A Nonparametric Comparison Of The Per Capita Yearly Economic Needs For The Water Supply In The USA-Mexico Border Region

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ABSTRACT

Based on demographic and economic information, this research paper evaluates a nonparametric comparison of the per capita yearly economic needs for water supply of two international regions conformed by 100 cities and/or communities (localities) along the border of United States and Mexico, from which 57 are located on the American side and 43 on the Mexican side; part of the discrepancy exhibited by both borders about the per capita yearly economic needs for water supply is explained as a reflection of the demographic-gap among adjacent localities of the common border region; we present confirmatory evidence of discrepancies. The per capita yearly economic needs estimate should be considered in order to increase the sustainability for water supply. The United States-Mexico border in terms of water supply needs should be interpreted as an issue of national security. If the accelerated rate of population growth on both sides of the border between United States and México continues including the area around the water river basins, this could produce a dramatic scenery in the future (for year2020): An expected percentage of population growth of 108 % accompanied with a long-term economic needs volume of $ 3,393,870,000.00

INTRODUCTION

The WIN (Water Infrastructure Network) Organization was formed by government authorities, administrators of health, environmentalists, engineers and technicians, and suppliers of potable water dedicated to the preservation, protection of the health, environment and economy. They published their first report in April 2000 "*Clean & Safe Water for the 21st Century*" ([16] Water Infrastructure Network "WIN", 2001) in which they documented the significant improvements in public health and quality of the water associated with the investments of the United States in water and infrastructure for water.

The report mentions a financial problem without precedent: During the next 20 years the systems of pick up, water purification, distribution and residual water treatment of the United States needs an investment of 23 billions of dollars per year to modernize and to replace the old and obsolete facilities (1950s). The second report recommends a series of public actions for being deprived to face the infrastructure challenges for the water supply during the next 20 years. The report mainly recommends too increase the financial support of the federal government, for which it proposes flexible forms of financial supports such as scholarships, subsidies, lending, and welfare credits.

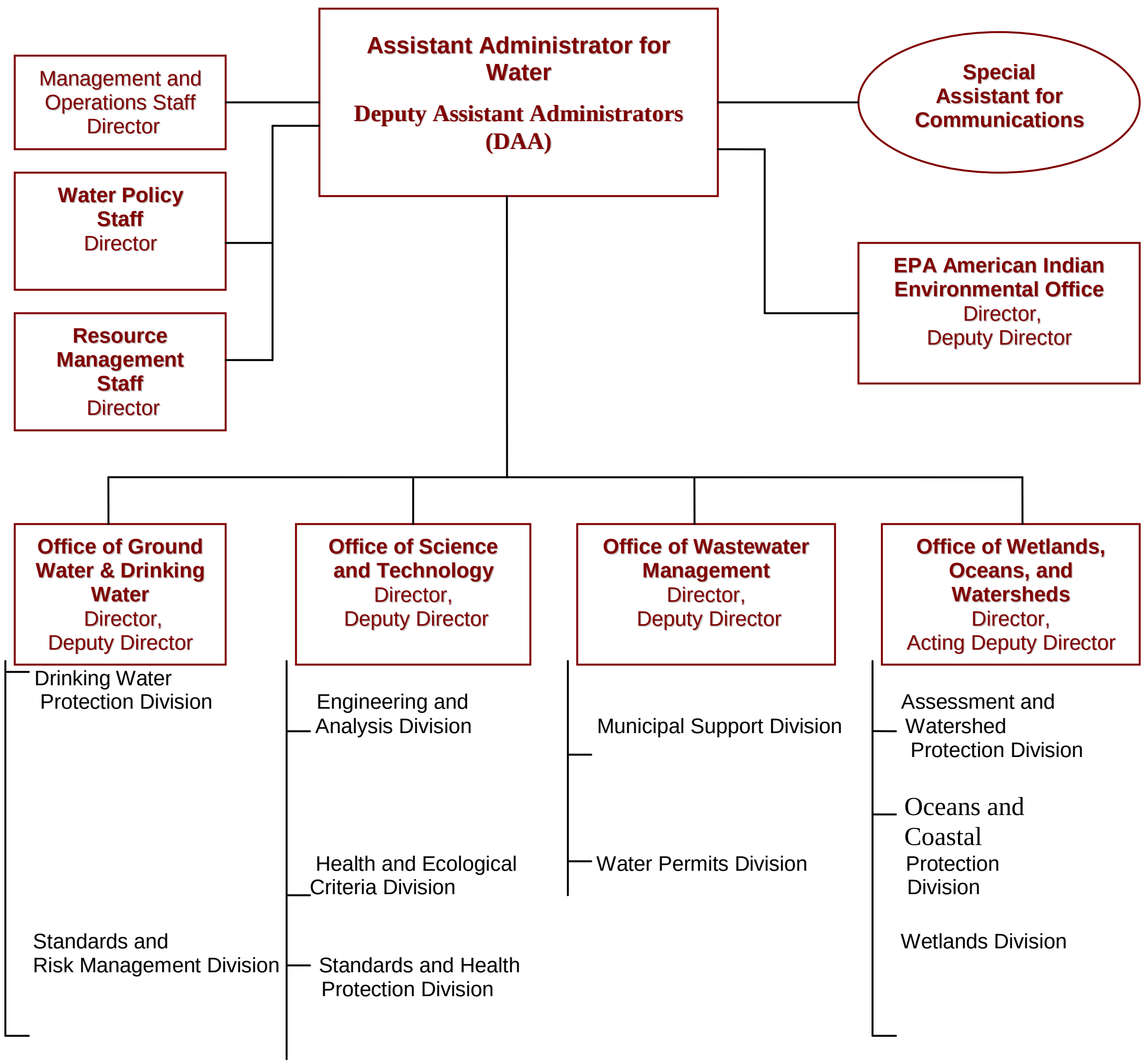
The necessities of aquifer resources in the short term are those priorities or requirements that are essential in suitably providing and maintaining the water supply in good condition ([13] Rothert, 2000), which must be completed in less than 3 years. On the other hand the long-term necessities are those that must be fulfilled in 20 years or less. However, the evaluation of the Border Environment Cooperation Commission (BECC) ([2] Cooke, 1996 & [12] Reed and Kelly, 2000) shows the short-term necessities for 94 of the 100 border communities; for the communities that show absence of information, may be mainly attributed to at least two probable causes:

1. The existence of factors of environmental risk that make it difficult for the evaluation of necessities ([10] Pina e Cunha *et al*., 2001).
2. The limited data and the lack of information that the habitants of the communities give to the municipal authorities.

Such economic needs of water resources can be classified in five categories: 1) Distribution and transmission, 2) treatment, 3) storage, 4) sources of supply, and 5) other.

The authorities at the Environmental Protection Agency (EPA) dealing with water issues have been organized according to the following Office of Water Organizational Chart:

Figure 1: EPA-Office of Water Organizational Chart



Source: U.S. Environmental Protection Agency

OBJECTIVE

To obtain statistical estimates ([1] Conover, 1980) of the per capita yearly cost for water supply in both sides of the USA-México border; and to explain that part of the discrepancy exhibited by both borders regarding the per capita economic needs for water supply is a reflection of the demographic-gap between neighboring localities.

METHODOLOGY

Data

This study was carried out with the data of 100 nearby cities and/or communities to the USA-Mexico border (see Appendix 2), from which 54 are distributed in the American side, 40 in the Mexican side, and 3 pairs (6 sites) report a joint population, but do not specify what population proportion corresponds to each border (Table 7).

The communities ([9] Peach and Williams, 1999 & [15] Santibanez-Romellon and Cruz-Pineiro, 2001) are grouped in 7 regions called hydrological river basins: Pacific Coastal, New River, Gulf of California Coastal, Red River, Northwest Chihuahua, Rio Grande, and Gulf of Mexico Coastal, as is shown in Table 3.

The data are available at Summary Report. EPA-832-R-00-001, January 2001. ([3] EPA, 2001).

Survey

The short-term needs (equivalent to a period of 3 years) were collected directly from the local municipal authorities by the BECC (Border Environment Cooperation Commission). The ratio between the short-term needs in millions of dollars and the year 2000 population was used as an estimate of the per capita economic needs for water supply for each of the bordering localities; these three-year ratios were (rescaled) divided by 3 in order to work with yearly estimates; and a statistical technique (potential or power curve fitting [8] Noggle, 1993) was used to estimate some missing values of economic needs.

Statistical Analysis and Results

Descriptive statistics

The summaries in Table 1 correspond to the variable obtained via the ratio between the water economic needs and the demographic population of year 2000 for every one of the available localities around the USA-Mexico border.

Table 1
Descriptive Statistics About The Per Capita Yearly Economic Needs (In Dollars)

Border	Number of localities	Mean	Standard deviation	Minimum	Maximum
USA	31	422.52	794.90	0	4000.00
Mexico	30	73.29	82.92	1.68	332.49

Nonparametric comparisons

One consideration in determining whether a parametric or a nonparametric ([5] Leedy, P. D., and Ormrod, 2001) method should be used is the set of assumptions about the population probability distributions from which the data was obtained. For example, in order to use the analysis of variance (ANOVA), which is a parametric technique, the response variable (per capita yearly economic needs) must be normally distributed at each of the two populations (borders). Moreover, two other required assumptions are: the observations represent independent random samples from the two populations (border regions); and the variance of the response variable must be the same for both borders, this last assumption is called 'homoscedasticity'.

Given the results from the Kolmogorov-Smirnov criteria to verify normality (p_values are 0.008 and 0.017 respectively, see Appendix 1 (Table 4), and the test of homogeneity of variances based on Levene statistic (p_value=0.001 (Table 5), we are not willing to assume that the two populations of the per capita yearly economic needs values are normally distributed with 'equal variances'; thus the normality and homoscedasticity assumptions do not hold in this case.

The nonparametric methods require no assumptions about the population probability distributions. Thus, the Mann-Whitney test was used, for which the hypotheses can be stated as follows:

Null H_0: The two populations are identical, or $F(x) = G(y)$
Alternative H_1: The two populations are not identical, or $F(x) \neq G(y)$

If there is a difference between populations, we assumed that the difference is in the location of the populations:

$F(x) \neq G(y)$, but $F(x) = G(y+c)$, where c is some constant.

Then the hypotheses can be stated in terms of the first moments of x and y, where x and y represent the per capita yearly economic needs of border locations divided in two groups of sizes $n_x=54$ and $n_y=40$ respectively.

H_0: $E(x) = E(y)$
H_1: $E(x) \neq E(y)$

Table 2
Mann-Whitney Test Results

Border	n	Sum of ranks	Mann-Whitney statistic	Z statistic	p_value
USA	31	1101.00	325.00	-2.021	0.043
Mexico	30	790.00			

Decision: Clearly, the null hypothesis H_0 is rejected at $\alpha < 0.05$.

Nonparametric confidence intervals estimates

The bootstrap confidence intervals of 95% for the per capita yearly economic needs average (in dollars) for water supply at two border regions were calculated as follows (see Figure 4):

$CI\ (\mu_{USA})_{95\%}$ = 151.10, 738.52
$CI(\mu_{México})_{95\%}$ = 47.66, 106.59

CONCLUSIONS

The variability in the per capita economic needs for water supply shown by the communities with very similar population magnitude indicates the presence of unknown factors (socioeconomic, environmental, etc.) which affect systematically the demand of aquifer resources ([17] Weshah, 2000); but in general, this study achieved its objective about to obtain a nonparametric bootstrap interval estimate $CI(\mu)$ of the per capita yearly economic needs average for water supply in both sides of the USA-México border region.

The discrepancy exhibited by both averages (mean values in Table 1) is a reflection of the demographic-gap ([7] Kelley, 1976) of adjacent localities at the common border (Figure 5), because in terms of economic needs (Table 6 at Appendix 1) both regions do not show a significant difference. This is confirmed through Figure 2, where both confidence intervals overlap; and also in terms of total population, both borders tend to be similar: USA and Mexico border populations in percentage represent 49.44% and 48.92% respectively (as is shown in Table 7).

Table 8 contains a strong confirmatory evidence of discrepancies exhibited by Figure 5: The hypothesis about the "exponential" distribution of the per capita yearly economic needs average in dollars at the USA border can be rejected (p_value=0.0001), while at the Mexican border such hypothetical distribution can't be rejected (p_value=0.383).

Figure 2
Graphical Representation Of The 95% Confidence Intervals For Short-Term Economic Needs Average (In Millions Of Dollars) For Water Supply At The Two Border Regions

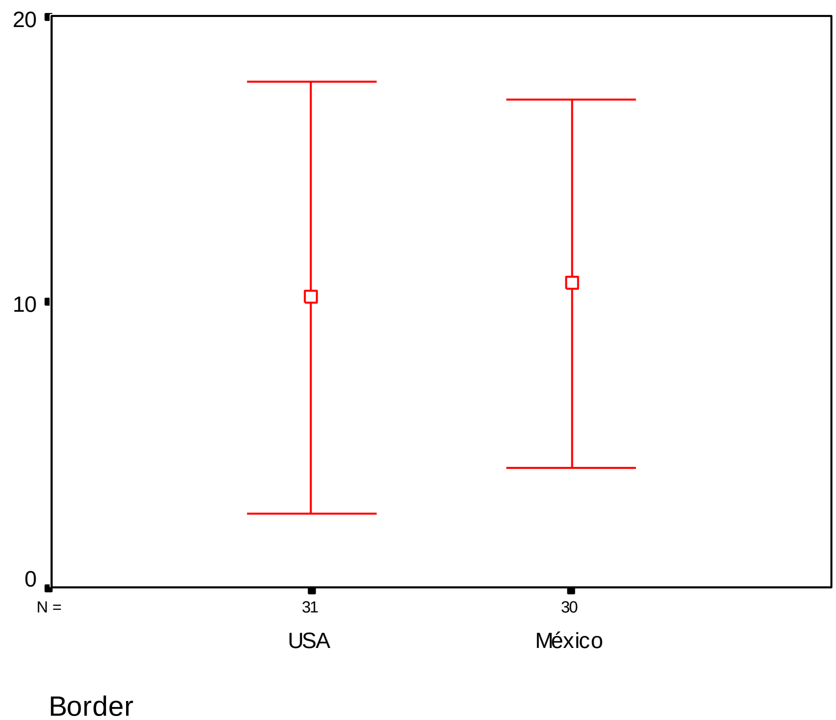
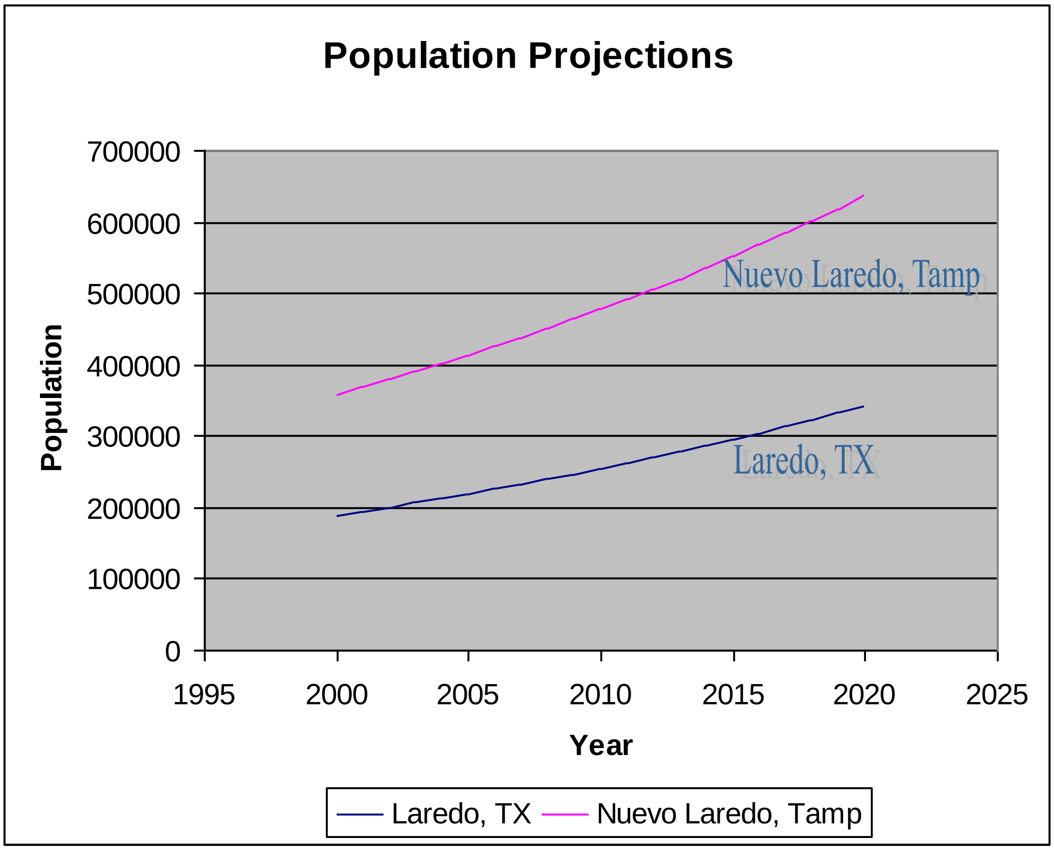


Table 3
Year 2000 Demographic Data And Short-Term Economic Needs Estimates (In Millions Of Dollars) For Water Supply Of 100 USA-Mexico Border Locations Grouped In 7 Hydrological River Basins (Tables 6 And 7)

Hydrological river basin	Border population of year 2000	Short-term economic needs estimates in millions of dollars
Pacific Coastal	4330600	107.01
New River	973200	62.22
Gulf of California	206900	42.27
Colorado River	1463600	130.13
Northwest Chihuahua	155800	37.85
Rio Grande	4604406	316.07
Gulf of Mexico	835800	62.24
TOTAL	**12570306**	**757.79**

The next graph (Figure 3) is a pictorial representation of the population projections for the border cities of Laredo, TX. and Nuevo Laredo, Tamp. ([14] Pena-Sanchez, 1997) from year 2000 until 2020; where we can see a classic local demographic-gap of two adjacent cities separated by the Grande River.

Figure 3
Population Projections For The International Border Cities Of Laredo TX And Nuevo Laredo, Tamp From The Year 2000 Until 2020



According to Figure 3, it appears to be evident that without sustainable economic development, an uncontrolled population expansion or a population expansion not parallel to an ordered economic growth could become one of the most aggressive factors (possibly the most aggressive factor) against the water supply resources of some region, due to its geometrical growth, in contrast to an available resource of linear growth, which would be economically disjointed or disproportionate to the existing resources in such region.

IN SUMMARY

The water supply and economic needs of the United States - México border (Tables 6 and 7) should be considered as an issue of national security:

Border region population of year 2000: 12,570,306 habitants.
Short-term economic needs: $ 757,790,000.00

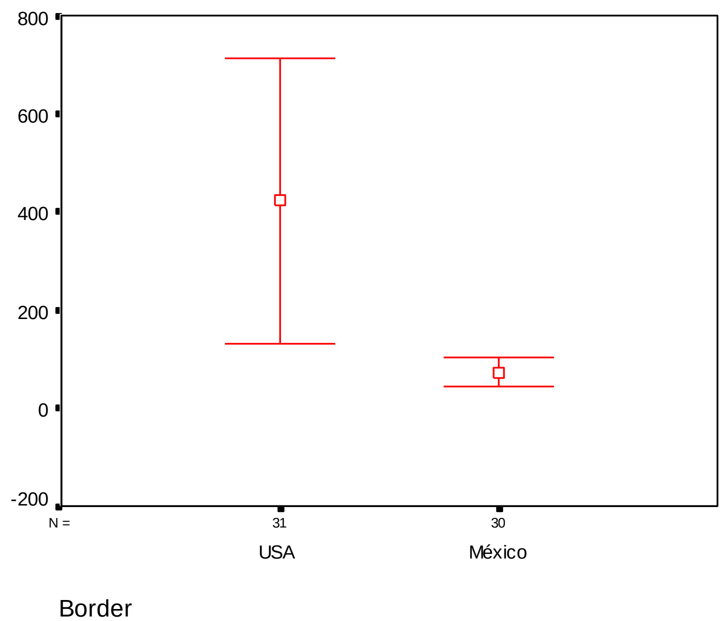
EXPECTED SCENERY

The systematical effect of the accelerated rate of population growth on both sides of the border United States and México including the area around the water river basins could produce the consequence of a duplicated population in less than 20 years. The per capita yearly economic needs estimates should be considered in order to increase the sustainability for water supply. Using a linear transformation in time domain and power regression modeling (as shown in Figure 3):

	Expected population: 26,188,250 habitants
Border region at year 2020:	Expected percentage of population growth: **108 %**
	Long-term economic needs: $ 3,393,870,000.00

A very valuable result to explain the statistical independence ([6] Mood *et al.*, 1974 & [11] Pindyck and Rubinfeld, 1991) of the estimated 95% bootstrap confidence intervals CI(μ) in dollars is the fact that they "do not overlap" ([18] Yoskowitz *et al.*, 2002), as shown in the next Figure; which is also a strong confirmation of a significant demographic-gap between nearby (neighbors) locations.

Figure 4
Graphical Representation Of The 95% Confidence Intervals For The Per Capita Yearly Economic Needs Average In Dollars For Water Supply At Two Border Regions Exposed In Section 3.3.3



APPENDIX 1

A) Summary of normality and homoscedasticity tests: Tables 4 and 5.
B) Descriptive statistics: Tables 6 and 7.
C) A result of the Kolmogorov-Smirnov test to verify the exponential distribution: Table 8.

Table 4
A Result Of The Kolmogorov-Smirnov Test For Normality
Of The Per Capita Yearly Economic Needs Average In Dollars

Measurement	USA border	Mexico border
N	31	30
Mean	422.52	73.29
Std. Deviation	794.90	82.92
Most Extreme Diff Absolute	0.298	0.282
Positive	0.284	0.282
Negative	-0.298	-0.194
Kolmogorov-Smirnov Z	1.657	1.547
p_value	**0.008**	**0.017**

Table 5
Results Of The Levene Test For Homogeneity Of Variances

Levene Statistic	degree of freedom 1	degree of freedom 2	P_value
11.793	1	59	**0.001**

Table 6
Descriptive Statistics For The Short-Term (3 Years Period) Economic Needs (In Millions Of Dollars) Per Border Region, Where The Sum Of Missing Values Was Estimated Via Potential (Power) Curve Fitting

Border	Localities	Mean	Standard deviation	Minimum	Maximum	Sum
USA	31	10.16	20.59	1	93	315.00
Mexico	30	10.63	17.33	1	81	319.00
Subtotal	61					634.00
Missing	39					123.79
TOTAL	100					**757.79**

Table 7
Descriptive Statistics For The Demographic Population Of Year 2000 Per Border Region, Where 3 Pairs Of Neighbors Localities Report Jointly Population Values

Border	Localities	Average	Standard Deviation	Sum	Percentage of Sum
USA	54	115103.70	282855.05	6215600	49.44
Mexico	40	153710.15	304223.12	6148950	48.92
Subtotal	94			12364006	98.36
Neighbors	6			206700	1.64
TOTAL	100			**12570306**	100.00

Figure 5
Demographic-Gap: Graphical Representation Of The 95% Confidence Interval For The Per Locality Population Average

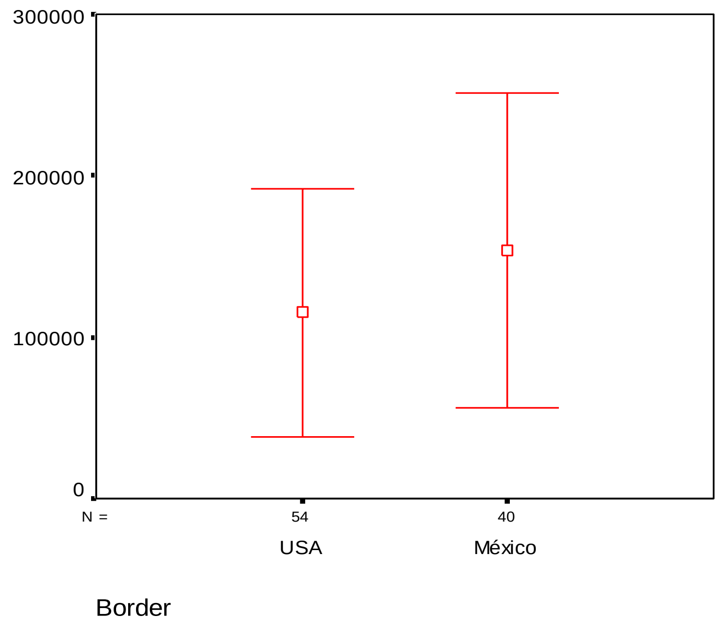


Table 8
A Result Of The Kolmogorov-Smirnov Test To Verify The "Exponential" Distribution Of The Per Capita Yearly Economic Needs Average In Dollars
(A Property Of This Distribution Is That The Mean And Standard Deviation Are Equal)

Measurement	USA border	Mexico border
N	31	30
Mean	545.75	73.29
Most Extreme Diff Absolute	0.478	0.166
Positive	0.478	0.166
Negative	0.000	-0.064
Kolmogorov-Smirnov Z	2.344	0.907
p_value	**0.0001**	**0.383**

APPENDIX 2: Rosters Of The 100 USA-Mexico Border Cities And/Or Communities

Roster 1
The 54 USA Border Cities And/Or Communities

California (CA)	**Arizona** (AZ)	**New Mexico** (NM)	**Texas** (TX)
1 Descanso	13 Bisbee	25 Columbus	26 Unincorporated and other Areas of Hidalgo City
2 San Diego	14 Douglas		27 Unincorporated and other Areas of Luna C.
3 Unincorporated and Other Areas of San Diego	15 Patagonia		28 Alpine
4 Blythe	16 San Luis		29 Alton
5 Brawley	17 Somerton		30 Del Rio
6 Calexico	18 Tombstone		31 Donna
7 Heber	19 Willcox		32 Eagle Pass
8 Palo Verde	20 Yuma		33 El Paso
9 Salton	21 Unincorporated and other Areas of Cochis C.		34 Fabens
10 Seeley	22 Unincorporated and other Areas of Pima C.		35Laredo
11 Westmorland	23 Unincorporated and other Areas of Santa C.		36 McAllen, Texas
12 Unincorporated and other Areas of Imperial Valley	24 Unincorporated and other Areas of Yuma C.		37 Mercedes
			38 Presidio
			39 Rio Grande
			40 Roma
			41Sanderson
			42 Weslaco
			43 Unincorporated and other Areas of Brewst C.
			44 Unincorporated and other Areas of Doña C.
			45 Unincorporated and other Areas of Hidalgo County Maverick C.
			46 Unincorporated and other Areas of El Paso Texas
			47 Unincorporated and other Areas of
			48 Unincorporated and other Areas of Presidio
			49 Unincorporated and other Areas of Starr
			50 Unincorporated and other Areas of Terrel
			51 Unincorporated and other Areas of Val Verde C.
			52 Unincorporated and other Areas of Webb County
			53 Brownsville
			54. Unincorporated and other Areas of Cameron County

Roster 2
The 40 Mexico Border Cities And/Or Communities

Baja California (BC)	Sinaloa (SN)	Chihuahua (CH)	Coahuila (CO)	Nuevo Leon (NL)	Tamaulipas (TM)
1 Ensenada	5 Altar	16 Ascensión	27 Ciudad Acuña	30 China/ General Bravo	31 Gustavo Díaz Ordáz
2 Tecate	6 Bavispe	17 Janos	28 Piedras Negras		32 Mier
3 Tijuana	7 Caborca	18 Nuevo Casas Grandes	29 Zaragoza		33 Miguel Alemán
4 Mexicali	8 Imuris	19 Las Palomas			34 Nava, CO
	9 Magdalena de Kino	20 Villa			35 Nueva Cd. Guerrero
	10 Puerto Peñasco	21 Ahumada			36 Nuevo Laredo
	11 Santa Ana	22 Ciudad Juárez			37 Reynosa
	12 Sásabe	23 Coyame			38 Rio Bravo
	13Agua Prieta	24 Guadalupe Bravos			39 Matamoros
	14 Cananea	25 Manuel Benavides			40Valle Hermoso
	15 San Luis Rio Colorado	26 Ojinaga			

Roster 3
The 6 USA-Mexico Border Cities And/Or Communities With Jointly Filled Information

Arizona (AZ) and **Sinaloa** (SN)		
1 Lukeville AZ	and	2 Sonoyta, SN
3 Naco, AZ	and	4 Naco, SN
5 Nogales, AZ	and	6 Nogales, SN

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