Abstract

Security services offer depends on the demand of that services. The changes of homicides across time affects the amount of resources required to offer security services. The planning and control of police services operation can be characterized through fixed and variable components for many geographical areas. In this text, cyclical components are identified since 2010 to 2020 for the criminal murder identification by police force corps. To accomplish that it is used open source or public information from information system SIEDCO offered by the Colombian National Police. Then it is used a regression model with categorical variables for this data base over dates and quantities from a national criminal murder point of view. From these models coefficients are obtained for the year and week of the facts.

Keywords
Criminal Murder, cyclicity, Justice Service, Colombia, Public Policy.
1. Introduction
Manage and analysis of information are fields that have been studied vastly in the XX and XXI centuries. It is right that fundamentals of information management can be traced from XVIII and XIX centuries using Fourier Methods but, its diffusion, use and automatization on enterprises, organization and institutes has yet a huge field of usage, implementation and adequation on the provision of justice services related with homicide records. For some periods of the 20th century Colombia has been the country with more homicides of the world. For that reason, identifying the cyclical components of this phenomena at the subnational territorial level can be useful for sourcing assignment, provision, prediction, available personal assignation for dissuasion activities and prevention.

1.1 Objectives
Identifying cyclical components for homicides in Colombia at national level. Estimate the contribution of the administrative records of homicides at a sub national level.

2. Literature Review
The modified ARIMA statistical models and its related with computational learning techniques are used for estimating and forecasting of crime behavior (Boppuru & Ramesha, 2020) presented on aggregate or percentage level (Amin et al., 2014) and, based on that they have been made specific models for homicide forecasting in Colombia for 5 years horizon based on 60 years homicide records from 1960 to 2019 (Ordonez-Eraso et al., 2020). Homicides in Colombia can be found concentrated in specific populations like syndicalist inside the diversity of power relations linked with organized crime (Dombois & Campos, 2018) or political reasons (Brauer et al., 2004), Matorc (2018) has the hypothesis that murders are related with political activity (P et al., 2015) (Romero-Rodriguez et al., 2017).

It is also so useful having models to identify the happening of these events (White et al., 2003), about this it is has appeared an interest of working with (Spelman, 2017) as it has been shown that the activity of the economic cycle causes or is associated cyclicly on homicide activity (Carranza Romero et al., 2011) even though with contradictory evidence at municipal level for specific periods where it is found that the more criminal activity the less economic activity. (Rozo, 2018) and it is too probable that with the same cyclical activity related with natural resources extraction (Romero et al., 2020) but that not as a consequence of only that causes and also not just for psychosocial causes as a different kinds of violence (Fandino-Losada, A., Guerrero, 2017), (“La Ley Justicia y Paz, Un Ej. Justicia Transic. En Colombia,” 2014), (Escobar-Echavarria et al., 2017), (Diaz et al., 2018), (Sherman, 2006), (Sandvik & Lemaire, 2017). However, it has found out cyclical behavior for criminal activity not just in Colombia but in United States and for long periods of time (Esguerra-Umaña & Parra-Ulloa, 2016) from the place that was considered to have the biggest homicide rate of the world (Cardona et al., 2005) with not just local effect but global(Raymond, 2014)(Richard, 1997).

For the above, this models could be potentially used in searching of having better public politics designs. (Correa, 2015), management of public force(Stepanyan (Gevorkyan), 2019) in an environment of frequent violence (“Polit. Violence Lat. Am.,” 2019) in or outside reconciliation processes (Seils, 2015), (Muñoz Cardona, 2016), because that needs a change on focus (Sedacca, 2019). From the point of view of the information recording it is neither found in all the territories nor all the times correct information, complete and without political bias that causes an undercording of criminal events. (Urdinola et al., 2017), both at global and latinamerican level (Le Clercq, 2016), (Le Clercq y Rodriguez, 2020).

3. Methods
From SIEDCO database from 2010 to 2020 managed by Colombian National Police it is made an aggregate database. Then an ANOVA model is used, followed by a group of regressions for temporal series for each of the records of the departments of Colombia.

4. Data Collection
Table 1 shows the number of persons registered as homicide lethal victims taken from SIEDCO managed by National Police Force Institution. The original database is on hour; the grouped database is over a diary base; the Table 1 is on annual base for each territorial main division to Colombia named Department. Table 2 shows some statistics at subnational level over monthly aggregated database by departments from 2010 to 2020. The great total is 123.457
homicides; greater numbers are to departments: Antioquia, Valle y Cundinamarca with 21,502; 21,309 and 12,723 homicides respectively.

Table 1 Number of homicides per year for each department of Colombia.

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Table 2 exposes the total sum since 2010 to 2020; over a monthly database descriptive statistics are showed: maximum, mean, minimum standard deviation; association with time is showed using Pearson correlation coefficient between time in months and quantity of criminal murders; finally probabilistic statistic are used to explore the tendencies around monthly grouped data from 132 monthly records: Kurtosis coefficient, Asymmetry coefficient and Near to normality classification.

Table 2 displays Pearson correlation coefficient; values less than -0.30 are for the departments: Boyacá, Caldas, Caquetá, Córdoba, Guaviare, Huila Magdalena, Meta, Quindio, Risaralda, Santander and Tolima. It means that for that departments in different proportion and quantity the more the time the less the homicides. In the other hand and opposite departments with a correlation more than 0.3 are: Atlántico, Bolívar, Cauca, Chocó, Cundinamarca, Guainia, Norte de Santander, San Andrés, Sucre and Vaupés. It means that the more the time the more the homicides. Departments that present a random behavior and no tendency in homicides are: Antioquia, Atlántico, Casanare, Cesar, Guajira, Nariño, Putumayo, Valle, Vichada and national total criminal murder record. Also this table shows curtosis
and asymmetry coefficients for identifying normal distribution presence: absolute values to both standardized curtosis and asymmetry less to 0, 60 are classified near to normality.

Table 2: Descriptive statistics for the number of homicides for each department of Colombia

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<td>151</td>
<td>99</td>
<td>28.44</td>
<td>-0.095</td>
<td>0.32</td>
<td>0.11</td>
<td>Yes</td>
</tr>
<tr>
<td>Quindío</td>
<td>2.338</td>
<td>252</td>
<td>217</td>
<td>177</td>
<td>24.69</td>
<td>-0.405</td>
<td>(1.18)</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Risaralda</td>
<td>3.211</td>
<td>436</td>
<td>292</td>
<td>200</td>
<td>72.33</td>
<td>-0.969</td>
<td>(0.03)</td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>Sanandrés</td>
<td>233</td>
<td>38</td>
<td>21</td>
<td>12</td>
<td>6.71</td>
<td>0.504</td>
<td>3.92</td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td>Santander</td>
<td>3.132</td>
<td>346</td>
<td>285</td>
<td>232</td>
<td>34.99</td>
<td>-0.630</td>
<td>(0.41)</td>
<td>(0.04)</td>
<td>Yes</td>
</tr>
<tr>
<td>Sucre</td>
<td>1.455</td>
<td>160</td>
<td>132</td>
<td>109</td>
<td>16.43</td>
<td>0.297</td>
<td>(1.09)</td>
<td>0.11</td>
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</tr>
<tr>
<td>Tolima</td>
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<td>363</td>
<td>301</td>
<td>228</td>
<td>37.27</td>
<td>-0.795</td>
<td>0.46</td>
<td>(0.50)</td>
<td></td>
</tr>
<tr>
<td>Valle</td>
<td>21.502</td>
<td>2.244</td>
<td>1.955</td>
<td>1.619</td>
<td>241.66</td>
<td>-0.126</td>
<td>(1.85)</td>
<td>(0.03)</td>
<td></td>
</tr>
<tr>
<td>Vaupés</td>
<td>26</td>
<td>6</td>
<td>2</td>
<td>-</td>
<td>1.69</td>
<td>0.553</td>
<td>0.88</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td>Vichada</td>
<td>193</td>
<td>23</td>
<td>18</td>
<td>13</td>
<td>3.56</td>
<td>0.051</td>
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<td>0.20</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>123.457</td>
<td>12.610</td>
<td>11.223</td>
<td>10.046</td>
<td>933.77</td>
<td>-0.079</td>
<td>(1.61)</td>
<td>0.11</td>
<td></td>
</tr>
</tbody>
</table>

5. Results and Discussion

5.1 Numerical Results
In order to decompose the modeled information using categorical linear regression by ordinary least squares, OLS, we use variables for each kind of date component: year, Month, week of year, day of month and day of week. The main reason the independence, recurrence and repetition of these categorical variables year by year. Table 3 shows coefficient for the week of the year and every one are significant, that means, each week has a different behave and the difference is statistically significant.

Table 3: Least squares estimators for the categorical variable week of the year.

<table>
<thead>
<tr>
<th>Week of Year</th>
<th>Value</th>
<th>Std. error</th>
<th>t</th>
<th>Pr &gt;</th>
<th>Lower L.</th>
<th>Upper L.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>-29.026</td>
<td>8.888</td>
<td>-3.266</td>
<td>0.001</td>
<td>-46.453</td>
<td>-11.600</td>
</tr>
<tr>
<td>3</td>
<td>-29.080</td>
<td>8.894</td>
<td>-3.269</td>
<td>0.001</td>
<td>-46.518</td>
<td>-11.642</td>
</tr>
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</table>
Table 4 displays the least squares estimations coefficients for each year coefficient for national criminal murder in: Non

<table>
<thead>
<tr>
<th>Year</th>
<th>Coefficient</th>
<th>t-value</th>
<th>P-value</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>-29,245</td>
<td>8,889</td>
<td>-3,290</td>
<td>0.001</td>
<td>-46,672</td>
</tr>
<tr>
<td>5</td>
<td>-29,374</td>
<td>8,866</td>
<td>-3,313</td>
<td>0.001</td>
<td>-46,756</td>
</tr>
<tr>
<td>6</td>
<td>-29,823</td>
<td>8,880</td>
<td>-3,359</td>
<td>0.001</td>
<td>-47,232</td>
</tr>
<tr>
<td>7</td>
<td>-30,224</td>
<td>8,893</td>
<td>-3,399</td>
<td>0.001</td>
<td>-47,660</td>
</tr>
<tr>
<td>8</td>
<td>-29,900</td>
<td>8,893</td>
<td>-3,362</td>
<td>0.001</td>
<td>-47,334</td>
</tr>
<tr>
<td>9</td>
<td>-28,712</td>
<td>8,882</td>
<td>-3,233</td>
<td>0.001</td>
<td>-46,124</td>
</tr>
<tr>
<td>10</td>
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<td>8,883</td>
<td>-3,264</td>
<td>0.001</td>
<td>-46,411</td>
</tr>
<tr>
<td>11</td>
<td>-29,191</td>
<td>8,893</td>
<td>-3,283</td>
<td>0.001</td>
<td>-46,625</td>
</tr>
<tr>
<td>12</td>
<td>-29,470</td>
<td>8,893</td>
<td>-3,314</td>
<td>0.001</td>
<td>-46,905</td>
</tr>
<tr>
<td>13</td>
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<td>-3,589</td>
<td>0.000</td>
<td>-49,268</td>
</tr>
<tr>
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<td>-3,471</td>
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<td>-48,161</td>
</tr>
<tr>
<td>15</td>
<td>-30,219</td>
<td>8,889</td>
<td>-3,400</td>
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<td>-47,647</td>
</tr>
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<td>-3,541</td>
<td>0.000</td>
<td>-48,929</td>
</tr>
<tr>
<td>17</td>
<td>-30,159</td>
<td>8,887</td>
<td>-3,394</td>
<td>0.001</td>
<td>-47,583</td>
</tr>
<tr>
<td>18</td>
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<td>8,879</td>
<td>-3,257</td>
<td>0.001</td>
<td>-46,327</td>
</tr>
<tr>
<td>19</td>
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<td>8,891</td>
<td>-3,157</td>
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</tr>
<tr>
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<td>-46,324</td>
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<tr>
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<td>8,894</td>
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<td>-45,766</td>
</tr>
<tr>
<td>22</td>
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<td>8,874</td>
<td>-3,293</td>
<td>0.001</td>
<td>-46,621</td>
</tr>
<tr>
<td>23</td>
<td>-27,365</td>
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<td>0.002</td>
<td>-44,771</td>
</tr>
<tr>
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<td>0.001</td>
<td>-46,098</td>
</tr>
<tr>
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<td>8,897</td>
<td>-3,117</td>
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<td>-46,628</td>
</tr>
<tr>
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<td>0.003</td>
<td>-44,283</td>
</tr>
<tr>
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<td>8,894</td>
<td>-3,098</td>
<td>0.002</td>
<td>-44,990</td>
</tr>
<tr>
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<td>8,898</td>
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</tr>
<tr>
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<td>-47,036</td>
</tr>
<tr>
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<td>-46,490</td>
</tr>
<tr>
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<tr>
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</tr>
<tr>
<td>35</td>
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<td>0.001</td>
<td>-46,035</td>
</tr>
<tr>
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<td>-27,673</td>
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<td>-45,071</td>
</tr>
<tr>
<td>37</td>
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<td>-46,508</td>
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<tr>
<td>38</td>
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</tr>
<tr>
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<tr>
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<tr>
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<td>-2,901</td>
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<td>-43,179</td>
</tr>
<tr>
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<td>8,897</td>
<td>-3,192</td>
<td>0.001</td>
<td>-45,842</td>
</tr>
<tr>
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<td>0.001</td>
<td>-46,474</td>
</tr>
<tr>
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<td>8,886</td>
<td>-3,138</td>
<td>0.002</td>
<td>-45,309</td>
</tr>
<tr>
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<td>-25,824</td>
<td>8,884</td>
<td>-2,907</td>
<td>0.004</td>
<td>-43,242</td>
</tr>
</tbody>
</table>

Table 4 displays the least squares estimations coefficients for each year coefficient for national criminal murder in: Non standardized coefficient, standardized coefficient, standard error of each coefficient, t value statistic, p-value from the t statistic, and the lower and upper coefficient limit. Table 5 shows the analysis of variance decomposition to the estimates of the coefficients for the linear model by ordinary less squares for each year. Values are significant to all
variables: Year, week of year, Day of month, Day of week using the p-values less than 0.05. Each variable are significant, the sum of squares modeled by all variables is 339.311 units, of this 241.044 units of information are loaded by Day of week variables.

Table 5 resume the model of categorical variables for number of homicides by year, week of the year, day of the month and day of the week. From whole information, 648k units, the modeled fraction is 339k that is a 52% from the total. 71% of the information is captured by the day of the week and year captures 20%.

Table 4 Least squares estimators for the categorical variable year.

<table>
<thead>
<tr>
<th>Year</th>
<th>N. Coefficient</th>
<th>S. Coefficient</th>
<th>Std. error</th>
<th>t</th>
<th>Pr &gt;</th>
<th>Lower L.</th>
<th>Upper L.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interception</td>
<td>81.45</td>
<td>8.81</td>
<td>9.24</td>
<td>0.00</td>
<td>64.17</td>
<td>98.72</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>6.27</td>
<td>0.14</td>
<td>0.94</td>
<td>6.66</td>
<td>0.00</td>
<td>4.43</td>
<td>8.11</td>
</tr>
<tr>
<td>2011</td>
<td>8.43</td>
<td>0.19</td>
<td>0.94</td>
<td>8.96</td>
<td>0.00</td>
<td>6.59</td>
<td>10.28</td>
</tr>
<tr>
<td>2012</td>
<td>8.84</td>
<td>0.2</td>
<td>0.94</td>
<td>9.39</td>
<td>0.00</td>
<td>7.00</td>
<td>10.69</td>
</tr>
<tr>
<td>2013</td>
<td>6.11</td>
<td>0.14</td>
<td>0.94</td>
<td>6.50</td>
<td>0.00</td>
<td>4.27</td>
<td>7.96</td>
</tr>
<tr>
<td>2014</td>
<td>0.61</td>
<td>0.01</td>
<td>0.94</td>
<td>0.65</td>
<td>0.51</td>
<td>-1.23</td>
<td>2.46</td>
</tr>
<tr>
<td>2015</td>
<td>-0.74</td>
<td>-0.02</td>
<td>0.94</td>
<td>-0.78</td>
<td>0.43</td>
<td>-2.58</td>
<td>1.11</td>
</tr>
<tr>
<td>2016</td>
<td>-1.65</td>
<td>-0.04</td>
<td>0.94</td>
<td>-1.75</td>
<td>0.08</td>
<td>-3.49</td>
<td>0.19</td>
</tr>
<tr>
<td>2017</td>
<td>-1.79</td>
<td>-0.04</td>
<td>0.94</td>
<td>-1.90</td>
<td>0.06</td>
<td>-3.64</td>
<td>0.05</td>
</tr>
<tr>
<td>2018</td>
<td>-0.23</td>
<td>-0.01</td>
<td>0.94</td>
<td>-0.25</td>
<td>0.81</td>
<td>-2.07</td>
<td>1.61</td>
</tr>
<tr>
<td>2019</td>
<td>-0.23</td>
<td>-0.01</td>
<td>0.94</td>
<td>-0.24</td>
<td>0.81</td>
<td>-2.07</td>
<td>1.61</td>
</tr>
<tr>
<td>2020</td>
<td>-2.05</td>
<td>-0.05</td>
<td>0.94</td>
<td>-2.18</td>
<td>0.03</td>
<td>-3.89</td>
<td>-0.21</td>
</tr>
</tbody>
</table>

Table 5 OLS for the number of homicides as a function of category variables year, week of the year, day of the month and day of the week.

<table>
<thead>
<tr>
<th>Source</th>
<th>DoF</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
<th>Pr &gt; F</th>
<th>% to model</th>
<th>% to total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>11</td>
<td>68.586</td>
<td>6.235</td>
<td>81.521</td>
<td>0.000</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td>Week of Year</td>
<td>53</td>
<td>18.383</td>
<td>347</td>
<td>4.535</td>
<td>0.000</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Day of Month</td>
<td>30</td>
<td>7.469</td>
<td>249</td>
<td>3.255</td>
<td>0.000</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Day of Week</td>
<td>6</td>
<td>241.044</td>
<td>40.174</td>
<td>525.258</td>
<td>0.000</td>
<td>71</td>
<td>37</td>
</tr>
<tr>
<td>Model</td>
<td>100</td>
<td>339.311</td>
<td>3.393</td>
<td>44.363</td>
<td>0</td>
<td>100</td>
<td>52</td>
</tr>
<tr>
<td>Error</td>
<td>4.037</td>
<td>308.767</td>
<td>76</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6 shows coefficients for every day of week 1 to Sunday, 6 to Friday. In all cases each day is statistically significative and different to the mean using a p value less than 0.05. Table 7 shows the Analysis Of Variance, ANOVA to general linear model for the homicides in function of each administrative political region in the country: each department. Independent variable is the number of administrative registers of homicides, dependent variable is each department. Departments explain the 555k/648k units of variance or 85% of the total information, that is, the model is significant with a p-value under 0.0001; that is some departments have a different murder rate. Data is used at daily level.

Table 8 shows the coefficients for each day of the month. Significant coefficients are the first 3 days of the month and 10 th day. That means, day of the month doesn’t have an incidence on homicides. Bolded figures are Table 6 shows coefficients for every day of week.

Table 6 Least squares estimators for the categorical variable day of the week.
### Table 7 ANOVA for the number of homicides by department.

<table>
<thead>
<tr>
<th>Source</th>
<th>DoF</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
<th>P(F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>32</td>
<td>555,116.61</td>
<td>17,347.39</td>
<td>676.031</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Error</td>
<td>4,105</td>
<td>92,961.01</td>
<td>22.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4,137</td>
<td>648,077.62</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 8 Least squares estimators for the categorical variable day of the month.

<table>
<thead>
<tr>
<th>Day Of Month</th>
<th>Value</th>
<th>Std. error</th>
<th>t</th>
<th>Pr &gt;</th>
<th>Lower L.</th>
<th>Upper L.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-17,291</td>
<td>0,510</td>
<td>-33,890</td>
<td>&lt;0.0001</td>
<td>-18,291</td>
<td>-16,290</td>
</tr>
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<td>2</td>
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### 5.2 Graphical Results

Figure 1 shows homicides by week in Colombia from 2010 to 2021, where it is identified a cyclical behavior by weeks. Figure 2 shows the aggregate of homicides by year where it is seen a decreasing tendency on the number of homicides across years, but with values that are significant. Maximus values are find at 2010, 2011 and 2012 decreasing from...
2013. Figure 3 and figure 4, shows standardized regression coefficients obtained for the variable year, followed by coefficients for variable week and for day of the week. It is identified a diminution of the number of homicides from 2012 and a increasing tendency from 2018. Days Saturday, Sunday and Monday has a increasing tendency.
5.3 Proposed Improvements

Its proposed expand this work by subnational data to observe each particular dynamyc link between National Murder Police Database and time dimension. In order to obtain a correlation with economic activity these variables could be linked with others of economic activity. Wavelet coefficients and, and granger causality could also be used for the study of this access as signals and editing with the detail of the daily information that is available.

5.4 Validation

Table 3 to table 8 contains inferential procedures to validate these coefficients for each model, sub dimension about time variable and uses kurtosis and skewness coefficients, in order to decompose the bias or to decompose the variance in their sources.

6. Conclusion

It is found out that time factors like year, week or day of the week could explain the variation of the homicides in Colombia. Evidence about incidence of time factors in homicides could be an insight of the presence of cycles on the occurrence of homicides. Spatial variable department showed to be significant in explaining homicides. That means, geography has a major impact in the presence of homicides.

References


Biography

Wilson Alexander Pinzón Rueda is Research Professor of Engineering, director of research groups of the Facultad Tecnologica of the Universidad Distrital Francisco José de Caldas, he is Industrial Engineer of the Universidad Distrital Francisco José de Caldas, master in Industrial Engineering of the Universidad de los Andes. Experience as a teacher in engineering programs at Universidad de la Salle, researcher teacher in master and doctorate programs at

Edgar Olmedo Cruz Mican is a researcher attached to MINCIENCIAS - COLOMBIA. He is a Business Administrator from the Jorge Tadeo Lozano University in Bogotá, with a Master's Degree in Business Administration (MBA), Doctor of Business Administration, Post-doctorate in Education, Social Sciences and Interculturality. He is currently pursuing his second doctorate in Educational Management and Policy. He has served as Rector, research professor in several higher education institutions, postgraduate teacher (master's and specializations), has been Manager in several companies in the real sector in Colombia and Venezuela. He is currently a scientific and methodological advisor for various projects, national and international lecturer on topics related to research and innovation. He belongs to several research groups, categorized by MINSCIENCES. He has written 15 books, 3 articles and 12 scientific book chapters on innovation, entrepreneurship and research.

He currently works as a scientific consultant for the company Scientometrics and Researching Consulting Group, a pedagogical advisor for the Sumapaz Province Police School, he is a research professor at UNIMINUTO, and a postgraduate professor at ECCI University. Throughout his work and academic career, he has achieved awards and distinctions, as well as a contribution to the generation of new knowledge.

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