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Article

HJ-Biplot for the study of unemployment and violence: A socio-economic and criminological analysis in Ecuador

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Abstract: This study examines the complex relationship between unemployment and violence in Ecuador for 2019–2022, using HJ Biplot analysis to uncover the underlying socio-economic and criminological dynamics. The study reveals a nuanced relationship between unemployment and different types of violence. While unemployment is significantly associated with homicides and murders, the association with femicides and hired assassinations is much weaker. Significant regional and temporal patterns and changes like violence are also observed, highlighting the need for dynamic and adaptive strategies. Exceptions in certain provinces, where patterns of violence and unemployment differ from the rest, highlight the importance of local approaches to policymaking.

Keywords: unemployment and violence in Ecuador; HJ Biplot; socio-economic dynamics and crime; public policies and security; multidimensional factors of violence; violence in Ecuador

1. Introduction

The complex interplay between homicidal violence and socioeconomic factors has been widely analyzed in various geographical and temporal contexts as researchers seek to understand the underlying causes and potential interventions. In particular, recent studies have underscored the critical role of conditions of vulnerability, such as economic inequality, unemployment, and social marginalization, in the incidence of homicide and other forms of interpersonal violence. This paper focuses on examining these relationships within the context of Ecuador, building on findings from other Latin American countries and Spain, to provide a comprehensive understanding of the multifaceted dynamics at play.

A significant body of research has explored the connection between socioeconomic conditions and homicidal violence. Jimenez-Garcia et al. (2024) investigated the phenomenon of homicide in Colombia's urban areas, highlighting how illegal markets, impoverished labor conditions, and unequal wealth distribution contribute to heightened homicide rates. Using a sample from Colombia's 32 departmental capitals and applying multivariate statistical tools such as Partial Least Squares Structural Equation Modeling (PLS-SEM), the study found a strong association between low income, unemployment, inequality, and increased risk of homicide, supporting the findings of Dávila and Pardo-Montaño (2019), who analyzed the impact of socioeconomic factors on homicide mortality rates in Colombia from 2000 to 2014, using negative binomial fixed-effects regression models with panel data. Their research confirmed a reduction in homicide rates, particularly among men aged 15–49, attributing this trend to improvements in socioeconomic conditions. Further

investigation by González and Camacho Ballesta (2019) revealed a negative relationship between economic growth and homicide rates, whereas unemployment correlated positively with homicide, emphasizing the socioeconomic dimensions of violent crime. Montoya and Pedraza (2009) provided additional insights by examining seasonal trends in violent deaths in Bogotá from 1997 to 2006. Utilizing autoregressive integrated moving average (ARIMA) time-series models, their study identified significant associations between violent deaths and economic indicators such as the consumer price index, unemployment rates, and the total number of employed persons. The findings underscored the role of economic cycles in shaping patterns of homicidal violence, highlighting a cyclical link between socioeconomic conditions and the level of violence in urban settings.

Gender-based violence also shows significant correlations with socioeconomic vulnerabilities. Illanes et al. (2007) identified violence, economic inequalities, and discrimination as key risk factors for mental health disorders among women in Chile. Their cross-sectional study in Temuco found that 41% of women exhibited symptoms of anxiety or depression linked to factors such as severe physical violence against children, sexual violence, lack of family support networks, and unemployment. These findings underscore the intersection of socioeconomic stressors and gender-based violence, contributing to mental health issues and perpetuating cycles of violence. Similarly, research in Mexico by López-Santiago et al. (2017) examined how socioeconomic marginalization, unemployment, and declining wages contribute to the generation of violence in the municipality of Valle de Chalco Solidaridad. Their mixed-methods approach revealed that economic discontent and frustration lead to various forms of violence, emphasizing the need for integrated policies that address economic and social vulnerabilities to mitigate violence.

The COVID-19 pandemic exacerbated existing vulnerabilities, leading to increased violence, particularly against women and marginalized groups. In Colombia, Angarita (2022) noted an increase in reports of gender-based violence and unemployment among women during the pandemic, highlighting a silent epidemic fueled by quarantine measures and economic instability. Ruiz-Pérez and Pastor-Moreno (2021) reviewed measures in Spain and other countries, stressing the importance of economic interventions to comprehensively prevent gender-based violence, as economic hardship and increased domestic burdens amplify vulnerabilities.

Understanding Violence in Ecuador: A Multivariate Approach:

Ecuador has faced significant public security challenges in recent years, with rising rates of murders, femicides, homicides, and hired killings. This study focuses on the period from 2019 to 2022, a time of social and political complexity exacerbated by the COVID-19 pandemic. Research indicates that violence in Ecuador manifests differently across populations and regions and is influenced by factors such as age, education, ethnicity, and socioeconomic status (Arias Fuentes et al., 2022; Ramirez et al., 2021). Territorial disputes, gang conflicts, and the pervasive impact of poverty and unemployment further complicate the violent landscape (Paetau, 2019). Studies have consistently highlighted a significant interaction between socioeconomic variables and violence. Economic hardship, such as high foreclosure and unemployment rates, has been linked to higher rates of various forms of violence including child abuse and

intimate partner violence (Koulani et al., 2023; Santaularia et al., 2023). The quality of life of married women is significantly affected by the interplay between socioeconomic status and domestic violence (Ejlskov et al., 2023). Evidence from Iran shows that economic growth and female employment rates affect violent crime rates, suggesting that economic variables are crucial in shaping violent behavior (Koulani et al., 2023).

Theories on the Relationship Between Unemployment and Violence:

Various theories explain how unemployment is related to violence. Strain theory suggests that unemployment generates stress and frustration by limiting economic and social opportunities, which can lead to violent behavior in response to these tensions (Agnew, 1992). On the other hand, subcultural theory proposes that chronic unemployment and poverty can foster the creation of criminal subcultures where violence becomes an accepted norm (Anderson, 1999). Additionally, from an economic perspective, unemployment can increase crime rates due to a reduction in opportunity costs for individuals involved in criminal activities (Becker, 1968). However, the exact relationship between unemployment and violence is not always straightforward and may vary depending on factors such as the cultural context, social policies, and the structure of the labor market.

Applying the HJ-Biplot Technique to Ecuador's Socioeconomic and Criminological Context:

This study employs HJ-Biplot, an advanced multivariate technique, to explore the complex dynamics between unemployment and various forms of violence in Ecuador. The capability of the HJ-Biplot to visually represent multiple variables in a two-dimensional space allows for an intuitive understanding of the relationships between socioeconomic conditions and violence. This approach aims to uncover patterns and correlations that can inform targeted policy interventions and integrate socioeconomic and criminological perspectives to effectively mitigate violence (Díaz-Faes et al., 2013b; Gómez-Marcos et al., 2022).

Public Policy Implications:

The role of public policies in preventing violence cannot be overstated. Legislative initiatives, social intervention programs, and judicial reforms are essential to creating safer societies (Hyman et al., 2023). However, policy effectiveness is often hampered by inconsistencies, inadequate implementation, and poor adaptation to local reality (Browne et al., 2023; Mathieu, 2023). Addressing these gaps through coherent and locally adapted policies is crucial for enhancing the efficacy of interventions, as evidenced by studies on malnutrition policies in Nigeria and Burkina Faso (Billings et al., 2021) and climate change adaptation measures in Nepal (Darjee et al., 2021).

2. Methodology

The study covers the period from 2019 to 2022. The data were obtained from the Ecuadorian Observatory of Organized Crime (OECO, n.d.) and the Open Data Bank of INEC (OECO, n.d.):

- Source of Unemployment Data: Unemployment data were obtained from the National Institute of Statistics and Censuses (INEC) of Ecuador. INEC provides both annual and quarterly unemployment rates broken down by province, using

household surveys and economic censuses.

- Source of Violence Data: Data on homicides, femicides, murders, and contract killings were sourced from the Ecuadorian Observatory of Organized Crime (OECO), which compiles reports from the national police and other official public security sources.
- Operationalization of Concepts: It is essential to clearly describe how the variables have been operationalized in this study. Below is an example of how this section can be drafted:
    - Unemployment: Unemployment is measured as the annual unemployment rate, representing the percentage of the economically active population that is unemployed and actively seeking work. The data have been standardized to facilitate comparisons across provinces and over different years.
    - Homicides, Femicides, Murders, and Contract Killings: The violence-related variables are measured in absolute terms, indicating the number of reported incidents for each type of crime (homicides, femicides, murders, and contract killings) per year in each province. These data have been normalized using the total population of each province to obtain incidence rates per 100,000 inhabitants, enabling more meaningful comparisons across different regions and time periods.

The unemployment and violence variables were standardized by columns. This standardization ensures that different units of measurement do not affect the results, and that each variable has a comparable impact on the graphical representation. Unemployment rates were represented as vectors in the biplot, while incidents of violence were shown in relation to specific provinces and years, allowing for a clear visualization of associations and patterns.

The multivariate technique chosen for the analysis was a biplot, which is useful for visualizing the relationship between variables and observations (Gómez-Marcos et al., 2022). In a biplot plot, the rows are represented by dots, while the columns are shown asvectors, providing a visual representation of the relationships between them in a two- dimensional plane. Arrows in the plot indicate both the direction and magnitude of the vectors.

In this study, we chose to use the HJ-Biplot, which guarantees the best quality of representation according to Galindo (1986). In addition, this approach facilitates the most efficient and complete exploration of the relationships between observations and variables (Gómez-Marcos et al., 2022).

The HJ-Biplot is based on the Singular Value Decomposition (SVD) of the data matrix. Suppose we have a data matrix X of size $n \times p$, where n is the number of observations and p is the number of variables. The SVD of X can be written as:

$$X = UDV^T \quad (1)$$

- U is an orthogonal matrix of size $n \times n$ containing the eigenvectors of XX^T
- D is a diagonal matrix of size $n \times p$ containing the non-negative singular values ordered in decreasing order.
- V is an orthogonal matrix of size $p \times p$ containing the eigenvectors of X^TX.

3. Construction of the HJ-Biplot

In the HJ-Biplot, a truncated version of the Singular Value Decomposition is used to reduce dimensionality and project the data into a two-dimensional space. The truncated version of X is represented as:

$$X \approx \{U\}_2\{D\}_2\,\{V\}_2^T \tag{2}$$

Here, $U2, D2\ and\ V2$ are reduced matrices that capture the two most important dimensions.

Projection Matrices *H* and *J*:

- Projection Matrix *H*: The matrix *H* is defined as $H = U_2D_2$. This matrix provides the projected coordinates of the rows of the original matrix *X* in the two-dimensional space. The rows of *H* represent the observations in the reduced space. In other words, each point in the HJ-Biplot corresponding to an observation is obtained by projecting the rows of *X* using *H*.
- Projection Matrix *J*: The matrix *J* is defined as $J = V_2$. This matrix provides the projected coordinates of the columns of the original matrix *X*. The columns of *J* represent the variables in the reduced space. In other words, each vector in the HJ-Biplot corresponding to a variable is obtained by projecting the columns of *X* using *J*.

For this study the representation of the graph (HJ-Biplot) is understood as follows: 1) Provinces for the rows. 2) Variables (Murders, Femicides, Homicides, Contract Killings, and Unemployment) for the columns (**Figure 1**).

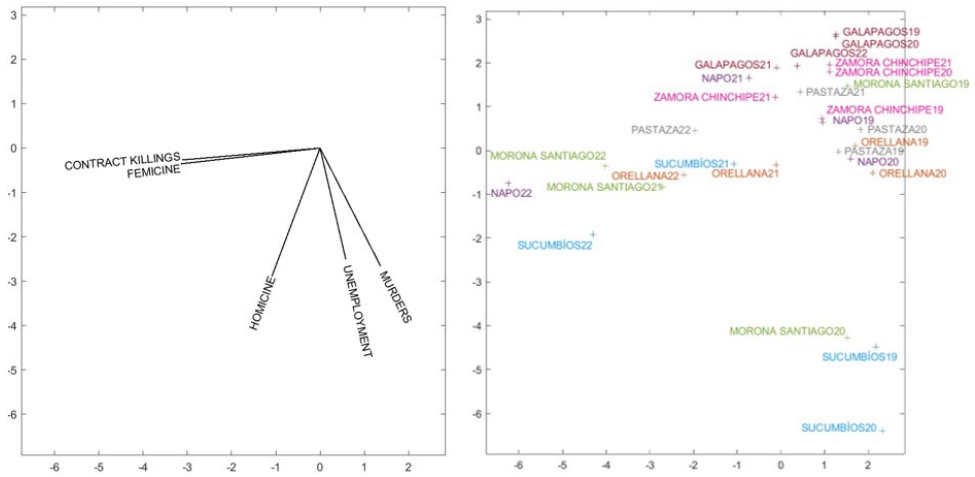

Figure 1. HJ Biplot.

An HJ-Biplot is interpreted as follows: 1) The proximity between observations (provinces) denotes the similarity between them. 2) The length of the vectors reflectsthe magnitude of the standard deviation of the factors. 3) The cosine of the angle between the vectors describes the association between variables: acute angles indicate direct correlation, obtuse angles indicate inverse correlation and right angles indicate independence. 4) The orthogonal projections of the rows onto the vectors indicate an optimal representation on that vector; the smaller the projection, the better therepresentation (Díaz-Faes et al., 2013a).

The data analysis was performed with the MultBiplot program developed by

Vicente- Villardón in 2010, MultBiplot is a MATLAB matrix-oriented programming environment.

The data have transformed: they have been standardized by column to address the different units of measurement of the variables. The quality of representation for the matrices was greater than or equal to 500, thus highlighting the relevance of the representation of the provinces in biplots.

4. Results

HJ Biplot: In the graphical representation using HJ-Biplot, the variables analyzed —murders, femicides, homicides, contract killings, and unemployment—will be illustrated through vectors. Each province, along with the specific year of the study, will be clearly marked.For example, "Guayas 19" will refer to data corresponding to the province of Guayas in 2019.

This approach allows for an accurate visualization of the relationships between the different variables, facilitating the understanding of the dynamics in each region and period analyzed. Clarity in the presentation of data is essential to identify patterns and trends that can inform effective policies and strategies to address the problems of violence and unemployment.

By labeling the provinces with their respective year of study, it ensures that each pieceof data is correctly contextualized, allowing for a temporal evaluation that is fundamental to understanding the evolution of the observed phenomena. This methodology reinforces the accuracy and usefulness of the analysis, providing a solid basis for informed decision-making and the implementation of effective solutions to the problems of violence and unemployment in the different provinces analyzed.

Coast Region: The results obtained through the HJ Biplot analysis of the provinces ofthe Coastal region indicate a complex dynamic between violence and unemployment during the 2019–2022 period. The cumulative inertia of axes 1 and 2 stands at 82.35%, providing a significant representation of the evolution of both phenomena. There is a marked correlation between femicides and contract killings, while unemployment has a stronger association with homicides and, to a lesser extent, with murders. In addition, it is observed (**Figure 2**) that the relationships between unemployment and both femicides and contract killings are minimal.

During 2019 and 2020, provinces such as El Oro, Esmeraldas, Guayas, Los Ríos, Manabí, and Santo Domingo de los Tsáchilas were characterized by high numbers of murders and significant unemployment. However, in 2021 and 2022, an increase incases of femicides and hired killings was observed. Santa Elena and Santo Domingo de los Tsáchilas, on the other hand, showed consistent and stable profiles throughout the period analyzed.

Focusing on specific provinces, El Oro showed high homicide and murder figures in the2019–2020 period, with averages of 18 and 67.5 victims respectively, placing it as the province with the second highest rates in the region. Significantly, the unemployment rate in this period reached 46.21%, also being the second highest. In the followingyears, 2021 and 2022, there was an alarming increase in femicides and contract killings, with averages of 441 and 15.5 cases respectively, maintaining its position in these unfavorable statistics, although with an approximate 10%

reduction in the unemployment rate.

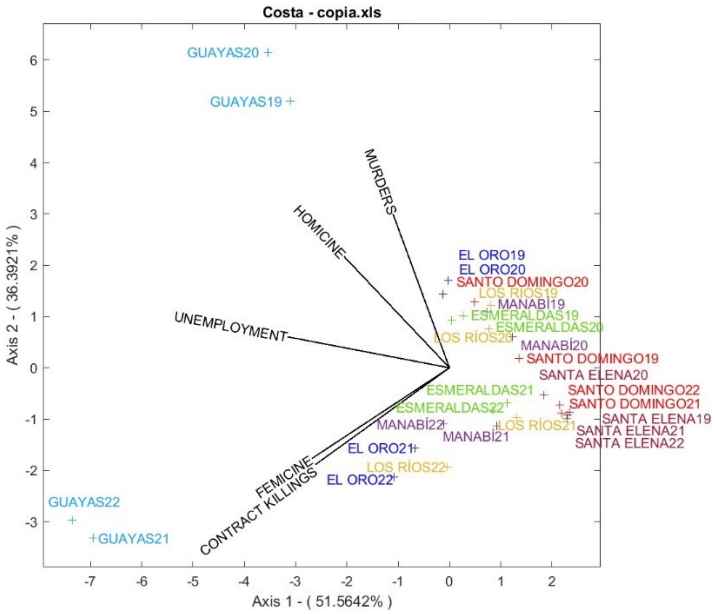

Figure 2. HJ Biplot: Coast region, axes 1–2.

For its part, the province of Guayas presented the highest numbers of murders and homicides between 2019 and 2020, with 429.5 and 22.5 cases respectively, and an unemployment rate of 4.08%. This trend continued in 2021 and 2022, with Guayas leading in the number of reported femicides and murders, reaching 1336 and 36.5 cases respectively. During the latter period, the province faced a 7.42% decrease in the employment rate, reflecting additional economic challenges.

Highlands region: In the highlands region, the HJ Biplot analysis (**Figure 3**) exhibits a cumulative inertia of 87.95% on axes 1 and 2, indicating a sufficient representation of the evolution of violence and unemployment between 2019 and 2022. This analysis reveals significant associations between contract killings, femicides, and unemployment, especially linked to homicides, although the connections between unemployment, femicides, and hired assassinations are limited. An inverse correlation is observed between murdersand hired killings. Except for Pichincha, the provinces of the Highlands follow a pattern of change like violence, like that observed in the Costa, movingfrom murders to femicides and contract killings from 2019 to 2022.

Within this region, the province of Azuay registered a high incidence of murders in2020 and 2021, with an average of 15 victims, one of the highest figures in the Highlands. During this same period, the unemployment rate in Azuay decreased by approximately 12%. Pichincha stands out as the only province with a constant dual characterization throughout the time studied, significantly represented by the number of homicides and unemployment. On average, 29 people were victims of homicides annually, the highest rate in the region, accompanied by an increase in the unemployment rate of 11.07%.

By 2022, Azuay, Loja, Imbabura, Cañar, Chimborazo, and Cotopaxi were characterized by high femicide and murder rates. Imbabura, Cotopaxi, and Cañar had the highest femicide rates, with averages of 30, 23.25, and 25.5 respectively. On the other hand,Loja and Azuay reported the highest numbers of murders in the region,

with averages of 5 and 2.25 victims respectively.

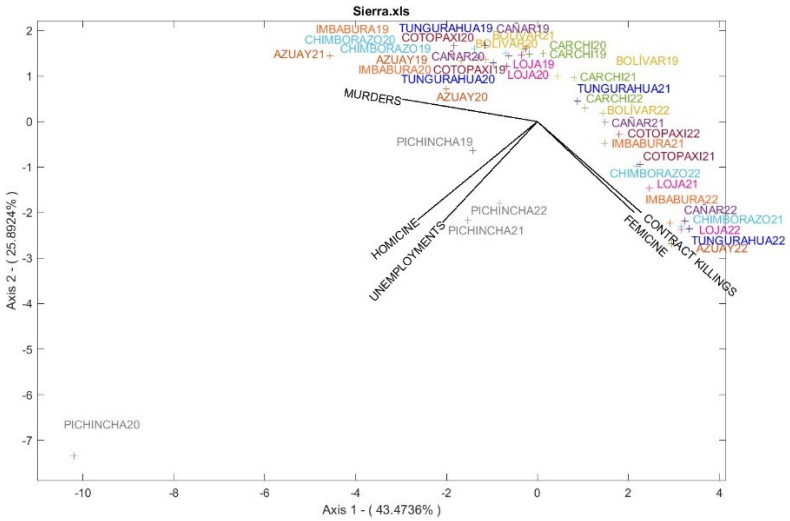

Figure 3. HJ Biplot: Highlands region, axes 1–2.

East and Insular Region: **Figure 4**, dedicated to the East and Insular region, exhibits a cumulative inertia of 78.76%, which provides a clear and detailed picture for the analysis of violence and unemployment in this region. This high percentage of cumulative inertia implies that the main axes of the analysis capture most of the variability in the data, providing an accurate and meaningful representation of the phenomena studied.

A notable connection between hired assassinations, femicides, and unemployment is highlighted, showing a particularly strong linkage with homicides and even more so with murders. This suggests that in the East region, extreme violence and unemployment are intrinsically related, creating a vicious cycle where one situation exacerbates the other. Conversely, the relationships between unemployment and femicides and contract assassinations are scarce, which could indicate that factors other than unemployment play a more crucial role in the incidence of these specific types of violence.

Consistent with patterns observed in other regions of the country, the 2019–2020 periodin the East region was marked by a significant prevalence of murders. This period was characterized by a high homicide rate, reflecting a worrying trend in terms of security and social stability. However, the years 2021 and 2022 saw a change in this dynamic, with a notable increase in the cases of femicides and contract killings. This change could be related to several variables, includingeconomic, social, and legislative changes affecting the region.

During 2020 and 2021, the province of Sucumbíos was distinguished by high murder rates, with an annual average of 24 victims. This figure places Sucumbíos as one of the provinces with the highest incidence of homicides in the region, reflecting seriousproblems of violence that require urgent attention.

Morona Santiago experienced the largest increase in unemployment in the region in 2020, with an alarming increase of 168%. This drastic increase in the unemploymentrate could be linked to economic and social instability, exacerbating problems of violence in the province.

In 2021 and 2022, Morona Santiago, Orellana, Sucumbíos, and additionally Napo in 2022, were the provinces most affected by murders and femicides. The highest numbers of femicides were recorded in these provinces, with Napo being the most impacted in 2022 with an average of 78.75 victims. It was followed by Sucumbíos with 62.25 victims, Morona Santiago with 39.25 and Orellana with 31.75 on average.

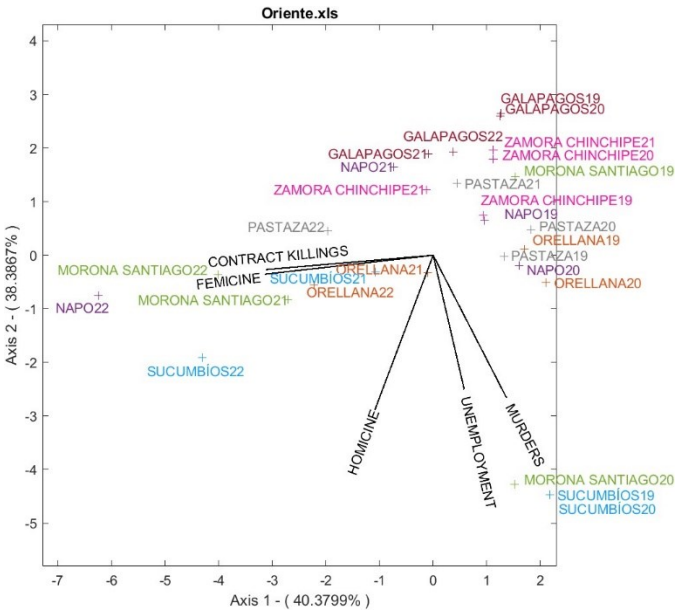

Figure 4. HJ Biplot: East and insular region, axes 1–2.

5. Discussion

The objective of this study is to analyze the correlation between unemployment ratesand the incidence of murders, femicides, homicides, and contract killings in Ecuador, to understand the socioeconomic dynamics underlying these forms of violence, and to propose recommendations for public policies to mitigate these phenomena. The HJ Biplot was optimal for capturing the complexity of the relationships between unemployment and different types of violence in each region.

The results presented in **Figures 1–3** show the complex dynamics of violence in Ecuador, evidencing the varied impact of unemployment on different violent crimes, as evidenced by Donoso et al. (2022) significant increase in violent crime throughout the country, particularly due to the strengthening of street gangs and drug cartels.

The correlation between contract killings and femicides suggests common underlying factors that could include power structures and gender. Femicide, which constitutes a significant portion of female homicide mortality, often occurs within relational dynamics where the perpetrator is usually a man (Whittington et al., 2023). Femicide is closely linked to gender-based violence, which requires its recognition as a distinct problem with unique characteristics (Walby, 2023). The evolving relationship between social structures and crime, particularly in terms of gender interactions, further underscores the changing explanatory power of known covariates of homicide overtime, highlighting the complex interplay between gender, power, and crime dynamics (Corradi et al., 2016).

The strong and direct relationship between murders and unemployment in our

results highlights the influence of economic conditions on public safety. The relationshipbetween murders and unemployment is not always straightforward, as several studies indicate. While some research suggests a significant impact of economic conditions on crime rates, including murders, other studies show that the association between crime and economic factors can be complex and dynamic (Zungu and Mtshengu, 2023). Moreover, the temporal stability of models linking unemployment and crime varies overtime, indicating a nuanced relationship (Ha et al., 2020). Furthermore, the response of crime rates to economic conditions, such as unemployment, has been found to bepositive, but not necessarily asymmetric in different economic cycles (Calvó-Armengol et al., 2007). Overall, while economic factors such as income inequality and unemployment may influence crime rates, the relationship between murders and unemployment is multifaceted and influenced by a variety of social, economic and policy-related factors.

In contrast, the weaker link between unemployment and homicides, as suggested by research, indicates that other factors such as personal conflicts or disputes may play a more important role in these cases. Studies have shown that while there is a relationship between unemployment and crime, it may not be as strong for violent crimes such as homicides (Herrera Giraldo et al., 2023).

In addition, research highlights that the incidence of homicides may increase disproportionately relative to other types of death during specific stages of the economiccycle, indicating a complex interplay of factors (Pappa et al., 2019). The characteristically weak relationship between unemployment and contract killings indicates thatorganized crime and broader conflicts associated with hired killings may be relativelyindependent of immediate economic conjunctures. While unemployment is traditionally linked to crime rates, studies focused on organized crime offenders have shown that employment may promote criminality in these groups (Frederick et al., 2016). Moreover, the dynamics of sicarios in the context of violence related to drug trafficking and criminal organizations in cities such as Cali have evolved independently of simple economic factors, showing a more complex relationship between crime and economic conditions (van Koppen et al., 2022). This indicates that organized crime and conflicts involving hired assassins may have deeper roots and motivations that go beyond economic circumstances, highlighting the multifaceted nature of criminal activities.

The evolution of the pattern of violence in the Costa region, from murders and unemployment in 2019–2020 to a focus on femicides and contract killings in 2021–2022, suggests changes in the underlying socioeconomic dynamics. Santa Elena is presentedas an exception, evidencing the possible influence of local factors such as security policies or community cohesion on the stability of violence patterns.

In the East region, a similar trend is observed with a transition in the dominant types of violence from 2019 to 2022. The association between unemployment and lethal violence underscores the potential economic causality behind the violence, while the weak relationships between unemployment and femicides or contract killings highlight the influence of cultural, social or organized crime factors beyond mere economic conditions (van Koppen et al., 2022; Whittington et al., 2023).

The results highlight significant patterns and changes like violence inEcuador,

showing pronounced regional and temporal differences. These results highlight the urgent need for nuanced public policies that transcend the economic causesof violence to encompass its social, cultural and structural complexities. The formulation and implementation of tailored and targeted policies are critical to addressing the multifaceted causes of violence.

Violence in the country, capturing the variety of its expressions in different regions and over time.

6. Conclusion

This study revealed the relationship between unemployment and various forms of violence in Ecuador, using HJ-Biplot analysis to investigate these dynamics from socioeconomic and criminological perspectives. The research showed that while unemployment has a significant impact on various types of violence, including murders,femicides, homicides and contract killings, the influences differ considerably across regions and over time. The patterns identified show a complex connection, where unemployment is strongly associated with homicides and murders, while its relationship with femicides and contract killings is much weaker and almost nonexistent.

The variability in the incidence of these violent crimes at the regional level highlightsthe need for tailored policies that focus not only on economic but also on social, culturaland structural dimensions. The changes observed in the patterns of violence, in particular the shift from a predominance of murders and unemployment in 2019–2020 to an increase in femicides and contract killings in 2021–2022, emphasize the importance of dynamic public policies capable of responding to the specific conditions and needs of each region and the changing dynamics of patterns of violence.

The exceptions in certain provinces, such as Santa Elena and Pichincha, where patterns of violence and unemployment differ from the rest, highlight the importance of implementing local strategies in policymaking. This indicates that, in addition to national actions, it is essential to implement regional and community-based interventions that specifically address the underlying causes of violence and unemployment in these contexts.

In conclusion, this socioeconomic and criminological analysis through the HJ-Biplot hasoffered valuable insights into how unemployment interacts with violence in Ecuador, highlighting the urgent need for informed and nuanced public policies. To effectively combat violence, the country must adopt a holistic approach that combines economic measures with strategies that confront the social, cultural and structural complexities, ensuring that these policies are sensitive toregional differences and adjust to emerging trends.

6.1. Study limitations

Despite the significant findings, this study has several limitations that should be considered:

1) Limited Study Period: The research focuses on a relatively short period, from 2019 to 2022. This limited time frame may not fully capture long-term trends or

fluctuations in the relationship between unemployment and violence, especially considering broader economic and social changes, such as the effects of the COVID-19 pandemic.

2) Aggregated Data at the Provincial Level: The use of aggregated data at the provincial level may conceal important variations at a more local level, such as differences between urban and rural areas. This could limit the understanding of how unemployment and other factors influence violence in different local contexts.

3) Lack of Additional Contextual Variables: Although the study focuses on unemployment and certain types of violence, it does not incorporate other variables that could be relevant for a better understanding of these phenomena, such as education, access to mental health services, or the effectiveness of public security policies. Including these variables could provide a more comprehensive view of the factors influencing violence.

4) Focus on Correlation, Not Causation: The use of HJ-Biplot allows for the analysis of correlations, but it cannot establish definitive causal relationships between unemployment and violence. A deeper analysis and additional methodologies are required to determine the causal mechanisms.

6.2. Areas for future research

1) Longitudinal Studies and Time Series Analysis: Future research could benefit from extending the study period to include more years, allowing for the analysis of long-term trends and the impacts of economic fluctuations on violence.

2) Micro-Regional Analysis: Including data at the city or neighborhood level would allow for a more detailed and precise analysis of how unemployment and other factors affect different communities. This could help identify more specific and effective interventions.

3) Incorporation of Additional Variables: Future studies could incorporate additional factors, such as the quality of education, social cohesion, and the presence of violence prevention programs, to gain a more comprehensive understanding of the dynamics of violence.

4) Causal Studies: Using causal analysis methods, such as natural experiments or structural equation models, could help identify the exact pathways through which unemployment influences violence, providing a stronger basis for public policy development.

Author contributions: Conceptualization, DAPG and FPEO; methodology, DAPG; software, DAPG; validation, FPEO, EJES and DJCD; formal analysis, DAPG; investigation, FPEO; resources, DJCD; data curation, DAPG; writing—original draft preparation, CSHD; writing—review and editing, CSHD; visualization, DAPG; supervision, EJES; project administration, EJES; funding acquisition, EJES. All authors have read and agreed to the published version of the manuscript.

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References

Agnew, R. (1992). Foundation for a general strain theory of crime and delinquency. Criminology, 30(1), 47-88.

Al, R. I. C. M. et. (2023). Analysis Of Guillermo Lasso's Government Proposal To Combat The High Rate Of Insecurity In The Country And Its Existing Legal Framework. Russian Law Journal, 11(8s), Article 8s. https://doi.org/10.52783/rlj.v11i8s.1294

Anderson, E. (1999). Code of the Street: Decency, Violence, and the Moral Life of the Inner City. W.W. Norton & Company.

Angarita, D. M. P. (2022). Gender violence in Colombia: Silent epidemic amid Covid. Revista Latinoamericana de Ciencias Sociales, Ninez y Juventud, 20(2). Scopus. https://doi.org/10.11600/rlcsnj.20.2.E04

Arias Fuentes, F. F., Arteaga, E., & San Sebastián, M. (2022). Social inequalities in women exposed to obstetric and gyneco-obstetric violence in Ecuador: A cross-sectional study. BMC Women's Health, 22(1), 419. https://doi.org/10.1186/s12905-022-01998-2. https://doi.org/10.1186/s12905- 022-01998-2

Becker, G. S. (1968). Crime and Punishment: An Economic Approach. Journal of Political Economy, 76(2), 169-217.

Billings, L., Pradeilles, R., Gillespie, S., Vanderkooy, A., Diatta, D., Toure, M., Diatta, D., & Verstraeten, R. (2021). Coherence for nutrition: Insights from nutrition- relevant policies and programmes in Burkina Faso and Nigeria. Health Policy and Planning, 36(10), 1574-1592. https://doi.org/10.1093/heapol/czab108.

Browne, K., Dzebo, A., Iacobuta, G., Faus Onbargi, A., Shawoo, Z., Dombrowsky, I., Fridahl, M., Gottenhuber, S., & Persson, Å. (2023). How does policy coherence shape effectiveness and inequality? Implications for sustainable development and the 2030 Agenda. Sustainable Development, 31(5), 3161-3174. https://doi.org/10.1002/sd.2598.

Bryant, L., & Lightowlers, C. (2021). The socioeconomic distribution of alcohol-related violence in England and Wales. PLOS ONE, 16(2), e0243206. https://doi.org/10.1371/journal.pone.0243206

Calvó-Armengol, A., Verdier, T., & Zenou, Y. (2007). Strong and weak ties in employment and crime. Journal of Public Economics, 91(1), 203- 233. https://doi.org/10.1016/j.jpubeco.2006.05.011

Corradi, C., Marcuello-Servós, C., Boira, S., & Weil, S. (2016). Theories of femicide and their significance for social research. Current Sociology, 64(7), 975-995. https://doi.org/10.1177/0011392115622256

Darjee, K. B., Sunam, R. K., Köhl, M., & Neupane, P. R. (2021). Do National Policies Translate into Local Actions? Analyzing Coherence between Climate Change Adaptation Policies and Implications for Local Adaptation in Nepal. Sustainability, 13(23), Article 23. https://doi.org/10.3390/su132313115.

Dávila, C. A., & Pardo-Montaño, A. M. (2019). Socioeconomic factors associated with the death rate by homicide in colombia, 2000-2014. Ciencia e Saude Coletiva, 24(8), 2793-2804. Scopus. https://doi.org/10.1590/1413-81232018248.29142017

Díaz-Faes, A. A., González-Albo, B., Galindo, M. P., & Bordons, M. (2013a). HJ- Biplot as a tool for inspection of bibliometric data matrices. Revista Espanola de Documentacion Cientifica, 36(1). Scopus. https://doi.org/10.3989/redc.2013.1.988

Díaz-Faes, A. A., González-Albo, B., Galindo, M. P., & Bordons, M. (2013b). HJ-Biplot as a tool for inspecting bibliometric data matrices. Journal española de Documentación Científica, 36(1), e001. https://doi.org/10.3989/redc.2013.1.988

Donoso, M. E. A., Maurisaca, N. E. C., & Reyes, J. E. A. (2022). Multiple Correspondence Analysis for the Study of Intentional Homicides in Ecuador. Revista Politécnica, 50(3), Article 3. https://doi.org/10.33333/rp.vol50n3.04

Ejlskov, L., Antonsen, S., Wulff, J. N., Agerbo, E., Plana-Ripoll, O., Sabel, C. E., Fan, C. C., Thompson, W. K., Mok, P. L. H., Pedersen, C. B., & Webb, R. T. (2023). Multilevel interactions between family and neighbourhood socioeconomic indices in childhood and later risks of self-harm and violent criminality in Denmark: A national cohort study. The Lancet Public Health, 8(2), e99-e108. https://doi.org/10.1016/S2468-2667(22)00292-4

Frederick, S. A., Jozefowicz, J., & Nelson, Z. T. (2016). A dynamic panel data study of the unemployment-crime relationship: The case of Pennsylvania. 36, 1497-1507.

Galindo-Villardón, P. (1986). An alternative simultaneous representation: HJ-Biplot. Questiió: Quaderns d'Estadística, Sistemes, Informatica i Investigació Operativa, 10(1), 13-23. Gómez-Marcos, M. T., Vicente-Galindo, M. P., & Rodero, H. M. (2022). Is the Shanghai Ranking a guarantee of high academic performance? Spanish Journal of Scientific Documentation, 45(1). Scopus. https://doi.org/10.3989/redc.2022.1.1805

González, B. M., & Camacho Ballesta, J. A. (2019). Evaluation of the economic consequences of occupational segregation by age in Spain IDAD SOCIAL. Journal of the Ministry of Employment and Social Security, 141, 219-249. Scopus.

Ha, O. K., Andresen, M. A., & Davies, G. (2020). The Temporal (In)Stability of the Unemployment and Crime Relationship. International Journal of Offender Therapy and Comparative Criminology, 64(8), 840-859. https://doi.org/10.1177/0306624X19896454

Herrera Giraldo, M. F., González Espitia, C. G., & Ochoa Díaz, H. (2023). The spatial and economic relationship between labour informality and homicides in Cali, Colombia. Development Policy Review, 41(5), e12709.

https://doi.org/10.1111/dpr.12709. https://doi.org/10.1111/dpr.12709.

Hyman, I., Vahabi, M., Bailey, A., Patel, S., Guruge, S., Wilson-Mitchell, K., & Wong, J. P.-H. (2023). Taking action on violence through research, policy, and practice. https://doi.org/10.32920/14642148.v1

Illanes V, E., Bustos M, L., Vizcarra L, M. B., & Muñoz N, S. (2007). Social and familial determinants of anxiety and depressive symptoms in middle to low income women. Revista Medica de Chile, 135(3), 326-334. Scopus.

Jimenez-Garcia, W. G., Arenas-Valencia, W., & Bohorquez-Bedoya, N. (2024). Understanding homicide in Colombian capital cities. A vulnerability study. Latin American Research Review, 59(1), 19-38. Scopus. https://doi.org/10.1017/lar.2023.46

Koulani, M., Rajabi-Gilan, N., Almasi, A., Khezeli, M., Shushtari, Z. J., & Salimi, Y. (2023). Socioeconomic Status and Domostic Violence Interact in Perdict of Quality of Life in Married Women: A Population-Based Study in Westeren Iran. Journal of Family & Reproductive Health, 17(1), 29-36. https://doi.org/10.18502/jfrh.v17i1.11974. https://doi.org/10.18502/jfrh.v17i1.11974

López-Santiago, M. A., Hernández-Juárez, M., & León-Merino, A. (2017). Marginalization and exclusion as possible socio-economic factors of urban violence: The Valle de Chalco Solidaridad, state of Mexico case. Papeles de Poblacion, 23(91), 171-199. Scopus. https://doi.org/10.22185/24487147.2017.91.008

Mathieu, E. (2023). Policy coherence versus regulatory governance. Electricity reforms in Algeria and Morocco. Regulation & Governance, 17(3), 694-708. https://doi.org/10.1111/rego.12488

Montoya, J. M., & Pedraza, R. S. (2009). Death from violent causes and economic cycles in Bogota, Colombia: A time-series study, 1997-2006. Journal Pan American Journal of Public Health/Pan American Journal of Public Health, 26(1), 23-30. Scopus.

OECO. (n.d.). Data viewer (Spanish). Available online: https://oeco.padf.org/visualizador-de-datos-denuncias-de-delitos-graves/ (accessed on 20 May 2024).

Paetau, M. (2019). The Colombian peace process and the complexity of violence: A sociocybernetic observation. Current Sociology, 67(4), 611-624. https://doi.org/10.1177/0011392119837570

Pappa, E., Lagerborg, A., & Ravn, M. O. (2019). Does economic insecurity really impact on gun violence at US schools? Nature Human Behaviour, 3(3), 198- 199. https://doi.org/10.1038/s41562-018-0351-2

Ramirez, M. R., Flores, J. E., Cheng, G., Peek-Asa, C., & Cavanaugh, J. E. (2021). Approach to analysing correlated contextual factors: An application for studies on violence. Injury Prevention, 27(2), 161-165. https://doi.org/10.1136/injuryprev-2020-043967

Reivan Ortiz, G. G., Yanza, R., Campoverde, X., Estrada Cherres, J. P., Reinoso García, L. P., Diaz, J., & Granero Pérez, R. (2023). A predictive model of perceived stress during the first wave of the COVID-19 pandemic in university students Ecuadorians. Frontiers in Psychiatry, 14. https://doi.org/10.3389/fpsyt.2023.1202625. https://doi.org/10.3389/fpsyt.2023.1202625

Ruiz-Pérez, I., & Pastor-Moreno, G. (2021). Measures to contain gender-based violence during the COVID-19 pandemic. Gaceta Sanitaria, 35(4), 389-394. Scopus. https://doi.org/10.1016/j.gaceta.2020.04.005

Santaularia, N. J., Ramirez, M. R., Osypuk, T. L., & Mason, S. M. (2023). Economic Hardship and Violence: A Comparison of County-Level Economic Measures in the Prediction of Violence-Related Injury. Journal of Interpersonal Violence, 38(5-6), 4616-4639. https://doi.org/10.1177/08862605221118966. https://doi.org/10.1177/08862605221118966

van Koppen, V., van der Geest, V., Kleemans, E., & Kruisbergen, E. (2022). Employment and crime: A longitudinal follow-up of organized crime offenders. European Journal of Criminology, 19(5), 1097-1121. https://doi.org/10.1177/1477370820941287

Walby, S. (2023). What is femicide? The United Nations and the measurement of progress in complex epistemic systems. Current Sociology, 71(1), 10- 27. https://doi.org/10.1177/00113921221084357

Whittington, R., Haines-Delmont, A., & Bjørngaard, J. H. (2023). Femicide trends at the start of the 21st. century: Prevalence, risk factors and national public health. actions. Global Public Health, 18(1), 2225576. https://doi.org/10.1080/17441692.2023.2225576.

Zungu, L. T., & Mtshengu, T. R. (2023). The Twin Impacts of Income Inequality and Unemployment on Murder Crime in African Emerging Economies: A Mixed Models Approach. Economies, 11(2), Article 2. https://doi.org/10.3390/economies11020058.