage* l'inflation, mais l'autonomie réelle (TOR) *réduit* cet effet.

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Centrale du Nigéria, de l'Afrique du Sud, du Ghana, de l'Angola, de la Tanzanie, de l'Ethiopie, du Kenya et de la République Démocratique du Congo (RDC) dont les spécificités peuvent être communes ou différentes. La périodicité est annuelle et part de 1980 à 2017.

d) Procédure D'estimation

La méthodologie utilisée est celle *des données de panel statique,* connu aussi sous le nom de données longitudinales. Elle a été récemment utilisée par Ltaief (2016). Ce type de données se caractérise par leur double dimension : une dimension individuelle i et une dimension temporelle t. Les données sur panel représentent un mélange de données en coupe instantanée et les séries chronologiques. Elles permettent ainsi d'observer plusieurs entités sur une période de temps (Gujarati, 2003).

IV. Présentation des Résultats Empiriques et Implications de Politique Monétaire

a) Résultats des Estimations

La synthèse des tests économétriques préliminaires apparait dans le *tableau 5* ci-dessous.

Tableau 5: Présentation de la Synthèse des Tests Econométriques Préliminaires.

Types de Test /D'estimation	Hypothèse Nulle	P-Value	Décision Sur Hypothèse Nulle	Conséquence
1- Test d'hétéroscédasticité de Breusch-pagan/Cook-Weisberg et correction de White.	Homocédasticicité (absence d'hétéroscédasticité).	0.0000	Rejeter	Présence d'hétérsocédasticité.
2- Test d'omission de Ramsey-Reset.	Le modèle n'a pas omis des variables explicatives pertinentes.	0.0088	Rejeter	Le modèle n'est pas bien spécifié par les MCO.
3- Test *Variance Inflation Factor* (VIF).	1 / VIF doit être supérieur à 0.1.	2.11	Ne pas rejeter	Absence des problèmes de multi-colinéarité.
4- Modèle à effets fixes (test l'existence d'effets individuels).	Pas d'effets spécifiques.	0.0250	Rejeter	Présence des effets individuels.
5- Modèle à effets aléatoires.	Spécificités individuelles du modèle sous forme aléatoire.	0.0109	Ne pas rejeter	Présence de spécificités individuelles.
6- Test de Breusch-Pagan Lagrangian multiplier test for random effects.	Rejet le choix d'une structure à erreurs composées aléatoires.	1.0000	Ne pas rejeter	Le test rejet les effets individuels aléatoires.
7- Test de Hausman (choix entre fixe et aléatoire).	Absence de corrélation entre les erreurs et les variables explicatives (erreurs composées efficaces).	0.3313	Ne pas rejeter	Le modèle est à effet aléatoires (modèle à erreurs composées efficace)
8- Test d'auto-corrélation intra-individus de Wooldridge.	Absence d'auto-corrélation des erreurs.	0.0032	Rejeter	La structure d'auto-corrélation est un AR1. Utilisation des MCG avec correction des erreurs.
9- Test de normalité de résidus Skewness/Kurtosis.	Les résidus sont normalement distribués	0.0000	Rejeter	Les résidus ne sont pas normalement distribués
10- Test d'endogénéité Durbin-Wu-Hausman.	Exogénéité de la variable LIBC et TOR	LIBC= 0.6642 TOR= 0.2767	/	- Exogénéité de la variables LIBC. - Exogénéité de la variable TOR.

Source: Construction et calculs de l'auteur.

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Les résultats de nos tests économétriques préliminaires nous montrent que le modèle est hétéroscédastique et autocorrélé AR1. Il est donc nécessaire d'appliquer les Moindres Carrés Généralisés (MCG) sur effets aléatoires comme Lucotte (2009), Kasseeah et al. (2011) et Ltaief (2016) pour corriger ce modèle de l'hétéroscédasticité et de l'autocorrélation AR1. Nous employons particulièrement la transformation de *Prais* et *Winsten*[3] (Chiappini, 2010) (voir *tableau 6*).

Tableau 6: Résultat de l'effet de l'autonomie des Banques Centrales sur l'inflation en ASS.

Variables	Coefficients	P-values
$LIBC_{i,t}$	-1.509888	0.000***
$TOR_{i,t}$	+0.7121376	0.020**
$OUV_{i,t}$	-0.0037673	0.000***
$MAMO_{i,t}$	-0.0023733	0.212
$PIB_{i,t}$	+0.002135	0.377
$DEBU_{i,}$	-0.0004052	0.618
$TCHA_{i,t}$	+0.0000354	0.237
$DEVFI_{i,t}$	+0.0020674	0.025**
$QIPR_{i,t}$	+0.0609854	0.000***
Constante	+1.350892	0.000***
Wald chi2 (9) = 137.64 / Prob > chi2 = 0.0000		

*Notes: *** significativité à 1% ; ** significativité à 5% ; * significativité à 10%.*
Source: Calculs des auteurs à partir de Stata 15.

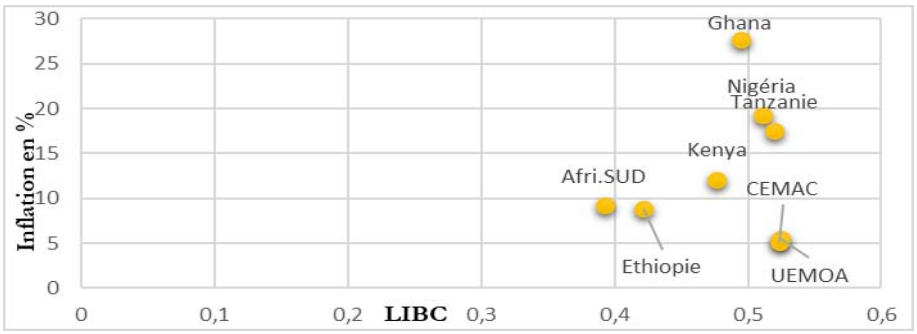
b) Implications Pour la Politique Monétaire

Globalement, les résultats obtenus sont intéressants. Notre modèle est de bonne qualité. D'après le *tableau 6,* nous remarquons qu'il est globalement significatif au seuil de 1% car (Prob > Chi2 = 0.0000) est inférieur à **5%**. Partant de là, plusieurs commentaires sont faits.

- Les résultats des estimations indiquent que le degré d'autonomie légale ($LIBC_{i,t}$) des Banques Centrales d'Afrique Subsaharienne décourage le niveau d'inflation. Il est statistiquement significatif à 1% et le signe négatif de son coefficient (-1.509888) est conforme à nos attentes. L'augmentation d'une unité supplémentaire du degré d'autonomie légale des Banques Centrales d'ASS entraine une diminution du niveau général des prix de 1.509888 fois cette unité. Ce résultat montre bien l'évidence d'un lien négatif entre l'autonomie légale et l'inflation en ASS, ce qui rejoint la théorie. Il s'inscrit également dans la même lancée des résultats obtenus par Jacome et Vasquez (2008), Klomp et De Haan (2010), Romelli (2015) et Garriga et Rodriguez (2017). En effet, cet aboutissement empirique peut se justifier par des efforts fournis au sein de la classe dirigeante des Banques Centrales de notre échantillon, notamment sur *l'aspect de la culture du droit et la rigueur dans le respect de la loi* (dispositions statutaires). Le caractère institutionnel de la Banque Centrale permettra ainsi de mettre cette dernière l'abri de toute influence des gouvernements, lui garantissant une grande autonomie dans la détermination de la politique monétaire. Pour illustrer cela, les *graphiques 1* et *2* ci-dessous nous font savoir que les Banques Centrales les plus autonomes de notre échantillon sur le plan légal sont respectivement celles de la RDC *(0.54 point)*, de l'UEMOA *(0.52 point)*, de la CEMAC *(0.52 point),* de la Tanzanie *(0.51 point)* et du Nigéria *(0.51 point)*. L'Afrique du Sud *(0.39 point)* et l'Ethiopie *(0.42 point)* sont les pays qui détiennent les Banques Centrales les moins autonomes. De même, la RDC et le Ghana détiennent la plus grande volatilité de l'inflation dans notre échantillon (voir *graphique 3)*.

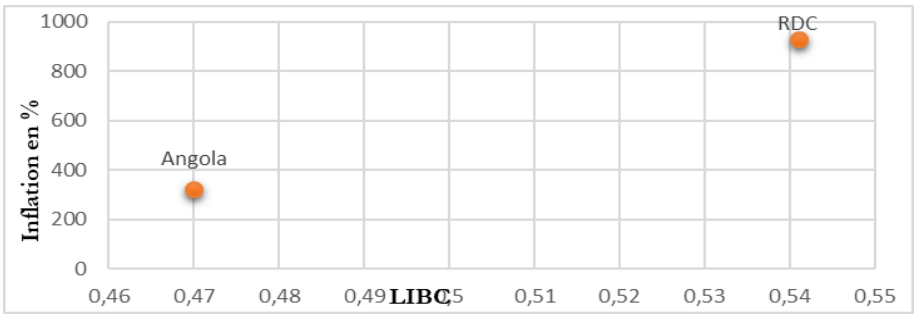
[3] Beck et Katz (2001) ont montré que sur un échantillon restreint, les MCG pouvaient produire des erreurs standards incorrectes. Ce biais provient du fait que la méthode des MCG estime un nombre excessif de paramètres dans la matrice de variance-covariance (Beck et Katz, 2001). Sur un petit échantillon comme le nôtre, on préfèrera appliquer la transformation proposée par Prais et Winsten afin d'éliminer l'autocorrélation des perturbations. De plus, la transformation de Prais-Winsten est plus pertinente pour l'estimation de panels non-cylindrés (tel le nôtre), où il existe des données manquantes à certaines dates. Sous Stata 15, l'estimation d'un panel non-cylindré n'est pas possible avec la méthode des MCG. Nous choisirons donc sous Stata 15, la structure PSAR1 pour corriger l'autocorrélation des erreurs. Le choix de PSAR1 permet aux individus d'avoir des coefficients différents.

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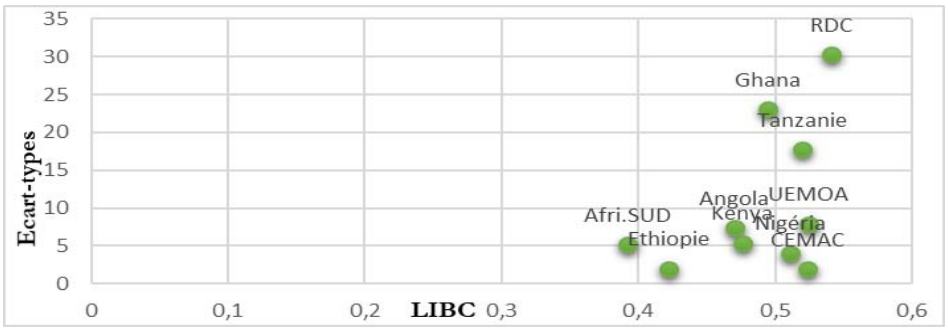
Source: Construction des auteurs à partir d'Excel 2016.

Graphique 1: Relation indice d'autonomie légale (LIBC) et inflation moyenne pour 08 pays de notre échantillon (1980-2017).



Source : Construction des auteurs à partir d'Excel 2016.

Graphique 2: Relation indice d'autonomie légale (LIBC) et inflation moyenne pour l'Angola et la RDC (1980-2017).



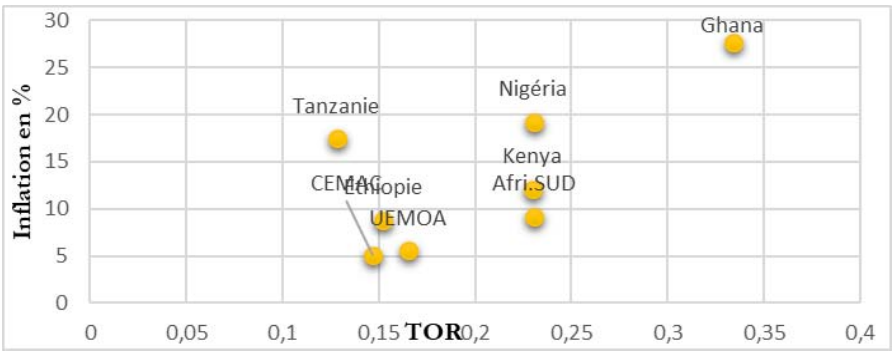
Source: Construction des auteurs à partir d'Excel 2016.

Graphique 3: Relation autonomie légale (LIBC) et volatilité moyenne de l'inflation dans notre échantillon total (1980-2017).

- Le coefficient du taux de rotation des gouverneurs ($TOR_{i,t}$) des Banques Centrales d'ASS est de signe positif *(+0.7121376)* contrairement à ce qui était prévu mais, il reste significatif à **5%**. Le rythme de rotation des gouverneurs conduit à une accélération du taux d'inflation. L'augmentation d'une unité supplémentaire du degré d'autonomie réelle des Banques Centrales d'ASS va entrainer une hausse du niveau général des prix de *0.7121376* fois cette unité. Ce résultat s'inscrit dans la logique de ceux de Strum et De Haan (2001), Dreher et al. (2008) et Kasseeah et al. (2011). En effet, comme ces derniers le précisent: « l'indice TOR est un *proxy* fiable pour la mesure de l'autonomie dans le cas des pays à revenu bas » car en ASS, l'autonomie réelle de la Banque Centrale est souvent différente des dispositions statutaires en la matière. Ainsi, le taux de rotation moyen des gouverneurs de notre échantillon sur la période d'étude semble être élevé (*0.21 point* en moyenne) d'où; le renouvellement élevé des gouverneurs pourrait décourager ceux-ci à mettre sur pied une politique anti-inflationniste à long terme, ce qui supposerait un faible niveau d'autonomie. Bien plus, l'absence de « *gouverneur conservateur* » à la Rogoff (1985) dont la fonction objective est la lutte contre l'inflation et le respect de la règle monétaire pourrait justifier ce résultat. Ces gouverneurs auraient donc tendance à ne pas respecter les dispositions statutaires, à financer les déficits budgétaires des gouvernements et en

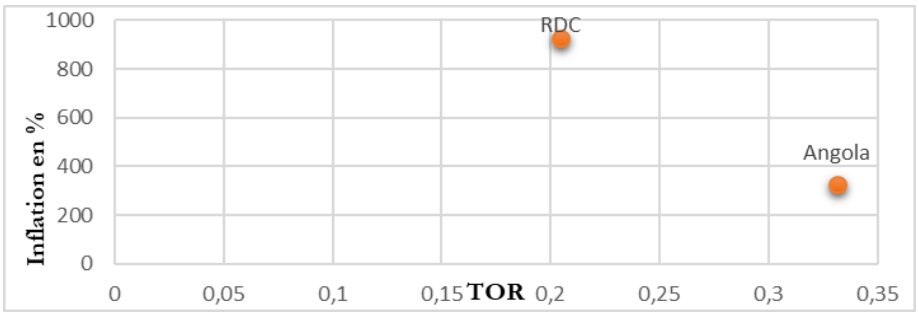
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conséquence créer l'inflation. Ce résultat rejoint également l'analyse de Fry (1998) qui montre que la taille du déficit public et ses modes de financement prévalent sur l'autonomie légale de la Banque Centrale. Bien plus, certains aspects informels et comportementaux de la relation entre les Banques Centrales et les gouvernements de notre échantillon peuvent justifier ce résultat (les conventions entre les Banques Centrales et les Etats, les influences politiques, la qualité du Conseil d'administration des Banques Centrales, la personnalité des individus à la tête de la Banque Centrale et la soumission ou non des Autorités Monétaires aux gouvernements). Enfin, l'application des politiques monétaires non conventionnelles et accommodantes pratiquées par les Banques Centrales en temps de récession en guise de soutien à l'économie peut aussi justifier le résultat obtenu pour cette variable. D'après les *graphiques 4 et 5,* le Ghana *(0.33 point)* et l'Angola *(0.33 point)* sont les pays qui détiennent les Banques Centrales les moins autonomes sur le plan réel. Les Banques Centrales les plus autonomes sur ce plan sont celles de la Tanzanie *(0.12 point)*, de la CEMAC *(0.14 point)*, de l'Ethiopie *(0.15 point)* et de l'UEMOA *(0.16 point)*. Les volatilités de l'inflation les plus basses sont observées dans la *CEMAC* et en *Ethiopie* (voir *graphique 6*).



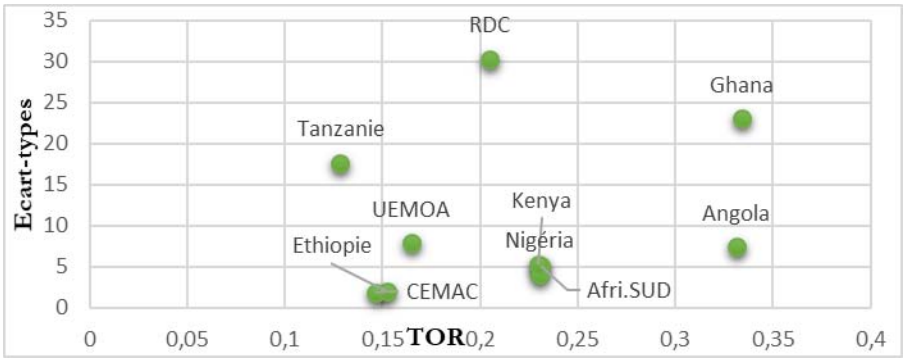
Source: Construction des auteurs à partir d'Excel 2016.

Graphique 4: Relation indice d'autonomie réelle (TOR) et inflation moyenne pour 08 pays de notre échantillon (1980-2017).



Source: Construction des auteurs à partir d'Excel 2016.

Graphique 5: Relation indice d'autonomie réelle (TOR) et inflation moyenne pour l'Angola et la RDC (1980-2017).



Source: Construction des auteurs à partir d'Excel 2016.

Graphique 6: Relation autonomie réelle (TOR) et volatilité moyenne de l'inflation dans notre échantillon total (1980-2017).

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- Le coefficient de la variable ouverture commerciale ($OUV_{i,t}$) est statistiquement significatif à 1%, et son signe négatif (-0.0037673) correspond à nos prévisions. Le niveau d'ouverture commerciale dans en ASS a tendance à baisser le niveau de l'inflation. Le coefficient du développement financier ($DEVFI_{i,t}$) est positif (+0.0020674) et statistiquement significatif à 5%. La variable qualité des institutions ($QIPR_{i,t}$) a également un coefficient positif (+0.0609854) qui est statistiquement significatif à 1%.
- Les variables masse monétaire ($MAMO_{i,t}$), Produit Intérieur Brut ($PIB_{i,t}$), solde budgétaire ($DEBU_{i,t}$) et taux de change réel ($TCHA_{i,t}$) sont non significatives.

Le *tableau 7* ci-dessous fait un récapitulatif entre les signes attendus et les résultats obtenus dans notre analyse.

Tableau 7: Tableau de comparaison entre les signes attendus et les signes obtenus.

Variables	Signes attendus	Signes obtenus
$LIBC_{i,t}$***	- (négatif)	- (négatif)
$TOR_{i,t}$**	- (négatif)	+ (positif)
$OUV_{i,t}$***	- (négatif)	- (négatif)
$MAMO_{i,t}$	+/- (incertain)	- (négatif)
$PIB_{i,t}$	+/- (incertain)	+ (positif)
$DEBU_{i,t}$	+ (positif)	- (négatif)
$TCHA_{i,t}$	+/- (incertain)	+ (positif)
$DEVFI_{i,t}$**	- (négatif)	+ (positif)
$QIPR_{i,t}$***	+/- (incertain)	+ (positif)
Rapport de validation	55,55%	
Décision	Significativité moyenne	

Source: Construction des auteurs.

*Avec : *, **, *** significativité respectivement à 10%, 5% et 1%. NB: Le rapport de validation se calcule en prenant l'ensemble des signes significatifs obtenus divisé par l'ensemble des signes attendus pour les variables d'interaction.*

c) Vérification de la robustesse des résultats

L'objet de ce paragraphe est de tester la robustesse des résultats pour nos variables d'intérêts. Dans un premier temps nous évaluons la solidité de nos résultats à l'aide d'un modèle dynamique. En fait, il s'agit de la méthode *Generalized Moments Method* (GMM) de Blundell et Bond (1998) sur panel dynamique, qui présente l'avantage de générer les instruments à partir des variables explicatives. Les résultats après estimations nous renseignent que seul l'indice d'autonomie légale ($LIBC_{i,t}$) est significatif à 1% et parvient à réduit le niveau d'inflation en ASS car, son coefficient est négatif(-1.360425). Le lien de l'autonomie légale est confirmé et rejoint les résultats de Romelli (2015). La variable autonomie réelle ($TOR_{i,t}$) quant à elle est positive et non significative(+0.4383794).

Toujours dans la même lancée de la robustesse de nos résultats, nous vérifions si nous obtenons les mêmes effets en faisant une opposition d'une part entre les pays pratiquant une stratégie de ciblage de l'inflation (Dummy1_cibleurs – à partir de l'année d'adoption de la stratégie de ciblage) et ceux qui ne la pratique pas (Dummy2_non-cibleurs) ; et d'autre part entre ceux évoluant en régime de change fixe et Union Monétaire (Dummy1_Fixe-Union) et ceux qui évoluent en régime de change flexible et hors Union Monétaire (Dummy2_Flexible-Non Union). Pour finir, nous évaluons explicitement l'impact des réformes des Banques Centrales sur le taux d'inflation pour l'ensemble de notre échantillon, en créant une variable binaire Dummy1_Refromes prenant la valeur 1 pour les années de réformes des statuts de la Banque Centrale visant à renforcer son autonomie, et Dummy0_Non-Refromes prenant la valeur 0 pour les années où il y'a pas eu de réformes. Signalons que nous testons uniquement les années de réformes dans notre estimation. Ces simulations se font en données de panel statique par la méthode des Moindres Carrés Généralisés Faisables appliqués sur les modèles à effets aléatoires avec transformation de Prais et Winsten, et corrigé de l'hétéroscédasticité et d'autocorrélation AR1.

D'après nos résultats, que nous soyons dans les pays cibleurs d'inflation (Ghana et Afrique du Sud) ou dans les pays non-cibleurs (08 autres pays), le degré d'autonomie légale ($LIBC_{i,t}$) des Banques Centrales permet de réduire le niveau d'inflation, car leurs coefficients sont négatifs (-1.515189) et significatifs à 1%. Par contre, l'autonomie réelle ($TOR_{i,t}$) de ces Banques Centrales va atténuer cet impact par leurs coefficients positifs (+0.7159008) et significatifs à 5%. La stratégie de ciblage de l'inflation adoptée par l'Afrique du Sud en 2002 et le Ghana en 2007 va permettre de réduire l'inflation dans ces pays car, nous obtenons un coefficient négatif (-0.0041325). Mais, cette variable Dummy1_cibleurs reste non significative. Ce résultat qui rejoint les travaux de Truman (2003) peut s'interpréter par l'argument développé par Gerlach (1999) qui soutient que: « Le ciblage d'inflation, en

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dotant l'autorité monétaire d'un mandat clair de maintien de la stabilité des prix, serait un substitut à l'autonomie légale de la Banque Centrale ». Par ailleurs, dans les huit (08) autres pays ne pratiquant pas de stratégie de ciblage (Dummy2_non-cibleurs), l'inflation semble progresser (+0.0041325) mais, de manière non significative.

Dans les pays formant une Union Monétaire et évoluant en régime de change fixe (CEMAC et UEMOA) Dummy1_Fixe-Union, et dans les huit (08) autres pays évoluent en régime de change flexible et hors Union Monétaire (Dummy2_Flexible-Non Union), le degré d'autonomie légale ($LIBC_{i,t}$) des Banques Centrales parvient à réduire le niveau d'inflation, car leurs coefficients sont de signe négatifs (-1.471146) et significatifs à 1%. Par contre, l'autonomie réelle ($TOR_{i,t}$) de ces Banques Centrales va décourager cet effet par leurs coefficients positifs (+0.7342985) et significatif à 5%. Que nous formons une Union Monétaire et évoluons en régime de change fixe (Dummy1_Fixe-Union), ou bien que nous évoluons séparément en régime flexible (Dummy2_Flexible-Non Union), dans les deux cas, les coefficients de ces variables restent non significatifs (-0.0466949 et +0.0466949 respectivement). Ce résultat semble un peu paradoxal car, notre échantillon comprend deux (02) Unions Monétaires qui détiennent des organisations institutionnelles les prédisposant à enregistrer significativement de faibles taux d'inflation. La CEMAC et l'Union Economique et Monétaire Ouest Africain (UEMOA), pour des raisons politico-historiques, sont dotées de Banques Centrales régionales ce qui devrait contribuer à la maîtrise significative de l'inflation dans ces Unions. Mais comme Giavazzi et Pagano (1988) vont le montrer, un engagement contraignant crédible à un régime de change fixe induit une stabilité des prix, sans perte de compétitivité. Cependant, si l'engagement n'est pas crédible, le résultat peut être biaisé à cause des épisodes de dévaluations.

Pour finir, les réformes entreprises afin de rendre plus autonomes les Banques Centrales dans leur lutte contre l'inflation fut limitées et n'ont pas eu les effets significatifs escomptés en ASS - Dummy1_ Refromes (-0.0117253). En effet, ces réformes jugées insuffisantes et peu effectives, n'ont pas entrainé un grand changement dans les pratiques monétaires, ce qui a eu peu d'incidence sur la politique monétaire et par conséquence sur l'inflation. Pour la plupart des Banques Centrales de notre échantillon, le cadre institutionnel est resté inchangé entre 1980 et 2000. Cette conclusion sur les réformes conforte nos résultats car, l'autonomie légale des Banques Centrales ($LIBC_{i,t}$), lors des années des réformes a pu réduire l'inflation (-1.505641) mais, le degré d'autonomie réelle ($TOR_{i,t}$) a atténué cet impact (+0.7185177). Ce résultat rejoint les travaux d'Acemoglu et al. (2008) sur les changements dans la législation de 52 Banques Centrales entre 1989 et 2003, et confirme le fait que l'autonomie légale des Banques Centrales est associée à une important baisse de l'inflation dans les pays ayant un niveau moyen de contraintes politiques. Le *tableau 8* fait un récapitulatif de nos des tests de robustesse.

Tableau 8: Récapitulatif des résultats des tests de robustesse pour nos variables d'intérêts.

Variables Zones	Dynamique de l'inflation ($Infltrans_{i,t}$)	Pays cibleurs d'inflation	Pays non-cibleurs d'inflation	Pays en Change fixe et Union Monétaire	Pays en Change flexible et Non Union monétaire	Réformes des statuts des Banques Centrales
Indice d'autonomie Légale $LIBC_{i,t}$	-1.360425 (0.003)***	-1.515189 (0.000)***	-1.515189 (0.000)***	-1.471146 (0.000)***	-1.471146 (0.000)***	-1.505641 (0.000)***
Indice d'autonomie Réelle $TOR_{i,t}$	+0.4383794 (0.145)	+0.7159008 (0.021)**	+0.7159008 (0.021)**	+0.7342985 (0.020)**	+0.7342985 (0.020)**	+0.7185177 (0.018)**
Dummy1_cibleurs	/	-0.0041325 (0.959)	/	/	/	/
Dummy2_non-cibleurs	/	/	+0.0041325 (0.959)	/	/	/
Dummy1_Fixe-Union	/	/	/	-0.0466949 (0.345)	/	/
Dummy2_Flexible-Non Union	/	/	/	/	+0.0466949 (0.345)	/
Dummy1_Réformes (année de réforme dummy1)	/	/	/	/	/	-0.0117253 (0.636)

*Notes: *** significativité à 1% ; ** significativité à 5% ; * significativité à 10% (…) les valeurs entre parenthèses sont les p-values.*
Source: Calculs des auteurs à partir de Stata 15.

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V. Conclusion

La présente étude a permis de vérifier que la condition d'une Banque Centrale autonome ne peut-être que nécessaire (pas nécessairement suffisante) à la stabilité des prix en ASS, dans la mesure ou certaines Banques Centrales restent confrontées à des difficultés dans l'atteinte de leurs objectifs officielles. Ainsi, isoler la politique monétaire des mains du pouvoir gouvernemental apparait alors comme le meilleur arrangement institutionnel pour lutter à long terme contre le biais inflationniste. En termes de recommandations nous encourageons les Banques Centrales de notre échantillon à opter pour plus d'autonomie réelle. Une meilleure gouvernance pourrait être mise en place au sein de ces Institutions car, il est important de préserver et de renforcer leur crédibilité. Il est également nécessaire d'instituer un mécanisme qui oblige ces Banques Centrales à rendre compte de leurs actions sur la politique monétaire, des missions et des objectifs financiers qui leurs sont assignés, et finalement les ressources qui leur sont allouées. Encore mieux, des efforts considérables restent à faire pour rendre plus lisibles la stratégie monétaire des Banques Centrales d'ASS à travers les actions de communication appropriées et des décisions objectives. L'autonomie et l'autorité des Banques Centrales d'Afrique Subsaharienne doivent être stipulées par les membres des conseils d'administration. Il serait par exemple nécessaire de réduire la participation des gouvernements dans la nomination et la révocation des dirigeants des Banques Centrales. Cela aiderait à dépolitiser le processus de nomination, et permettrait de réduire la dépendance personnelle des gouverneurs et autres organes de directions vis-à-vis des autorités politiques qui les nomment. Les nominations par le biais des organismes professionnels indépendants ou les procédures de nomination double-véto pourraient être utilisés. Si la nomination est toujours faite par le gouvernement, alors il devrait y avoir un processus de consultation à multi-facettes et vaste, impliquant soit des cabinets indépendants, soit l'Assemblée Nationale ou le Sénat.

Nous plaidons également pour un renforcement supplémentaire des conditions d'immunité contre les licenciements abusifs des dirigeants des Banques Centrales. Les statuts des Banques Centrales d'Afrique Subsaharienne devraient indiquer clairement et explicitement les conditions de licenciements potentiels, afin de réduire des renvois pour des motifs politiques ou d'ingérences. En outre, tous les cas de limogeage devraient être étudiés à fond pour éviter les licenciements abusifs qui à l'avenir, créent potentiellement la dépendance des gouverneurs de Banques Centrales vis-à-vis des autorités politiques. A cela, nous recommandons particulièrement un prolongement de la durée des mandats des gouverneurs, de sorte qu'ils soient plus long que le cycle électoral ou de la durée de mandat des autorités gouvernementales. Fort est de constater que les Banques Centrales de la zone d'Afrique Subsaharienne ont encore besoin d'établir des mécanismes ouverts, clairs et explicites de résolution des conflits politiques entre la Banque Centrale et les gouvernements respectifs. Elles doivent en outre s'efforcer jouir d'une grande autonomie économique afin de mieux déterminer les modalités de refinancement des Etats et l'utilisation des instruments de politique monétaire. Les arrangements ou contrats institutionnels entre autorités monétaires et le gouvernement doivent être transparents.

Toutefois nous retenons que la BEAC, qui déjà grâce à son caractère supranational n'était pas totalement inféodée aux autorités politiques, a accompli des progrès non négligeables en terme d'évolution institutionnelle. De plus, l'autonomie de la Banque Centrale pourrait être un facteur de pérennité de l'intégration économique des pays composant l'UEMOA et la CEMAC face aux perturbations politiques qui les touchent fréquemment. C'est dans cette perspective que Guillaumont (2006) recommande de renforcer l'autonomie de ces Banques afin d'accroître la confiance dans la valeur de la monnaie qu'elles émettent, d'une part, et de garantir la pérennité de l'intégration monétaire et économique de l'Afrique de l'Ouest et de l'Afrique Centrale, d'autre part.

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Annexe

Annexe 1: Estimation par les Moindres Carrés Généralisés Faisables appliqués sur le modèle à effets aléatoires avec transformation de Prais et Winsten corrigé de l'hétéroscédasticité et l'autocorrélation AR1 pour l'ensemble de l'échantillon.

```
Prais-Winsten regression, correlated panels corrected standard errors (PCSEs)

Group variable:   pays                          Number of obs      =       271
Time variable:    priode                        Number of groups   =        10
Panels:           correlated (unbalanced)       Obs per group: min =        10
Autocorrelation:  panel-specific AR(1)                         avg =      27.1
Sigma computed by casewise selection                           max =        38
Estimated covariances      =        55          R-squared          =    0.2954
Estimated autocorrelations =        10          Wald chi2(9)       =    137.64
Estimated coefficients     =        10          Prob > chi2        =    0.0000
```

transinfl	Panel-corrected Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
libc	-1.509888	.250018	-6.04	0.000	-1.999914	-1.019861
tor	.7121376	.3062093	2.33	0.020	.1119784	1.312297
ouv	-.0037673	.0007415	-5.08	0.000	-.0052207	-.002314
mamo	-.0023733	.0019008	-1.25	0.212	-.0060988	.0013522
pib	.002135	.0024176	0.88	0.377	-.0026033	.0068734
debu	-.0004052	.0008126	-0.50	0.618	-.0019979	.0011876
tcha	.0000354	.0000299	1.18	0.237	-.0000232	.0000939
devfi	.0020674	.0009225	2.24	0.025	.0002593	.0038754
qipr	.0609854	.0139584	4.37	0.000	.0336274	.0883433
_cons	1.350892	.1642601	8.22	0.000	1.028948	1.672836
rhos	= -.0527711	-.0050626	.7740555	.6986606	.8472605	... .8664062

Source: Calculs des auteurs à partir de Stata 15.

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Hybrid Model of Artificial Neural Networks and Principal Component Decomposition for Predicting Greenhouse Gas Emissions in the Brazilian Region of MATOPIBA

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Keywords: brazilian agriculture, EMBRAPA, change in land use, cerrado biome, evolution of GHG emissions.

GJHSS-E Classification: JEL Code: Q54, Q15



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Hybrid Model of Artificial Neural Networks and Principal Component Decomposition for Predicting Greenhouse Gas Emissions in the Brazilian Region of MATOPIBA

Milena Monteiro Feitosa [α] & E José de Jesus Sousa Lemos [σ]

Abstract- Greenhouse gas (GHG) emissions in agricultural production represent a global environmental challenge, and it is necessary to understand the factors that influence them to develop sustainable practices. The general objective of this research is to investigate some of the factors that probably influence GHG emissions and reductions in agricultural production in the MATOPIBA region of Brazil between 2006 and 2017. A hybrid methodology was used, and the first stage used linear models (decomposition into principal components) and non-linear models (artificial neural networks) to determine the relationships that should exist between the dependent variable (GHG emissions) and 11 variables. The data was obtained from the 2006 and 2017 Brazilian Agricultural Census, MapBiomas, SEEG, and NOAA. The results showed that of the 373 municipalities that make up MATOPIBA, only 100 did not see an increase in GHG emissions between 2006 and 2017. The principal component decomposition method reduced the 11 initial variables into 3 orthogonal and unobserved variables. In one of the unobserved variables, 4 of the five variables that are supposed to cause a reduction in GHG emissions were brought together. The 5 variables thought to have caused an increase in GHG emissions were condensed into 5.

Keywords: brazilian agriculture, EMBRAPA, change in land use, cerrado biome, evolution of GHG emissions.

I. Introduction

Brazilian agriculture is recognized worldwide for its prominence in the global market, especially in producing grains and foods such as soybeans, corn, cotton, orange juice, cocoa, coffee, sugar, and meat (FAOSTAT, 2020). In recent years, the expansion of soybean cultivation in Brazil has intensified, consolidating the country as one of the world's leading exporters. This growth is due to the advance of new agricultural frontiers such as the MATOPIBA region, which covers parts of the frontiers of the states of Maranhão, Tocantins, Piauí, and Bahia, located predominantly in the Cerrado biome (Santos & Naval, 2022).

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Since the creation of the Brazilian Agricultural Research Corporation (EMBRAPA) in 1973, the knowledge generated by this institution has been fundamental in developing and adapting technologies for the tropical conditions of this type of production, especially in the Cerrado. This has boosted the development of the country's agricultural sector. These innovations have established Brazil as one of the largest global food producers and exporters (Nehring, 2016; Souza et al., 2020; EMBRAPA, 2024).

However, despite the economic growth driven by the agricultural sector, this is one of the activities responsible for greenhouse gas (GHG) emissions, due to the use of fossil fuelbased fertilizers, the burning of biomass, the high density of cattle per unit area, and the use of heavy agricultural machinery, which also uses this type of fuel in its energy matrix (Liu et al., 2017). According to the Food and Agriculture Organization of the United Nations (FAO), the agricultural sector may be responsible for up to 21% of the world's GHG emissions (FAO, 2016).

The increase in the greenhouse effect can be exacerbated by the rising levels of carbon dioxide (CO2) in the atmosphere (Myhre et al., 2013), which is attributed to various causes. Agricultural production can contribute to this process through the actions described in the previous paragraph. However, paradoxically, plants play a crucial role in reducing these emissions through the biochemical phenomenon known as photosynthesis. During photosynthesis, plants capture CO2, solar energy, water, and nutrients from the soil, transforming them into organic matter and releasing oxygen as a byproduct. Because of this phenomenon, CO2 is often known as the gas of life. It can therefore be inferred that deforestation may be one of the primary causes of the reduced capacity to capture CO2, which is ultimately released by various sources (Felício, 2014).

Thus, one of the primary sources of CO2 emissions is the burning of fossil fuels (Forster et al., 2007). Additionally, land use changes can alter the flow of carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O)- greenhouse gases that result from modifications to biogeochemical processes (Forster et al., 2007; Houghton et al., 2012; Kirschbaum et al., 2012; Kim & Kirschbaum, 2015).

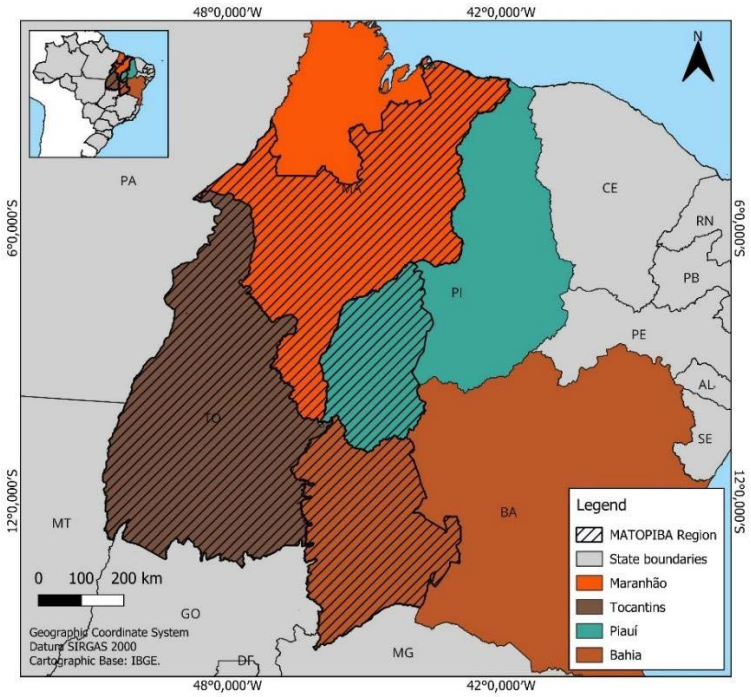
Worldwide, it is estimated that approximately 420 million hectares of forest have been cleared since

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1990. More than half (54%) of the world's forests are concentrated in just five countries: Russia, Brazil, Canada, the United States, and China. Meanwhile, agricultural land areas expanded by 6% between 2000 and 2021, contributing to a growth of 38% in permanent crops and 12% in temporary crops (FAO, 2020).

In 2021, Brazil had 66 million hectares of arable land, with a 20% increase in agricultural areas due to the expansion of temporary crops (FAO, 2023). It is, therefore, necessary to evaluate more rigorously how land is utilized as the main production factor in agriculture and its relationship with greenhouse gas emissions, given that it is directly related to changes in soil organic carbon stocks. This, in turn, is important for determining soil quality, natural fertility, agricultural productivity, and the fixation of atmospheric carbon dioxide (CO_2) (Kumar et al., 2022). In addition, the use of fire related to land use change can also reduce soil organic carbon stocks (Van der Werf et al., 2006; Van der Werf et al., 2010; Kim & Kirschbaum, 2015).

In recent decades, since its implementation in the 1980s, the MATOPIBA agricultural frontier, which includes parts of the states of Maranhão (135 of its 217 municipalities), Tocantins (all 139 municipalities), Piauí (33 of its 224 municipalities), and Bahia (30 of its 417 municipalities on the frontier) (Figure 1), has emerged as one of the main regions for the expansion of grain production, especially soybeans.



Source: Developed by the author.

Figure 1: Location Map of the MATOPIBA Region

According to data from IBGE's Municipal Agricultural Production (PAM), in 2023 the 337 municipalities of MATOPIBA recorded a 9.6% increase in cultivated area compared to the previous year. Consequently, production reached 18,943,144 tons, an increase of 11.2%, with an average yield of 3,581.94 kg/ha, representing a growth of 1.44% compared to 2022.

In addition, between 2013 and 2017, the GDP of agriculture in MATOPIBA reached R$17.1 billion, with an average annual growth rate of 7.7% (Souza, Magalhães & Castro, 2022). However, this economic growth has also had environmental impacts. Between 2010 and 2013, the MATOPIBA region was responsible for 45% of forest carbon emissions resulting from agricultural expansion in the Cerrado, with Maranhão making one of the largest contributions (14.42%) (Noojipady et al., 2017).

The conversion of native Cerrado areas into agricultural land intensifies deforestation (Rausch et al., 2019). In 2023, according to the Annual Report on Deforestation in Brazil, the MATOPIBA region was responsible for almost half (47%) of the loss of native vegetation in Brazil, with 858,952 hectares deforested, representing an increase of 59% over the previous year. Of the 50 municipalities with the most deforestation in the country, 33 are in the Cerrado, and the 10 with the largest deforested areas are in this biome. The state of Maranhão led the national ranking, with 331,225 hectares deforested, an increase of 95.1%. The state of Tocantins experienced a 177.9% increase in deforestation, with 230,253 hectares cleared, while

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Bahia deforested 290,606 hectares, representing a 27.5% increase compared to 2022 (RAD, 2023).

This change in land use, resulting from the conversion of native areas into agricultural land and pastures, drives deforestation and promotes the frequent use of fire (Reddington et al., 2015; Spera et al., 2016). According to data from MapBiomas Fogo, between 1985 and 2023, around 199.1 million hectares were burned in Brazil, of which 44.6% (equivalent to 88.5 million hectares) were in the Cerrado biome, while the Amazon biome accounted for 19.6% (MapBiomas Project, 2023).

Although fire is a natural element used to clear areas where crops or pastures will be planted, it is becoming a threat due to its increasing frequency and the possibility of it getting out of control in the Cerrado due to agricultural expansion and deforestation. The Cerrado is responsible for 48% of the country's soybean production and approximately a quarter of this production area is located in MATOPIBA (Pitta et al., 2017; Soterroni et al., 2019; Silva et al., 2021; MapBiomas Project, 2023).

Given this scenario, studying the evolution of greenhouse gas (GHG) emissions and identifying the factors that likely contribute to the reduction or expansion of these emissions in the MATOPIBA region is essential for guiding public policies and investments that promote agriculture with lower or zero GHG emissions (Bezerra, 2022).

Based on the above, this research aims to answer the following questions: 1 - How many municipalities in MATOPIBA had an increase or decrease in GHG emissions between 2006 and 2017? 2 - Which variables, and in what proportions, probably influenced these emissions in this time interval?

To answer these questions, the general objective of this study is to investigate the factors that influence GHG emissions and reductions in agricultural production in the MATOPIBA region between 2006 and 2017. Specifically, the study seeks to: a - Ascertain the number of municipalities in the MATOPIBA region and, by state, identify which had an increase or decrease in GHG emissions between 2006 and 2017; b - Analyze the interaction between the variables tested in determining GHG emissions in this period; c - Evaluate how GHG emissions are influenced by the synergies between the indicators analyzed.

II. Material and Methods

a) *Database and Construction of Indicators*

The research uses secondary data extracted from the 2006 and 2017 Agricultural Censuses, MapBiomas, NOAA (National Oceanic and Atmospheric Administration), and SEEG (System of Estimates of Greenhouse Gas Emissions and Removals), from which information was obtained on the variables that are supposed to affect greenhouse gas emissions in the municipalities of the MATOPIBA region over these 11 years. The variables and data sources used are shown in Table 1.

Table 1: Variables that, by Hypothesis, Affect Greenhouse Gas (GHG) Emissions Positively (+) or Negatively (-) between 2006 and 2017 in MATOPIBA in this Research

Variables	Hypothesis of the relation between Yi and Xij	Definition	Sources
Y_i	GHG Emissions	(GHG_{2017}/GHG_{2006}) Emissions	Greenhouse Gas Emissions - SEEG (OC, 2022).
X_{i1}	(-)	(Municipal average annual rainfall2017) / (Municipal average annual rainfall2006)	NOAA (2022)
X_{i2}	(-)	(Vegetation cover) [(Crop areas + forest areas) / (total establishment area 2017)] / [(Crop areas + forest areas)/ (total establishment area 2006)]	Agricultural Censuses of 2006 and 2017 / IBGE
X_{i3}	(-)	[(Agricultural production value2017) / (Harvested agricultural area2017)] / [(Agricultural production value2006) / (Harvested agricultural area2006)]	Agricultural Censuses of 2006 and 2017 / IBGE
X_{i4}	(-)	[(Livestock production value2017) / (Pasture area2017)]/ [(Livestock production value2006) / (Pasture area2006)]	Agricultural Censuses of 2006 and 2017 / IBGE
X_{i5}	(-)	[(Recovered areas2017) / (Deforested areas2017)]/ [(Recovered areas2006) / (Deforested areas2006)]	MapBiomas

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X_{i6}	(+)	[(Cattle quantity2017) / (pasture areas 2017)] / [(Cattle quantity2006) / (pasture areas 2006)]	Agricultural Censuses of 2006 and 2017 / IBGE
X_{i7}	(+)	[(Total tractors and machinery2017) / (total establishment area2017)] / [(Total tractors and machinery2006) / (total establishment area2006)]	Agricultural Censuses of 2006 and 2017 / IBGE
X_{i8}	(+)	[(Expenditure on agricultural pesticides2017) / (total area of municipal establishments 2017)] / [(Expenditure on agricultural pesticides2006) / (total area of municipal establishments 2006)]	Agricultural Censuses of 2006 and 2017 / IBGE
X_{i9}	(+)	[(Industrial sector GDP2017) / (Total municipal GDP2017)] / [(Industrial sector GDP2006) / (Total municipal GDP2006)]	Agricultural Censuses of 2006 and 2017 / IBGE
X_{i10}	(+)	CV rainfall 2017/ CV rainfall 2006	NOAA (2022)
X_{i11}	(+)	(Burn scars areas 2017 / Burn scars areas 2006)	MapBiomas

Source: Compiled based on data from SEEG, MapBiomas, Agricultural Census (2006 and 2017), IBGE, and NOAA (2022).

The methodological approaches adopted to achieve the objectives of this research begin with the development of the indicators used. To assess changes in greenhouse gas (GHG) emissions between 2006 and 2017, in addition to the impact of the variables presented in Table 1 on these emissions, the indicators are constructed as follows: the relationship between the values observed in 2017 (final year) and those in 2006 (initial year) is estimated for both GHG emissions and the explanatory variables.

This makes it possible to identify whether each variable increased or decreased over the period analyzed. In municipalities where the ratio between GEE2017 and GEE2006 is greater than 1, there has been an increase in emissions; if it is less than 1, there has been a reduction. The same process is applied to the explanatory or independent variables (Table 1).

b) Methodology Adopted to Assess the First Research Objective

To achieve the first objective of the research, we estimated the total number of municipalities where the ratios of GHG emissions in 2017 were higher than those observed in 2006. In these instances, the ratios are represented as Yi2017/Yi2006. Additionally, we measured the relationships between the variables believed to have influenced GHG emissions between 2006 and 2017, denoted as Xij2017/Xij2006.

c) Methodology for Achieving the Second Objective

To estimate the synergy between the variables that are thought to have influenced GHG emissions, Factor Analysis (FA) was used, using the principal component decomposition technique.

Before using the principal component decomposition model, it was decided to transform all the variables into indices. The indices range from 1 to 100. In the case of the dependent variable, the ratio of GHG emissions between 2006 and 2017, the following procedure was adopted. The municipalities were ranked in descending order by the ratio of GHG emissions between 2006 and 2017. Therefore, the higher the value of this ratio, the higher the GHG emissions between 2006 and 2017. For this reason, the highest emissions value was assigned the index=100. The other values were adjusted proportionally using a simple, straightforward rule of three. Thus, in the municipality where the GHG emissions index = 100, there was the highest emission of this gas between 2006 and 2017. In those municipalities where the GHG index is close to 1, this means that there was the greatest reduction in these emissions.

About the 11 independent variables used to cause GHG emissions, the following criteria were adopted. All 5 variables whose hypothesis in this study establishes that they should cause a reduction in GHG emissions between 2006 and 2017 (GHG2017/2006 ≤1) were ranked in ascending order. The lowest value (worst case) is assigned an index of 100. The remaining values are adjusted proportionally using a simple inverse rule of three. These variables are marked with a (-) sign in Table 1 indicating that, by hypothesis, they cause a reduction in GHG emissions.

The other 6 independent variables which, by hypothesis, should cause an increase in GHG emissions (GHG2017/2006) were ranked in descending order. The highest value of these variables (worst case) was assigned an index of 100. The other values are adjusted proportionally using a simple, direct rule of three. These variables are marked with a (+) sign in Table 1 indicating that, by hypothesis, they cause an increase in GHG emissions.

i. *Summary of the Factor Analysis Model as it Applies to the Study*

A summary of the factor analysis method applied in this study is presented below. In general, the factor analysis model can be expressed as follows:

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$$X = af + e \quad (1)$$

In equation (1), $X = (X_1, X_2, ..., X_p)^T$ is a transposed vector of observable variables, while $f = (f_1, f_2, ..., f_r)^T$ represents a transposed vector consisting of r latent ($r < p$) factors that are not directly observable. The matrix a of coefficients has dimension (p x r) of fixed coefficients, known as factor loadings; and $e = (e_1, e_2, ..., e_r)^T$ is a transposed vector of random terms. It is generally assumed that $E(e) = E(f) = 0$.

At the outset, the estimated factor loadings may not be definitive; however, the factor analysis method enables the rotation of this initial structure for enhanced interpretation. In this study, varimax orthogonal rotation was used, which has the advantage of making the factors independent (Dillon & Goldstein, 1984; Johnson & Wichern, 1988; Basilevsky, 1994; Fávero et al., 2017).

To construct the index, the factor scores are estimated after the orthogonal rotation of the initial structure. The factor score positions each observation in the space of common factors. Thus, for each factor fi, the i-th factor score that can be extracted is defined by Fi, and can be expressed as:

$$F_i = b_1X_{i1} + b_2X_{i2} + .. + b_pX_{ip}; \; i = 1, 2, .., n; \; j = 1, 2 .., p \quad (2)$$

Where $b_1, b_2, ..., b_p$ are regression coefficients; $X_{i1}, X_{i2}, ..., X_{ip}$ are "p" observable variables.

Although Fi is not directly observable, it can be estimated using existing factor analysis techniques, using the matrix of observable variables X. Thus, equation (2) can be rewritten in a more compact form using matrix notation:

$$F_{(n \times q)} = X_{(n \times p)}.B_{(p \times q)} \quad (3)$$

In equations (2) and (3), the factor scores are influenced by the magnitude and units of the X variables. To avoid this problem, the X variables are normalized, resulting in:

$$Z_{ij} = [(X_i - m_{xi}) / s_{xi}]; \quad (4)$$

Where m_{xi} is the mean of X_i, and S_{xi} is its standard deviation. Thus, equation (4) can be modified to:

$$F_{(n \times q)} = Z_{(n \times p)}.b_{(p \times q)} \quad (5)$$

In equation (5), the vector "b" replaces "B", since the variables are already normalized. Pre-multiplying both sides of the equation by $(1/n)Z^T$, where n is the number of observations and ZT is the transposed matrix of Z, gives us:

$$(1/n)Z^TF = (1/n)Z^TZb. \quad (6)$$

The expression $(1/n)\ Z^TZ$ corresponds to the correlation matrix of the X variables, called R. The matrix $(1/n)\ Z^TF$ represents the correlation between the factor scores and the factors themselves, called L. The equation is redefined as:

$$L = R.b \quad (7)$$

If R is a non-singular matrix, verified by the Bartlett test, the analysis can proceed. Thus, the hypothesis that the matrix of correlations between the variables is not an identity matrix must be rejected, with at least a 5% error level (Fávero, 2017).

If R is non-singular, multiply both sides of equation (7) by the inverse matrix of R (R^{-1}), resulting in:

$$b = R^{-} .L. \quad (8)$$

For the estimated model to be statistically valid, it is essential to conduct the Kaiser-MeyerOlkin (KMO) test, which should yield a value greater than 0.5. Additionally, the total variance explained by the orthogonal factors must exceed 50% (Hair et al., 2005; Maroco, 2003; Fávero, 2017).

After determining the "b" vector (as shown in equation 8), the compositions of each estimated factor are identified based on the magnitudes of the factor loadings. The factors, which are a reduction of the original variables ($k < n$), can be redefined and renamed according to the magnitudes of the factor loadings that each variable presents in each component factor.

The principal component decomposition process permits the generation of factor scores. These factor scores, represented by FE, are normalized variables with a mean of zero and a standard deviation of one. Positive and negative values gravitate around this zero mean FE. These factor scores can be converted into partial indices associated with each municipality (Ii) using equation (9). These partial indices can be supplemented, depending on the variables grouped in the composition of each factor score that generated it.

$$I_i = (FE_i - FE_{MN})/(FE_{MX} - FE_{MN}) \quad (9)$$

In equation (9), FEi is the i-th normalized factor score, FEMN is the minimum value of the factor score, and FEMX is the maximum value. In this manner, the Ii indices will range between zero and one, and they will be utilized in this study to identify the expected results for the second objective.

The relationship between GHG emissions and the partial indices (I1; I2, ..., Ip) can be described by the following equation:

$$GHG_i = f(I_1; I_2, ..., I_p) \quad (10)$$

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This equation summarizes how the indices derived from the factor scores explain the variation in GHG emissions in the different municipalities.

ii. *Methodology Adopted to Achieve the Third Objective*

To achieve the third objective of this research, the Artificial Neural Networks (ANN) model was used to investigate how GHG emissions are influenced by the synergy of partial indices (I_1, I_2, ..., I_p). ANNs are part of computational artificial intelligence. One of the main areas of application of ANNs is in the prediction of multivariate statistical data that is both nonlinear and non-parametric (Sharda & Patil, 1992; Lee et al., 2017).

Zhang et al (1998) report that one of the procedures of computational artificial intelligence normally used to predict time series is the training of ANNs, based on the architecture and learning of the human brain. In this way, according to Zhang et al (1998), ANNs work like the human brain, seeking to recognize regularities and patterns in data, being able to learn from experience, and make generalizations based on previously accumulated knowledge. ANNs are non-linear models, unlike traditional forecasting models such as Box & Jenkins (1976) and Pankratz (1983), which assume that the series studied are generated by linear processes.

When designing an ANN model, we can envision it as a network of artificial 'neurons' organized into layers. The variables used to predict (inputs) a dependent variable (output) form the lower layer, while the predicted variables form the upper layer. The ANN model also allows for the possibility of intermediate layers, generally known as hidden layers (Sharda & Patil, 1992).

Designed to represent how the human brain processes information, ANNs are computer algorithms that add knowledge by detecting patterns and correlations and can be trained through experience. They consist of hundreds of artificial neurons (or nodes) interconnected in hierarchical layers. Each neuron has a specific output function and the connection between each two nodes has a weight, constituting its artificial neural network memory. It is through these weights that the power of neural computations is reflected, i.e. the degree of influence that one cell exerts on another.

Built to simulate the biological function of a neuron, each node has weighted inputs, a transfer function, and an output. Feedforward neural networks linearly transmit information, from the input layer to the output layer, and are among the most popular types used in various applications (Figure 1) (Agatonovic-Kustrin; Beresford, 2000; Gómez, Fernández & Peñuela, 2021).

In this research, the process begins with data entry, in which the explanatory variables correspond to the partial indices generated by factor analysis, and the dependent variable is represented by GHG emissions (Yi). The data was randomly divided into two sets: 70% was used to train the model and 30% was reserved for the test set (Liu &Cocea, 2017; Dao et al., 2020). The output of a neuron can be written mathematically:

$$Yi = f(n) \quad (12)$$

Where n is the weighted sum of the input signals plus an adjustment term (bias), defined as: n =

$$n = \sum_{i=1}^{p}(w_j \, . X_j) + b \quad (13)$$

Where Xi_1, Xi_2, ..., Xi_p are the neuron's input signals (partial indices generated by factor analysis); w_1, w_2, ..., w_p are the weights associated with each input, determining the importance of each signal in the process; "b" is the bias term, used to adjust the flexibility of the model; and f (*) is the activation function, responsible for the non-linearity of the model, enabling the network to learn complex relationships between the data.

The model's performance was assessed using quantitative metrics, including the Root Mean Square Error (RMSE), the Mean Absolute Error (MAE), and the Mean Absolute Percentage Error (MAPE). The lower the estimated values for these measurements, the better the adjustments. The RMSE is calculated by the root mean square difference between the predicted and observed values, shown in Equation 14. It provides an overview of the model's accuracy. The lower the RMSE, the more accurate the model. The Mean Absolute Error (MAE), as measured by equation (15), is also a metric used for evaluating models. Finally, the Mean Absolute Percentage Error (MAPE), as measured by equation (16), expresses errors as a percentage, making it easier to interpret the observed values (Pham et al., 2018; Elsaraiti, 2024). Using several metrics is advantageous for obtaining a broader view of the model's performance from different perspectives (Tripathy & Prusty, 2021).

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(v_{observed} - v_{predicted})^2} \quad (14)$$

$$MAE = \frac{1}{n}\sum_{i=1}^{n} | v_{observed} - v_{predicted} | \quad (15)$$

$$MAPE = \frac{1}{n}\sum_{i=1}^{n} \left| \frac{v_{observed} - v_{predicted}}{v_{predicted}} \right| * 100 \quad (16)$$

III. Results and Discussion

To enhance the clarity of the presentation and discussion of the results, they have been organized according to the timeline of the research objectives.

a) Results Found for the First Objective

Table 3 and Figure 2 show the absolute and relative frequencies of the MATOPIBA municipalities for

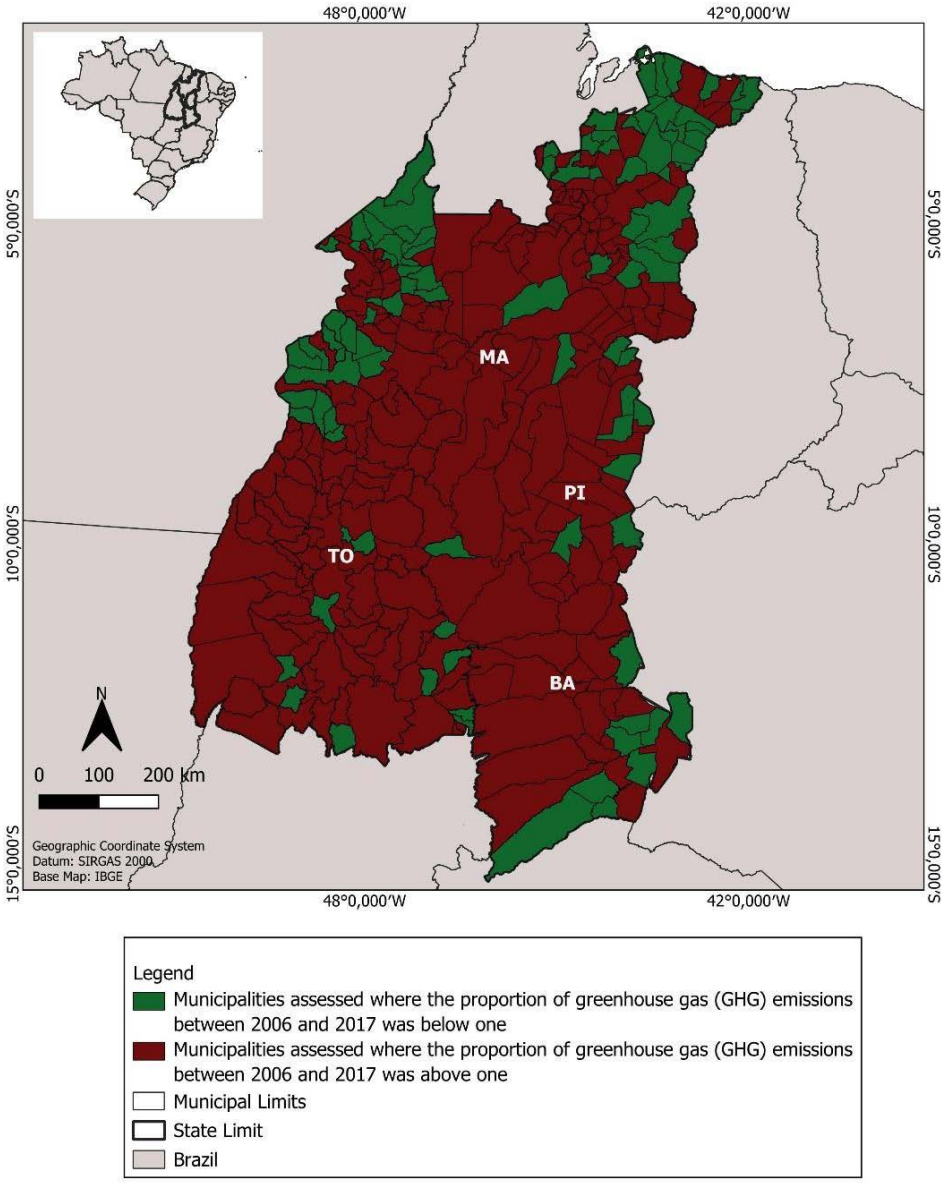
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states that showed an increase or decrease in GHG emissions between 2006 and 2017.

Table 3: Absolute and Relative Frequencies of GHG Missions in MATOPIBA Municipalities from 2006 to 2017

States	Absolute frequencies of municipalities where the ratio of GHG emissions between 2017 and 2006 was less than 1 (GHG < 1)	Relative Frequency (%)	Absolute frequencies of municipalities where the ratio of GHG emissions between 2017 and 2006 was greater than 1 (GHG >1)	Relative Frequency (%)
Maranhão	50	37	85	63
Tocantins	33	23,7	106	76,3
Piauí	8	24,2	25	75,8
Bahia	9	30	21	70
Total	100	100	237	100

Source: Based on the survey results.



Source: Based on the survey result.

Figure 2: 2017/2006 GHG Ratio for the MATOPIBA Region

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There was a predominance of municipalities with an increase in GHG emissions during the analyzed period. Of the 337 municipalities in the MATOPIBA region, 237 (approximately 70.3%) experienced an increase in emissions, while 100 (29.7%) reported a reduction. Among the municipalities in the state of Maranhão, 50 out of a total of 135 (37%) experienced a reduction in emissions, while 85 (63%) reported an increase. In Tocantins, of the 139 municipalities, 33 (23.7%) registered a decrease in emissions, while 106 (76.3%) showed an increase. In Piauí, out of 33 municipalities, only 8 (24.2%) reduced emissions, while 25 (75.8%) experienced an increase. In the state of Bahia, out of a total of 30 municipalities in MATOPIBA, 9 (30%) reduced emissions, while 21 (70%) showed an increase (Table 3).

b) Results Obtained for the Second Objective

Table 4 presents the results obtained from the principal component decomposition procedure of the factor analysis (FA) conducted in this research.

Table 4: Results Found Showing the Decomposition of the 11 Original Variables into 3 Main Components

		Rotated components Matrix			Component Score Coefficient Matrix		
Variables		1	2	3	1	2	3
Index of rainfall	X_{i1}	0.000	0.009	**1.000**	-0.001	-0.003	**0.500**
Index of vegetation cover	X_{i2}	-0.296	**0.856**	-0.006	0.036	**0.281**	-0.008
Index of agricultural production value	X_{i3}	-0.225	**0.896**	0.013	0.061	**0.306**	0.001
Index of relative livestock value	X_{i4}	-0.035	**0.788**	0.008	0.098	**0.291**	-0.001
Index of rlative recovered areas	X_{i5}	-0.264	**0.941**	0.009	0.056	**0.317**	-0.001
Index or relative cattle quantity	X_{i6}	**0.927**	-0.260	-0.009	**0.219**	0.029	-0.004
Index of_relative_machinefy	X_{i7}	**0.947**	-0.170	-0.024	**0.237**	0.066	-0.013
Index of relative expenditure in pesticides	Xi_8	**0.865**	-0.258	0.013	**0.202**	0.021	0.007
Index of_relative_industrial GNP	X_{i9}	**0.927**	-0.083	-0.001	**0.243**	0.096	-0.002
Index of relative_cv rainfall	X_{i10}	0.000	0.009	**1.000**	-0.001	-0.003	**0.500**
Index of relative Burn scars areas	X_{i11}	**0.937**	-0.199	0.020	0.230	0.053	0.010
Kaiser-Meyer-Olkin Measure of Sampling Adequacy:							0.738
Bartlett's Test of Sphericity							
Approx. Chi-Square							8186,727
Degrees of Freedom							55
Significance level.							0.000
Total Variance Explained (%)							88.232
Variance Explained by Component 1 (%)							40.464
Variance Explained by Component 2 (%)							29.575
Variance Explained by Component 3 (%)							18.193

Sources: Results found in the search

Observations: Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization. Component Scores. Rotation converged in 4 iterations.

The evidence presented in Table 4 indicates that the adjustment obtained using the principal component decomposition (PCD) method was statistically significant. The Bartlett test, which yielded a high level of significance (p = 0.00), demonstrated that the correlation matrix of the independent variables is not an identity matrix. The estimated statistic for the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) test was 0.738, and the total variance explained by the adjusted model was approximately 88.232¨%. The variances explained by each estimated component after Varimax orthogonal rotation were 40.464%, 19.373%, and 18.137%, respectively, for components 1, 2, and 3. These results indicate that the greatest synergy captured by the DCP procedure was in component 1, which measures the ratios of: the number of cattle per hectare; the number of tractors and machinery; spending on pesticides; and industrial GDP about the total GDP of the municipalities; and the evolution of burn scars in the period studied. All these variables captured in this component, as assumed in this research, must have positively affected greenhouse gas emissions between 2006 and 2017. This synergy, as we have seen, is responsible for explaining 40.464% of the total explanatory capacity of the model generated (Table 4).

From the results shown in Table 4, it can also be seen that associated with the second component generated in the research, whose variance explains approximately 29.575% of the total explained variance, are four of the five variables that are supposed to cause a reduction in greenhouse gas emissions: the vegetation cover index; the index that measures the productive potential of crops; the index that measures

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the productive capacity of animal husbandry and the index that measures the recovery of degraded areas.

For the third component, the greatest synergies were between the variables rainfall index, which is supposed to reduce GHG emissions, and the index measuring rainfall instability, as measured by the coefficients of variation, which is supposed to increase GHG emissions. These two variables account for 18.193% of the total explained variance. Based on these results, the matrix was generated, which is made up of 3 factor scores that capture these synergies (Table 4).

c) Results Obtained for the Third Objective

As shown above, the third objective of this research sought to assess how GHG emissions are influenced by the synergies between the indicators analyzed. To do this, the GHG emissions ratios between 2006 and 2017 were transformed into indices. In the previous step, when using FA, it was assumed that the relationships between the variables were linear. Thus, the three estimated factor scores are linearly independent. In this step, it is assumed that the relationship between the GHG emissions index between 2006 and 2017 and the independent variables transformed into factor scores is non-linear. The artificial neural network (ANN) model is used to perform the test. The results are shown in Table 5 and Figure 3.

Table 5: Estimation results using ANN, with the GHG emissions index as the dependent variable and the FS1, FS2 and FS3 indices as independent variables

$GHG_{2017/2006}$ emissions ≤ 1			$GHG_{2017/2006}$ emissions >1	
Relative error in the Training period (%)	1.011		Relative error in the Training period (%)	1.002
Relative error in the Testing period (%)	0.908		Relative error in the Testing period (%)	0.997
Number of Units in Hidden Layer including 1 bias Hiden Layer	3		Number of Units in Hidden Layer including 1 bias Hiden Layer	4
Independent Variable Importance			Independent Variable Importance	
Variabels	Importance (weights)		Variabels	Importance (weights)
FS1	0.276		FS1	0.486
FS2	0.496		FS2	0.391
FS3	0.228		FS3	0.123
Acuracy tests			Acuracy tests	
RMSE	3.12		RMSE	10.49
MAE	2.52		MAE	6.58
MAPE	13.11		MAPE	21.29

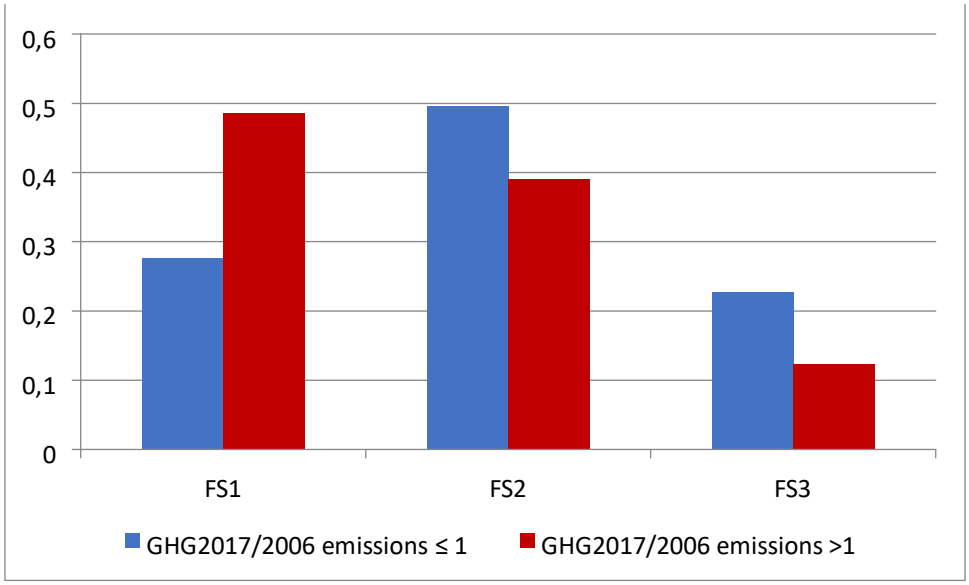
Sources: Results found in the search

The results presented in Table 5 and Figure 3 show that, in the 100 municipalities where there was a reduction in GHG emissions between 2006 and 2017, the score of the factor that brings together the four variables (FS2) that hypothetically impact this reduction had the highest weight (0.496), followed by the score of FS2, bringing together the variables that, by hypothesis, contributed to the increase in GHG emissions between 2006 and 2017, with a weight of 0.276. Meanwhile, FS3, which brings together the variables associated with rainfall and instability, weighted 0.228.

Among the six variables transformed into indices, which were hypothesized to contribute to the increase in GHG emissions between 2006 and 2017, five were grouped into score factor 1 (SF1), with an estimated weight of 0.486. Factor score 2 (FS2) had a weight of 0.391 in this definition, while factor score 3 (FS3) had a weight of 0.123 (see Table 5 and Figure 3).

These results prove the hypotheses of this research, indicating that the variables that were supposed to cause a reduction and increase in GHG emissions between 2006 and 2017 in Matopiba. It can also be seen that the prediction errors in both the training and testing phases were quite low. In addition, the RMSE, MAE, and MAPE tests also showed very low values, thus confirming the accuracy of the adjustments.

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Figure 3: Relative importance of each factor score in Matopiba municipalities with GHG emissions ≤ and GHG emissions > 1

As shown in the evidence presented in Table 5, to estimate the weights associated with each of the independent (explanatory) variables in the group of 100 MATOPIBA municipalities where the GHG ratio ≤ 1, the ANN model used 3 Units in Hidden Layer, including 1 Hiden Layer bias. To estimate the importance of the explanatory variables in municipalities where the GHG ratio > 1, the model used 4 Units in the Hidden Layer, including 1 Hiden Layer bias. In municipalities where GHG emissions are less than or equal to 1, the highest weight was estimated for variable FS2 (0.480), followed by FS3 (0.286), and the lowest weight was associated with the independent variable FS1 (0.234). These results highlight the significance of all the original variables synthesized in FS2, as they are expected to contribute to reducing greenhouse gas emissions. Therefore, the research hypothesis is confirmed.

About the estimated weights for the variables constructed linearly for the municipalities in which the GHG ratios > 1, it can be seen that, as expected, the greatest weighting was given to the FS1 combination (0.629), which synergistically brings together practically all the original variables that are assumed in this research to have contributed to the increase in greenhouse gas emissions between 2006 and 2017. It can be seen that the rainfall ratios, as well as the rainfall instability ratios measured by the coefficients of variation, both contributed to a reduction and an increase in GHG emissions.

IV. Conclusions

From the results of the evidence extracted from the research, it was shown that of the 327 municipalities that are part of the MATOPIBA agricultural frontier region, 100 experienced a reduction in GHG emissions between 2006 and 2017, the period in which this research was carried out. In the remaining 237 municipalities, GHG emissions increased over the same period.

We tested 5 variables that were assumed to have led to a reduction in GHG emissions in the period under investigation and 6 variables that were assumed to have led to an increase in emissions. The methodological procedures used in this research are unprecedented in this type of study, in that it uses two models in sequence. This study employed a model that assesses linear relationships through factor analysis using the principal component decomposition technique. In this process, the 11 observed variables were reduced to three unobserved variables, referred to as factor scores. These factor scores are orthogonal and linearly independent.

In the second methodological stage, the relationships were estimated between the dependent variable that measures GHG emissions between 2006 and 2017 and the three-factor scores in which the 11 original independent variables were synthesized by synergy. At this stage, it was assumed that the relationships were non-linear. Therefore, artificial neural networks (ANN) were employed to evaluate the weights that each of the three factor scores contributes to explaining the dependent variable.

It was observed that the assumptions made for this research were confirmed. Of the five variables hypothesized to contribute to a reduction in GHG emissions, four were grouped together in one of the factor scores and had the highest weighting in explaining greenhouse gas emissions in the MATOPIBA

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municipalities that experienced a decline in GHG emissions between 2006 and 2017.

On the other hand, of the 6 variables that were tested and assumed to have led to an increase in greenhouse gas emissions between the two periods, 5 were brought together in synergy in another factor score (unobserved variable generated by the linear procedure) and had the highest weighting in the municipalities that had an increase in GHG emissions between 2006 and 2017.

Thus, the results of this research can indicate the paths that should be followed in agricultural practices on this agricultural frontier. Furthermore, they can guide future studies by identifying which variables may contribute to the emission or reduction of GHG emissions.

The overall conclusion of this research is that the two questions motivating its execution were answered, and the proposed objectives were achieved. The municipalities in the MATOPIBA region that increased and decreased GHG emissions between 2006 and 2017 were identified, along with the variables and their respective weightings that influenced these changes in emissions.

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1. Authors must go through the complete author guideline and understand and *agree to Global Journals' ethics and code of conduct,* along with author responsibilities.
2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
5. Authors should submit paper in a ZIP archive if any supplementary files are required along with the paper.
6. Proper permissions must be acquired for the use of any copyrighted material.
7. Manuscript submitted *must not have been submitted or published elsewhere* and all authors must be aware of the submission.

Declaration of Conflicts of Interest

It is required for authors to declare all financial, institutional, and personal relationships with other individuals and organizations that could influence (bias) their research.

Policy on Plagiarism

Plagiarism is not acceptable in Global Journals submissions at all.

Plagiarized content will not be considered for publication. We reserve the right to inform authors' institutions about plagiarism detected either before or after publication. If plagiarism is identified, we will follow COPE guidelines:

Authors are solely responsible for all the plagiarism that is found. The author must not fabricate, falsify or plagiarize existing research data. The following, if copied, will be considered plagiarism:

- Words (language)
- Ideas
- Findings
- Writings
- Diagrams
- Graphs
- Illustrations
- Lectures

- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

Authorship Policies

Global Journals follows the definition of authorship set up by the Open Association of Research Society, USA. According to its guidelines, authorship criteria must be based on:

1. Substantial contributions to the conception and acquisition of data, analysis, and interpretation of findings.
2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

Changes in Authorship

The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

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Appealing Decisions

Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

Declaration of funding sources

Global Journals is in partnership with various universities, laboratories, and other institutions worldwide in the research domain. Authors are requested to disclose their source of funding during every stage of their research, such as making analysis, performing laboratory operations, computing data, and using institutional resources, from writing an article to its submission. This will also help authors to get reimbursements by requesting an open access publication letter from Global Journals and submitting to the respective funding source.

Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for writing a good quality Social Science Research Paper

Techniques for writing a good quality homan social science research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of homan social science then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.



6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.
Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

19. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

20. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

21. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

22. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

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Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.



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Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.



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Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."



Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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