Economic Shifts Along the US-Mexico Border: Investigating the Changes in Location Quotient at the Block Level in Four US Border Cities from 2004 to 2015.

CAPSTONE REPORT

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Abstract:

US border cities are often considered “city-pairs” with coinciding Mexican industrial cities. Current literature suggests that the export economy of these Mexican cities increases employment in US border cities for the transport/warehousing, retail trade, and manufacturing sectors from the years 1976 to 2006. Focusing on Douglas, AZ, Nogales, AZ, Calexico, CA and San Diego, CA, this study uses LODES WAC census block level data and a location quotient analysis to (1) determine if these three industries have continued to grow from 2004 to 2015 using summary statistics, still maps, and animated maps (2) determine if these shifts are related to US/MX border proximity using regression techniques. It was found that the location quotient for manufacturing decreased in all cities but San Diego, with location quotient values being strongly related to border proximity. Similarly, all cities but San Diego showed a decrease in retail trade location quotient, although this trend was not always related to border proximity. California border cities showed a decrease, but Arizona cities showed a continued increase in transport/warehousing location quotient with most cases related to border proximity. These results suggest that while spillover effects continue to exist in these US/MX city pairs, they are largely concentrated in the transport/warehousing sector, with the maturation and continued development of Mexican industrial cities likely leading to less manufacturing needs in US border cities across the study period.

Introduction:

American cities that share a border with Mexico have strong cultural and economic ties to nearby Mexican cities (Herzog 2014). Cities that lie north of the border in US territory usually have numerous industries dedicated to the distribution and sale of products created in the sprawling Mexican cities attached to them, for example the quiet city of El Paso, Texas and its

bustling neighbor Ciudad Juarez, Chihuahua. Due to the inherent bi-national economic connections brought upon by this proximity, US border cities can serve as study areas for identifying the impacts of Mexican industrialization on the US economy, with authors often describing border cities as natural laboratories in which to study the effects of trade policy (Hanson 1996).

Mexican border cities have seen a massive increase in industrialization after the incorporation of various binational trade agreements, such as the North American Free Trade Agreement (NAFTA) in 1994 (Ustr.gov) and previously the 1965 Border Industrialization Program, enacted by the Mexican government, which sought to move industrialization north to create a stronger Mexican export economy (Watkins 1994). The result of these policies is the continuing development of large manufacturing plants built in Mexican border cities to allow for cheap labor and the easy transfer of products to the larger US market. These manufacturing plants, called "maquiladoras" in Spanish, have drastically altered the economies and livelihoods of Mexican residents in terms of income and employment. Even in 1990, 85.6% of export assembly plants were located in Mexican States that border the US (Hanson 1996). One study focusing on the border city of Ciudad Juarez, Chihuahua indicated that the city had experienced unprecedented growth that altered the form, function, and social complexion of the city (Esparza et al. 2004), this trend is true for all Mexican cities touching California, Arizona, New Mexico, and Texas.

While the impacts of job creation and a shift towards an industrial economy are well known in Mexico (Peach et. al 2004), fewer studies have observed the associative changes in the American cities attached to these Mexican cities. While it remains a struggle for Mexican citizens to visit these cities, one may hypothesize that the American border city has benefited in

terms of economy and job creation from the growth of their southern neighbors. Of the few studies conducted, some have concluded that the maquiladora industry has played a key role in the economic development throughout the U.S.–Mexico border region, particularly in manufacturing sectors on both sides of the border (Ramos-Francia and Chiquiar 2005).

This thinking leads to the research questions analyzed in this project (1) how have certain industries in US cities that share a border with Mexican cities changed as the result of the continuing industrialization of Mexico's northern border? (2) How does this compare to cities that do not share a border with Mexico?

To answer this, the states of California and Arizona are selected for analysis, with special attention paid to San Diego, CA, Calexico, CA, Nogales, AZ, and Douglas, AZ.

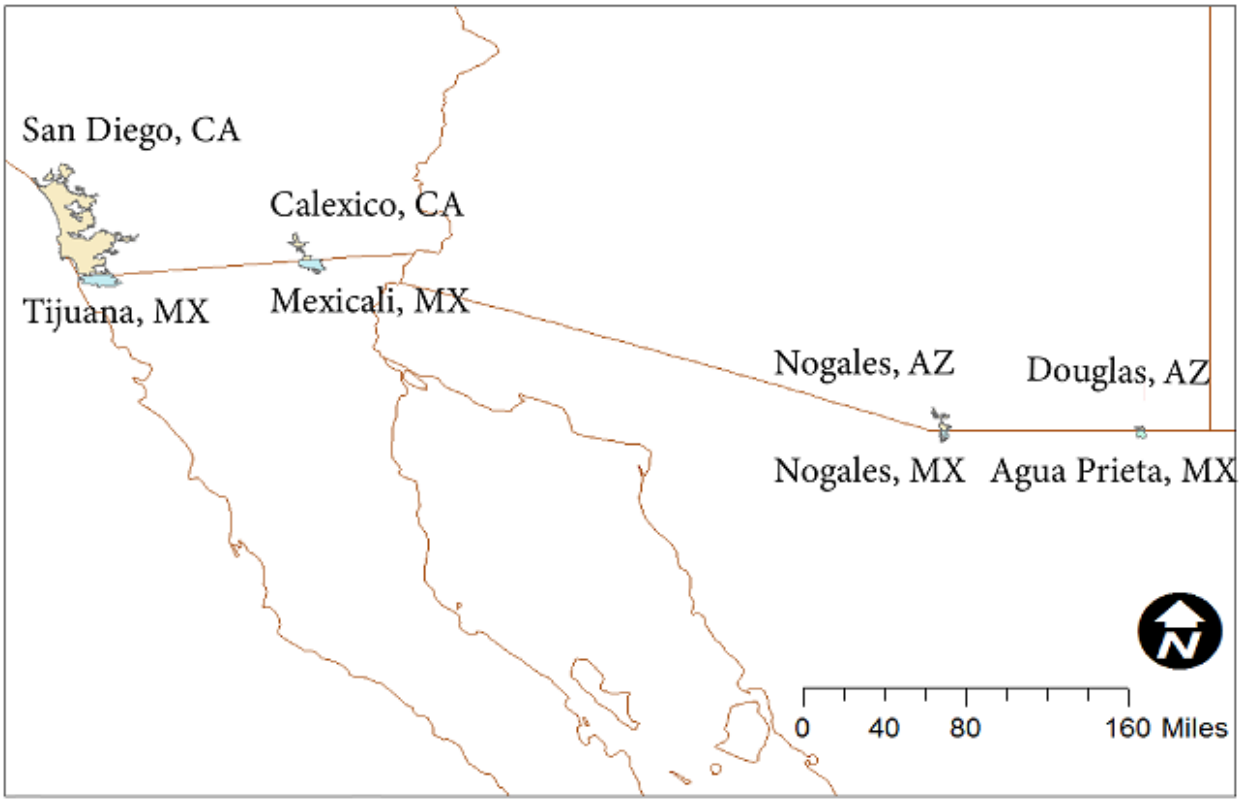


Fig 1. This map shows the urban areas of the four city-pairs selected for analysis

These cities have populations greater than 15,000 as of 2010, and border the Mexican industrial cities of Tijuana, Mexicali, Nogales, and Agua Prieta respectively. To understand economic shifts in these cities, jobs were used as a metric for change. Particularly the location quotient for relevant industries at the block level. It is hypothesized that these sample cities would show an increased amount of job growth, and associatively location quotient, particularly among jobs relating to transport and warehousing, manufacturing, and retail trade, the three US industries expected to be most directly related to the growing export economy of Mexican border cities as evidenced by the literature.

This project seeks to produce visualizations of this change between 2004 and 2015 using both conventional and open source GIS techniques, interpret the differences between the cities, and ultimately use regression techniques to see if location quotient changes in these cities are divergent from more northern cities.

Previous Studies:

Several studies have attempted to discern the direct effect of the Mexican border economy on US border cities. These analyses rely on complicated econometrics and time series looking to discern the impacts of the Mexican economy on economic growth in US cities, usually measured in employment or sales. At the most basic level, some studies have sought to capture and share Mexico's maquiladora growth data provided by the Instituto Nacional de Estadistica y Geografia (INEGI), the rough equivalent of the US Census Bureau, which disseminates the results of Mexican population and economic censuses. The following table from a 2014 study by Polish economists shows how the number of maquiladoras and maquiladora

employees has increased from 1965 to 2012. Interestingly there seems to be a small drop in these values following the 2008 US financial crisis, although they seem to remain stable over time.

Year	Maquiladoras	Employment
1965	12	3,000
1970	120	20,327
1980	620	119,546
1990	1,920	460,258
2000	3,590	1,291,232
2001	3,630	1,198,942
2002	3,003	1,071,209
2003	2,860	1,062,105
2004	2,810	1,115,230
2005	2,816	1,166,250
2006	2,810	1,202,134
2012	**5,055**	**2,000,247**

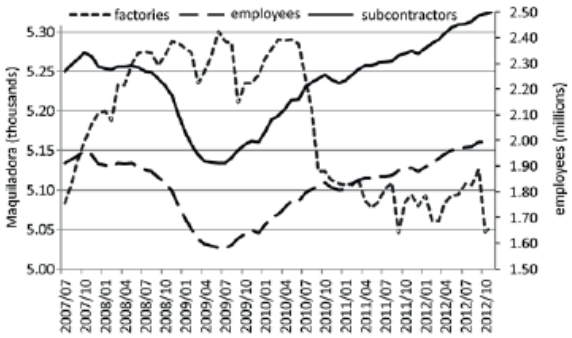


Fig. 2. Number of maquiladoras and employment values in 2007–2012

Source: INEGI. Estadística Integral del Programa de la Industria Manufacturera, Maquiladora y de Servicios de Exportación

Fig 2. This table shows the number of maquiladoras and employment values in 1965-2012 (Doroki et al. 2014)

Similarly, the following table shows a fairly constant growth of maquiladora revenue across 2007 to 2012, indicating overall expansion.

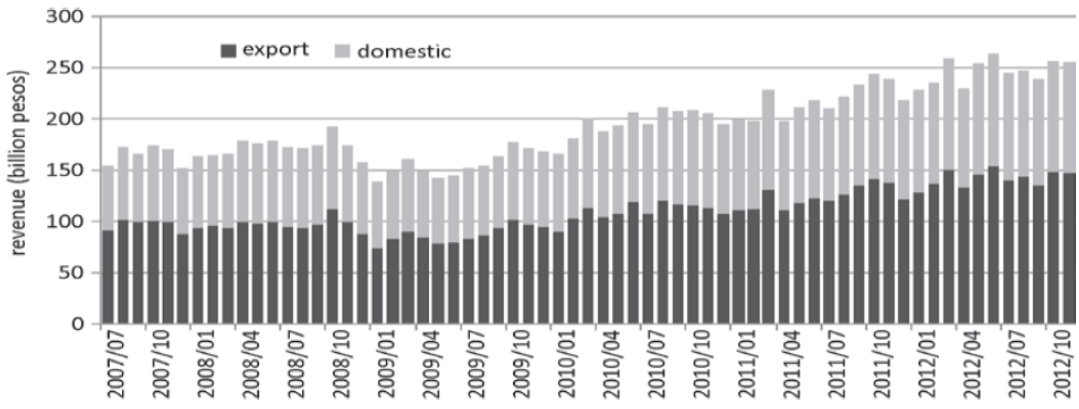


Fig. 5. Maquiladora revenue from the domestic market and from abroad in 2007–2012

Source: INEGI. Estadística Integral del Programa de la Industria Manufacturera, Maquiladora y de Servicios de Exportación

Fig 3. This table shows the Number of maquiladoras and employment values in 1965-2012 (Doroki et al. 2014)

The studies that have attempted to go into greater detail into the impact of this economic growth in Mexico on US border cities have generally concluded there can be some impact, although it is generally hard to measure due to the influence of regional, national, and international business cycles (Fullerton 1998). With that in mind, multiple key studies have sought to address this research topic. These studies have generally covered the years 1978 to 2006 and conclude that the US border town industries most impacted by maquiladora growth include retail, manufacturing, and transportation. For example, focusing on studies that looked at US border town employment data from the 1970s to the mid-1980s, a study using monthly data from 1978 to 1984 found that maquiladora activity in Ciudad Juarez has a positive and statistically significant impact on manufacturing employment in El Paso, while maquiladora output in Reynosa has a positive and statistically significant impact on retail trade employment in McAllen (Davila et al. 1984). Another study monitoring a similar time period found that the development of new maquiladora plants triggers an increase in services on the U.S. side of the border such as legal, engineering, and financial services as well as customs, brokerage, warehousing, and transportation services (Patrick 1990).

This increase in the retail sector in US border towns is likely due to maquiladora workers or executives purchasing items in the US, where many items such as health products are cheaper. A study focusing on maquiladora workers in Agua Prieta, Sonora found that maquiladora workers spent 40 percent of their wages in Arizona (Ladman et al. 1972). Similar increases in retail sales were found in Texas border cities, where an estimated 10 percent increase in maquiladora employment translated into a 23 percent increase in retail sales in Brownsville, a 13 percent increase in Laredo, an 11 percent increase in El Paso, and a 7 percent increase in McAllen (Holden 1984). Similar results for the US manufacturing industry in the same time

period were found, with a 10.0% increase in export manufacturing in a Mexican border city leads to a 2.4 to 4.9% increase in manufacturing employment and a smaller increase in non-manufacturing employment in the neighboring U.S. border city (Hanson 1996). The same can be said for other industries, a study found the resulting U.S. employment growth in wholesale trade to be 2.1 to 2.7% and transportation to be 1.7 to 2.7 (Hanson 2001).

Then focusing on studies that looked at employment data from the 1990s to the mid-2000s, it was found that a 10 percent increase in maquiladora production leads to a 0.5 to 0.9 percent increase in employment across multiple cities (Cañas et al. 2013). This study suggested that as the Mexican export economy has matured, other industries such as finance, insurance, legal and accounting have grown as a reflection of the business services US border cities provide to Mexican maquiladoras in addition to the core industries touched on by the other papers. Confirming the same results from the studies focused on an earlier time period, a second study focusing on the 1990s concluded that among Texas border cities expansion was seen in transportation sector due to the increase in international traffic, the retail sector inflated by serving two cities, and the government sector swollen by border enforcement and by public programs that address high poverty levels (Gilmer et al. 2001).

Overall these studies show the many impacts of Mexican export manufacturing on employment growth in US border cities, and the benefit of considering US border cities as intricately linked to their Mexican counterparts. US and Mexican border towns have been called by some economists as “binational regional production centers” or “city-pairs” (Hanson 1996) to account for this intimately linked economy. Looking forward, there is abundant evidence that maquiladoras and industrialization in northern Mexico can increase employment in many sectors, but most reliably in retail, manufacturing, and transportation. This, paired with information from

the Instituto Nacional de Estadistica y Geografia (INEGI) which indicates continued moderate maquiladora growth indicates that these trends have continued into the years not yet covered in the literature i.e. 2007 to 2018. This project seeks to fill in this temporal gap in the literature, build on of the results in the aforementioned studies, and focus on the same retail, manufacturing, and transportation industries in this new time period, 2004 to 2015. However, this project seeks to differentiate itself from these studies by using several GIS visualization techniques, using higher resolution employment data (block level Workplace Area Characteristics (WAC) LEHD Origen-Destination Employment Statistics (LODES)) as opposed to Metropolitan Statistical Areas, and representing economic changes as an industrial sector's location quotient.

Data:

To obtain high resolution employment data, the LEHD Origen-Destination Employment Statistics (LODES) version 7 was used. As version 7 is "enumerated" by 2010 census block boundaries, a 2010 census block tigerline file was obtained to join this data to produce a shapefile for analysis. The "Workplace Area Characteristics" WAC LODES was downloaded for the states of California and Arizona for the years 2004 and 2015. These years represented the earliest and most recent years available for the LEHD dataset. Since this project is oriented around discerning changes in employment patterns where the current literature leaves off, it was important to find data that fit the unstudied 2007 to 2018 period as close as possible.

The WAC data provides a count of the number of jobs by industry per block. These jobs counts can be considered a proxy for economic shifts in the studied cities. This data only provided information for blocks that contained at least one job, as a result, blocks with no WAC information were assigned a job count of 0 for all job categories. Of interest was the WAC

classification CNS07 which contains NAICS sectors 44-45 which are retail trade, CNS05 which contains NAICS sectors 31-33 which are manufacturing, and CNS08 which contains NAICS sectors 48-49 which are transportation and warehousing. Of the multiple WAC files available, the data that included the total number of jobs for all job categories such as primary, private, federal etc. ex. "az_wac_S000_JT00_2004.csv" was selected for analysis.

To determine the block level employment characteristics in each of the four study cities, an Urban Areas census geography file was used to create separate shapefiles of block level employment data for each city to produce summary statistics and create city level maps. In addition to these city shape files, a state wide block level shapefile was created for both Arizona and California. This state-wide block level shape file allowed for regressions to determine state level trends, as the value for each block could be considered in the anlaysis.

Methods:

1. *Analyze the block level changes in location quotient by sector in the states of California and Arizona.*

The goal of this initial analysis was to produce a block level geography shapefile for each state, and then each city, that had the location quotient for the retail, manufacturing, and transport/warehouse sectors for 2004, 2015, and the percent change between these two years. The data wrangling and shapefile creation was undertaken in R statistical open source software. This provided many benefits, as the work flow was reproducible and easily shared. Further, given the large amount of data being processed, using R cut down greatly on processing time for merges and calculations.

The location quotient was decided upon as the best way to interpret economic change, as it takes into account the relative local importance of a certain industry as compared to state values.

The location quotient can be described as a ratio that compares a region to a larger reference region according to some characteristic or asset (Sentz 2014). As a result, this value is much more informative than just working with employment growth or decline as it will show the relative importance of a census block compared to state. Other benefits of incorporating this analysis include the ability to determine which industries make the regional (or city level) economy unique, and which industries are rising or diminishing relative to state level trends (Sentz 2014).

LQ = (Local industry emp. / Local total emp) /
(state industry emp. / state total emp)

Meaning of LQs:
Equals 1.0: local importance = state importance
Under 1.0: local importance < state importance
Over 1.0: local importance > state importance

In more detail, the script created for this analysis reads in the 2004 LODES WAC information, calculates the state total for a certain industry by summing the totals from all provided blocks, calculates the state total for all jobs, then divides these two to create the state wide value, serving as the denominator of the location quotient. The script will then create a new variable that calculates the block total for a certain industry divided by the total number of jobs in that block, this serves as the numerator in the location quotient. Another variable is then created that stores the location quotient for each block by dividing these two values. The same process is undergone for the 2015 Lodes WAC information, such that each block will also have a location quotient for a specified industry relative to 2015 state values. These two resulting data frames that hold the 2004 and 2015 location quotient information are then joined based on block ID, and a final variable is calculated that shows the percent change in location quotient from 2004 to 2015, ex. ((2015LQ-2004LQ)/2004LQ)*100). This final data frame is then joined to a

block level shapefile of a specified state that is read into the script using the shapefile function in the Raster package. This final shapefile is written, then manipulated in ESRI Arcmap for visualization purposes.

Given the resolution of working with block level data, a Hot Spot Analysis (Getis-Ord Gi*) was incorporated using Euclidian distance as a distance method. Grouping data by census tract was also considered to visualize these location quotient results, however the differences in average tract size between cities was very large, making it more difficult to compare trends across cities. This Hot Spot Analysis indicates where high or low values, in this case percentage change in location quotient between 2004 and 2015, cluster spatially. To be considered a statistically significant hotspot, a block with a high percent change value will also need to be surrounded by other high percent value change blocks. This analysis weighs groups of blocks compared to their surroundings, and if they are significantly different, a hot or cold spot will be assigned to the location. As a result, the overall spatial pattern becomes more digestible to the viewer, eliminating the issue of a difficult to interpret block level resolution.

Ultimately this process was performed for the states of Arizona and California. The block level shapefile for California only includes southern California due to its size, however the location quotient calculations take into account statewide values.

2. *Analyze the block level changes in location quotient per block by sector in the cities of Douglas, AZ, Nogales, AZ, Calexico, CA, San Ysidro, CA using animated maps showing every year from 2004 to 2015.*

Another advantage of using R statistical open source software for data analysis are the well-developed visualization packages and ability to iterate through large amounts of data using loops.

These concepts are combined to develop the animated maps for each of the four cities in this project, and for each sector. The script developed for this portion of the analysis begins by reading in the LODES WAC data for each state for each year from 2004 to 2015, a total of twelve years of data per state. A loop was incorporated that reads through each data frame, calculates the location quotient for a particular industry as in the first analysis and joins this table to a city shapefile. Still in the loop, this shapefile is then transformed to espg 4326 or WGS84, placed over a google satellite base map as part of the package ggmap, then symbolized using ggplot2, given a unique title that corresponds to the year of the data, and finally saved as a.png file with a unique filename. The final part of this script will run through these stills using a package called magick and assemble them into a .gif file at two frames per second. Ideally, being able to visualize the year to year changes in a digestible format, may help to uncover some of the changes not captured by comparing data from 2004 to 2015 directly. For simplicity of interpretation, the location quotient values shown in each map were reduced to values over and below one, this allows the viewer to interpret how blocks have shifted from above and below state averages over time.

3. *Analyze the impact of US/MX border proximity on the % change in location quotient per sector using regression techniques.*

As mentioned previously, one of the central hypotheses put forward by economists studying the relationship between Mexican industrialization and US border cities, is that there are spillover effects into the US market. One may expect the sectors of interest in this project, retail, manufacturing, and transport/warehousing, to grow in state importance due to the growth of maquiladoras. This can in part be addressed by the previous two analyses, in that location

quotients will indicate if the US border economies in question are over the value of 1, and if this has remained true over the course of the study period. However, to further enhance this result, determining if there is a spatial explanation for the location quotient may help to determine if the proximity to Mexican cities is related to the location quotient value change over time. If so, this may suggest that the border region is an area with unique economic patterns, and that these may be related to the export economy of Mexican border cities.

A way to approach this is to use R statistical software to run linear regressions with the dependent variable as % change in location quotient values from 2004 to 2015. Then assign the first independent variable as a dummy variable for all blocks within 20 miles of the border, the second as a dummy variable to all blocks in urban areas in the state, to serve as a control for the economic benefits of being in an urban area. Ultimately this hopes to show what proximity to the border means for % change in location quotient values from 2004 to 2015, not including the influence of being in an urban area. This will be run for both AZ and CA, as well as for the dependent variables location quotient values for 2004 and 2015, in addition to % change in location quotient. While causality will be impossible to determine without a complex econometrics analysis, which can still be debated due to the influence of regional, national, and international business cycles (Fullerton 1998), the result of these regressions may help to better explain the spatial trend of location quotients in the states in question to see if there is any impact of being located close to the border on location quotient. If a given state is shown to have a significant relationship between the location quotient of a sector and border proximity, this may mean that the location quotient values determined in the previous analyses are in fact due to this unique economic region.

Results:

Summary Statistics:

Douglas, AZ Urban Area				
	Manufacturing	Retail Trade	Transport/Warehousing	Total Jobs
Jobs 2004	57	714	32	2557
Jobs 2015	0	646	73	2680
LQ 2004	0.4312	2.2664	0.4444	
LQ 2015	0	1.9487	0.8832	
pct. Change LQ	-100%	-14.02%	98.74%	

Table 1. Source: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

Nogales, AZ Urban Area				
	Manufacturing	Retail Trade	Transport/Warehousing	Total Jobs
Jobs 2004	205	1989	647	8665
Jobs 2015	233	1694	1003	8691
LQ 2004	0.4577	1.8631	2.6516	
LQ 2015	0.4235	1.5757	3.7421	
pct. Change LQ	-7.47%	-15.42%	41.13%	

Table 2. Source: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

Calexico, CA Urban Area				
	Manufacturing	Retail Trade	Transport/Warehousing	Total Jobs
Jobs 2004	936	651	1131	29560
Jobs 2015	117	597	886	33217
LQ 2004	0.2965	0.204	1.212	
LQ 2015	0.0441	0.1818	0.8284	
pct. Change LQ	-85.13%	-10.88%	-31.65%	

Table 3. Source: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

San Diego, CA Urban Area				
	Manufacturing	Retail Trade	Transport/Warehousing	Total Jobs
Jobs 2004	106773	125005	21006	1153816
Jobs 2015	105356	130031	23125	1295499
LQ 2004	0.8665	1.004	0.5767	
LQ 2015	1.0149	1.0153	0.5544	
pct. Change LQ	17.12%	1.13%	-3.87%	

Table 4. Source: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

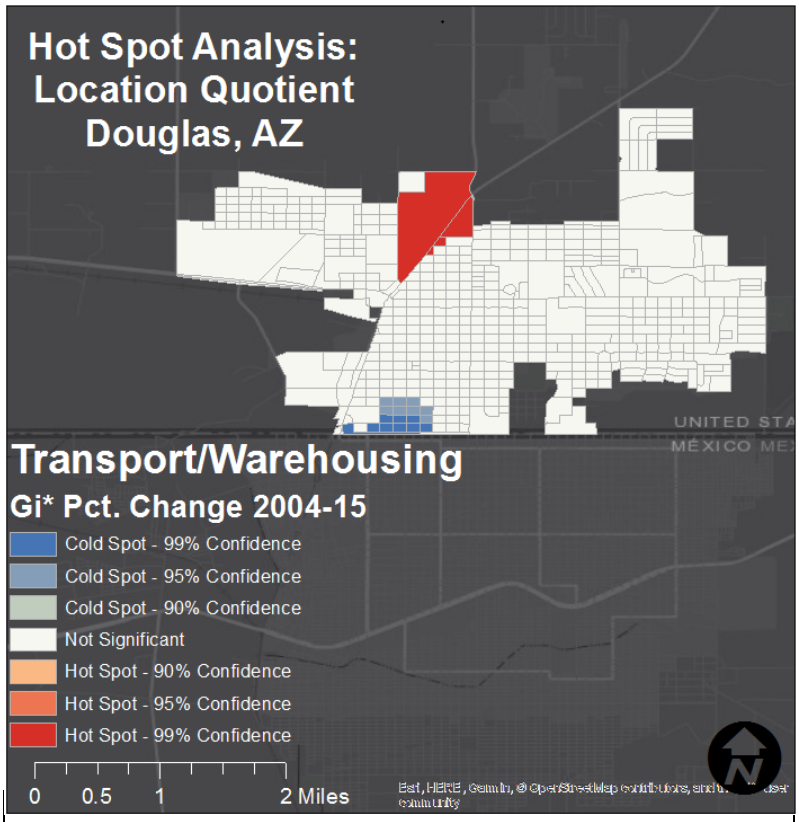


Fig 4. Transport/Warehousing Sector (NAICS 48-49)
Source: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

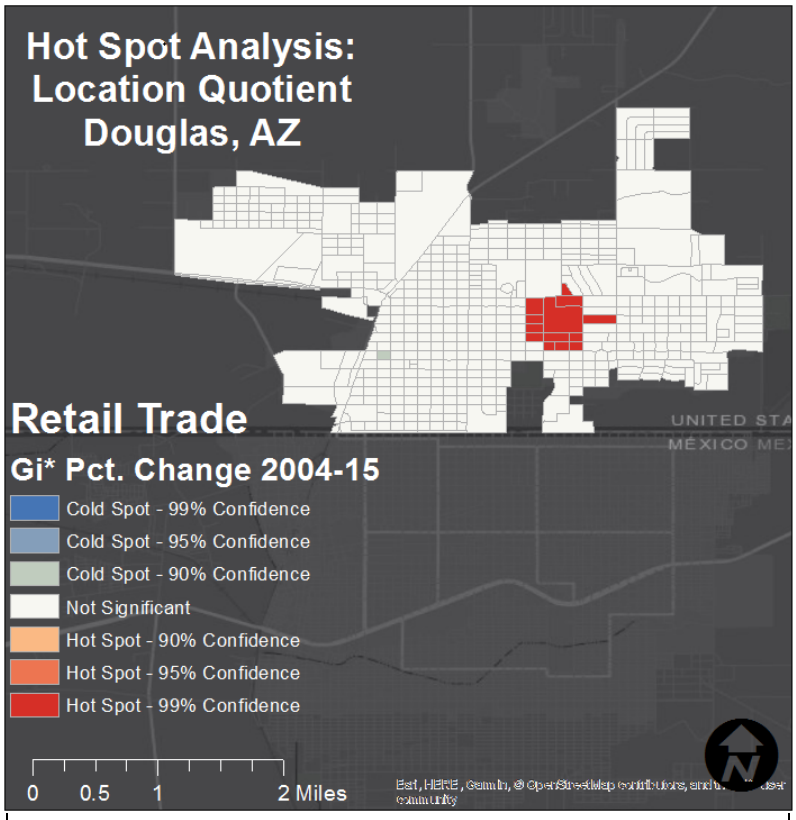


Fig 5. Retail Trade Sector (NAICS 44-45)
Source: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

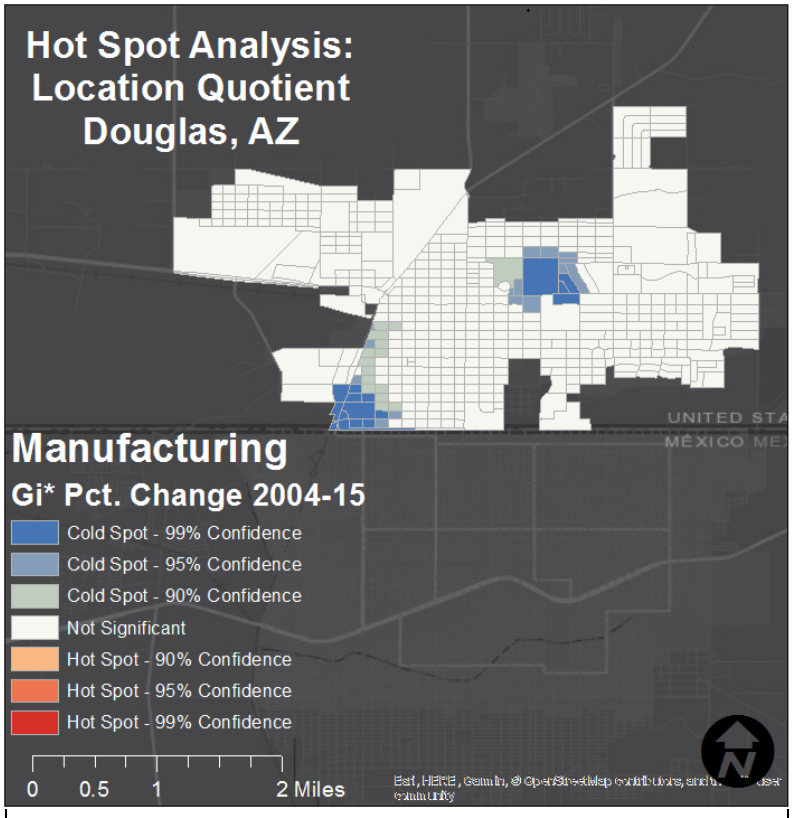
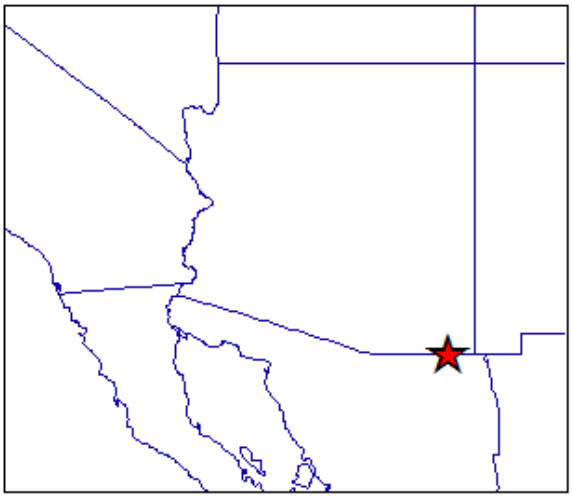


Fig 6. Manufacturing Sector (NAICS 31-33)
Source: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

These three figures show the results of a Hot Spot Analysis (Getis-Ord Gi) using Euclidian distance as a distance method. This analysis indicates where high or low values, in this case percentage change in location quotient between 2004 and 2015, cluster spatially. Percent change in location quotient from 2004 to 2015 was calculated as ((2015LQ-2004LQ)/2004LQ)*100) for each industry.*



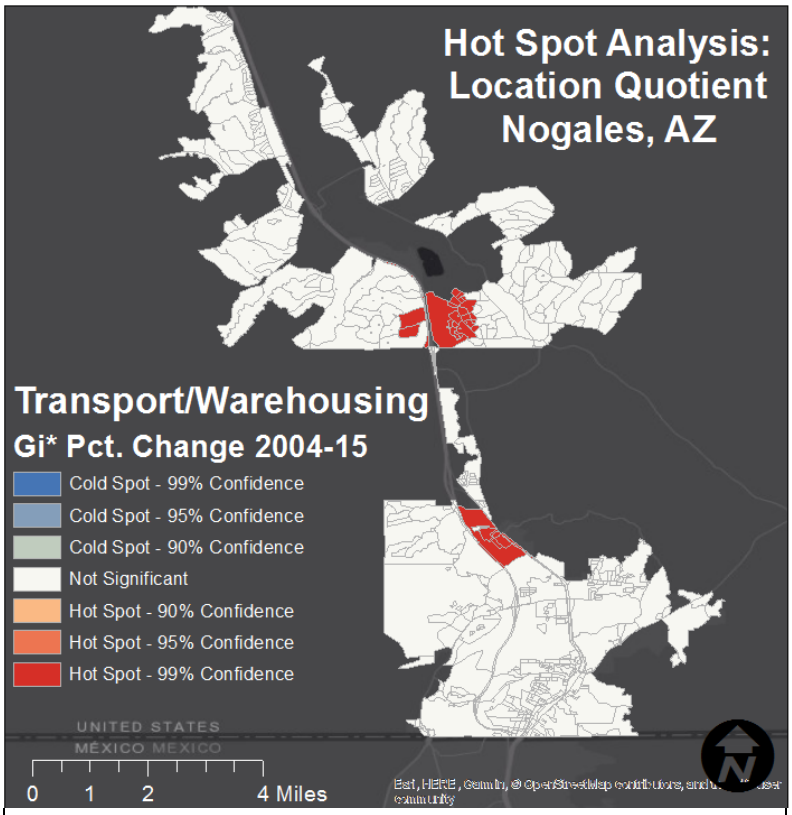


Fig 7. Transport/Warehousing Sector (NAICS 48-49)
Source: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

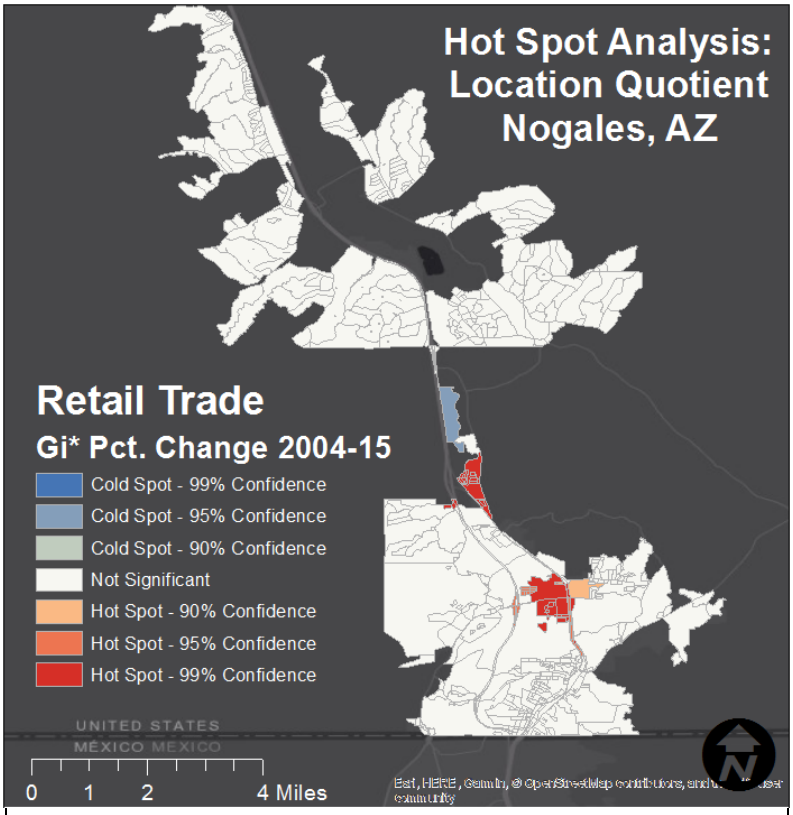


Fig 8. Retail Trade Sector (NAICS 44-45)
Source: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

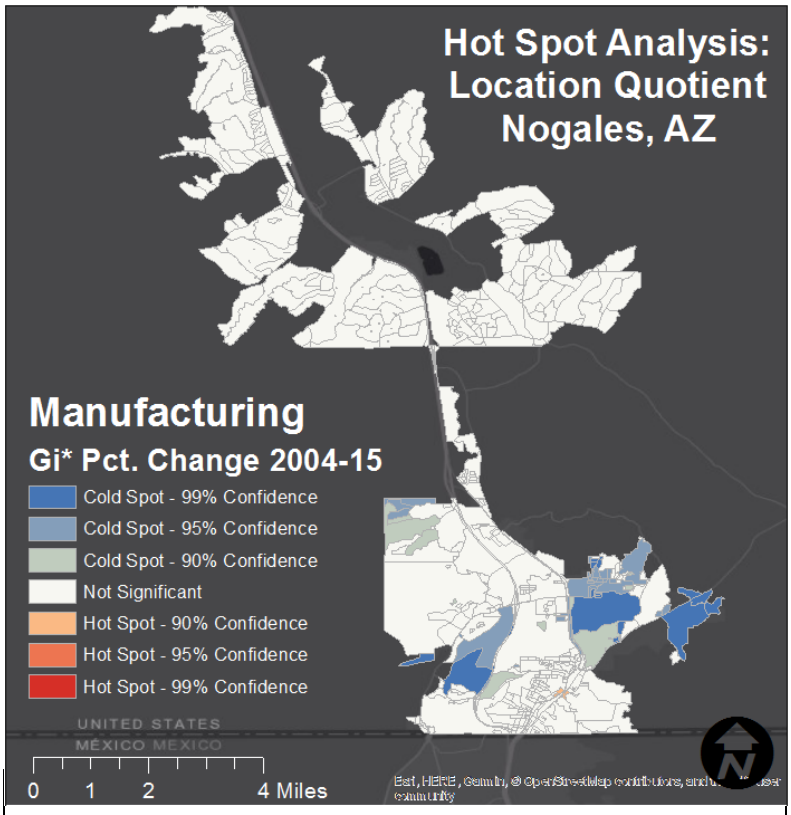


Fig 9. Manufacturing Sector (NAICS 31-33)
Source: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

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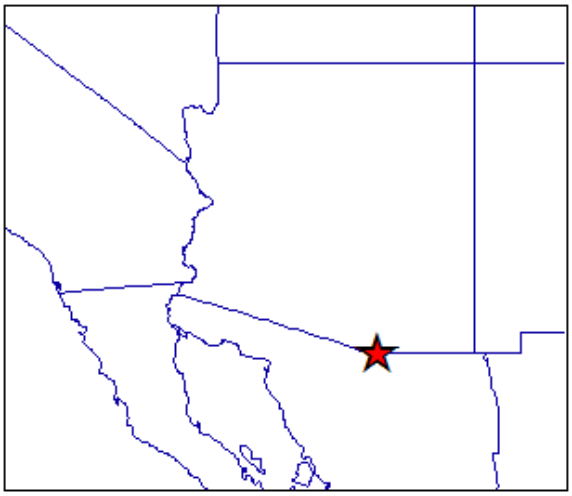


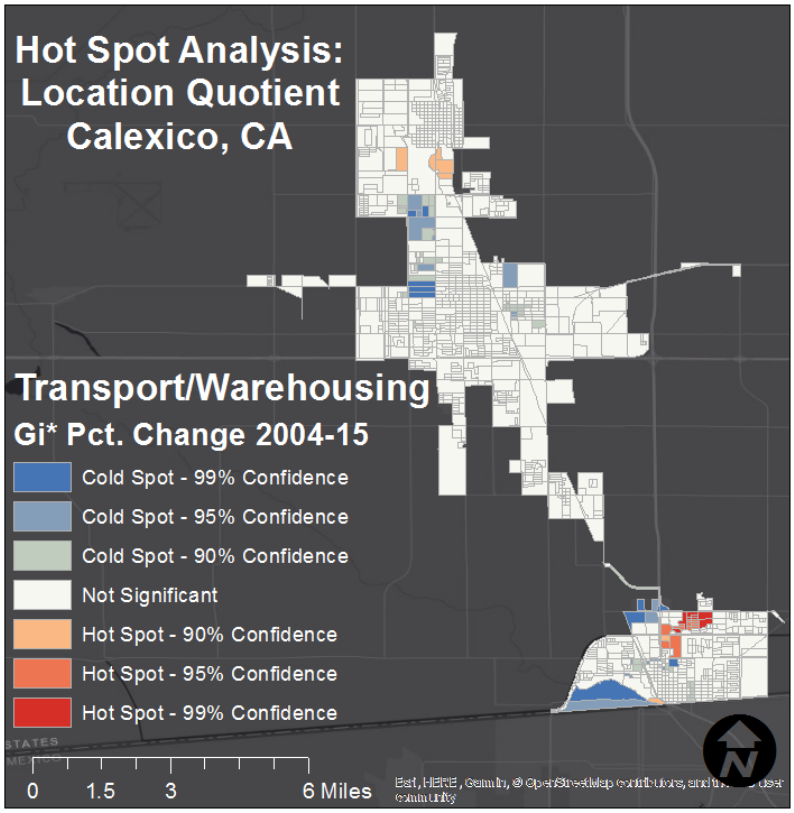


Fig 10. Transport/Warehousing Sector (NAICS 48-49)
Source: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

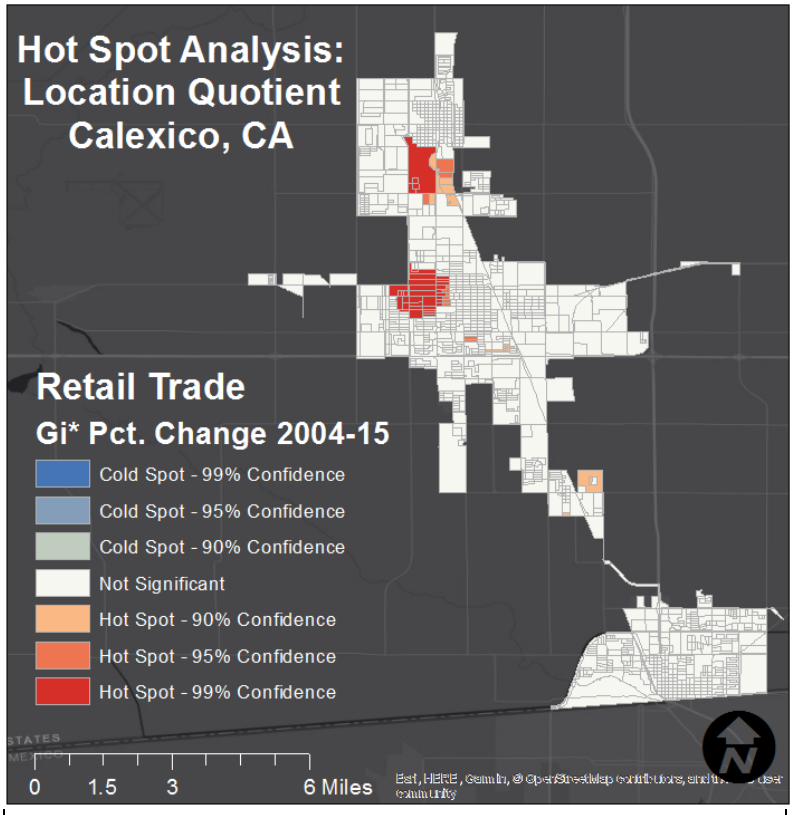


Fig 11. Retail Trade Sector (NAICS 44-45)
Source: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

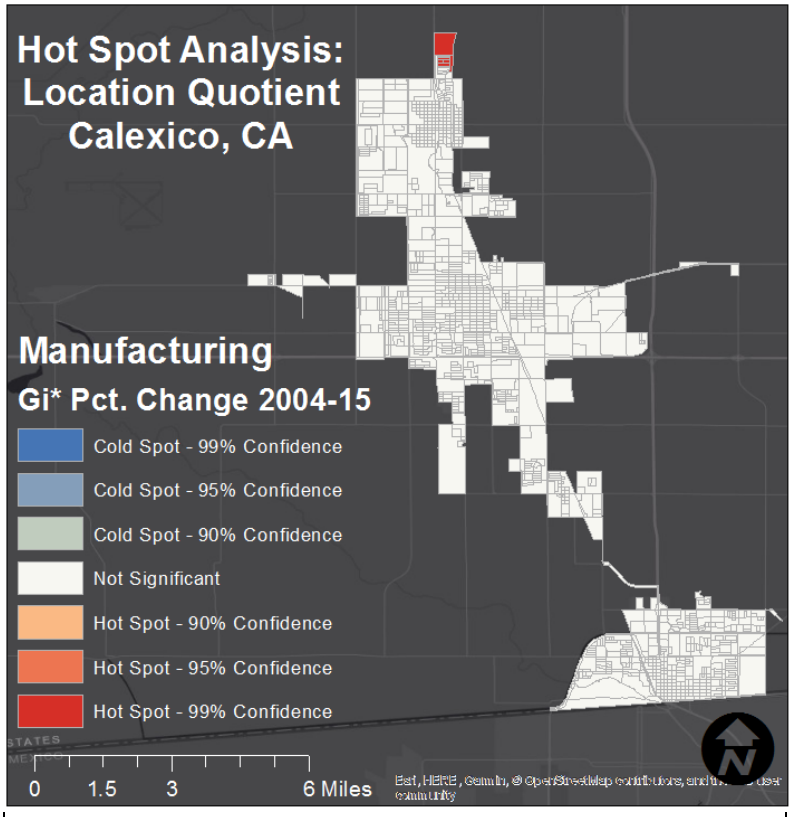
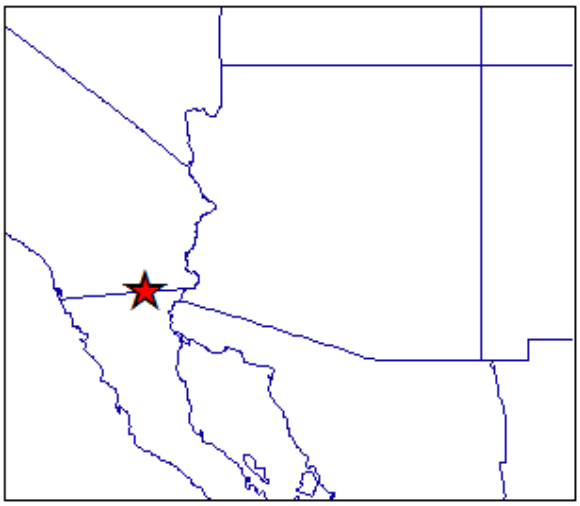


Fig 12. Manufacturing Sector (NAICS 31-33)
Source: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

These three figures show the results of a Hot Spot Analysis (Getis-Ord Gi) using Euclidian distance as a distance method. This analysis indicates where high or low values, in this case percentage change in location quotient between 2004 and 2015, cluster spatially. Percent change in location quotient from 2004 to 2015 was calculated as ((2015LQ-2004LQ)/2004LQ)*100) for each industry.*



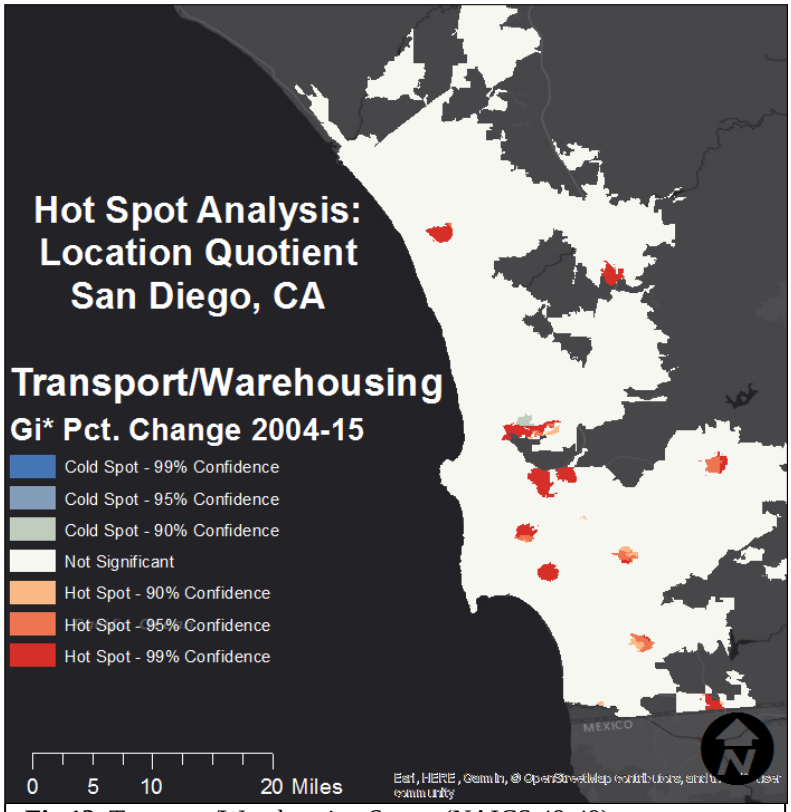


Fig 13. Transport/Warehousing Sector (NAICS 48-49)
Source: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

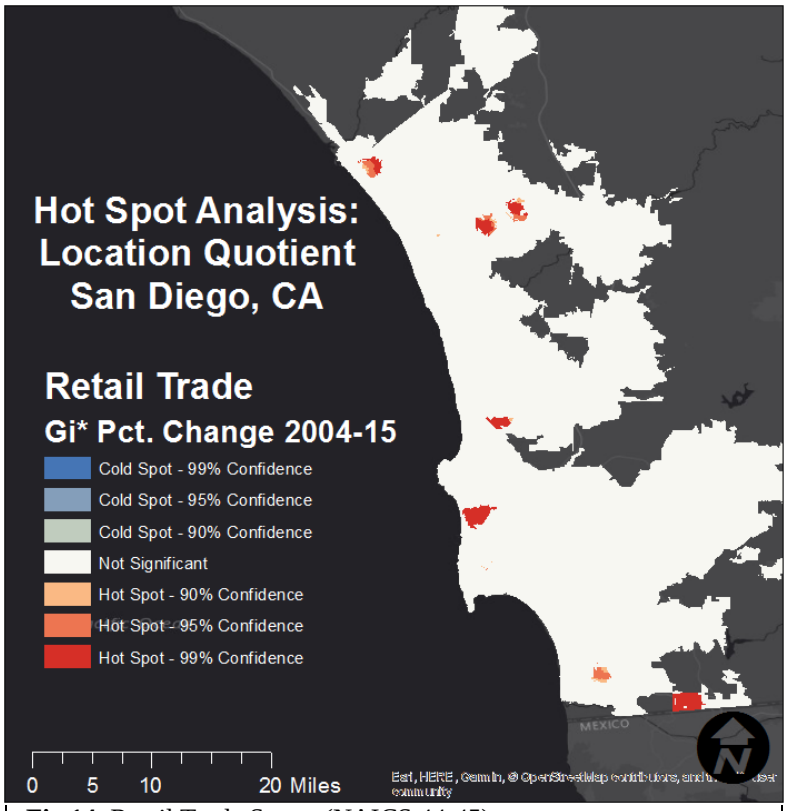


Fig 14. Retail Trade Sector (NAICS 44-45)
Source: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

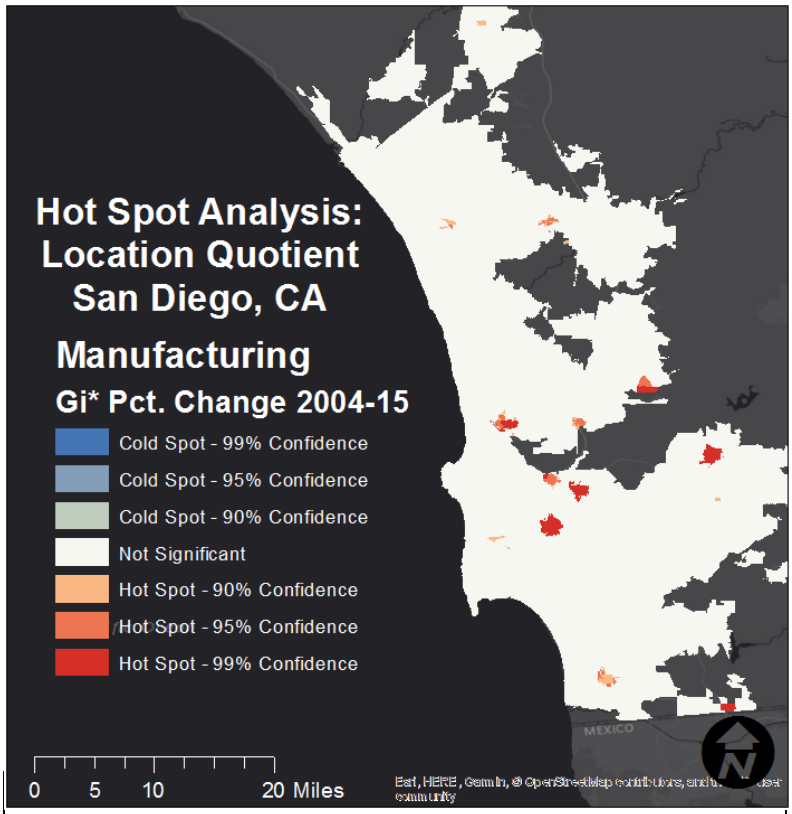
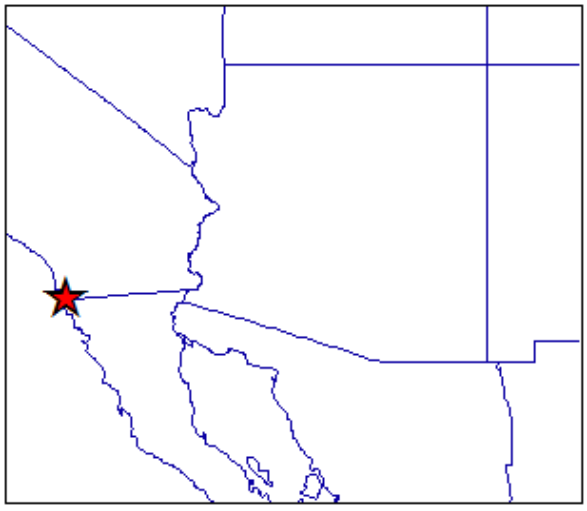


Fig 15. Manufacturing Sector (NAICS 31-33)
Source: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

These three figures show the results of a Hot Spot Analysis (Getis-Ord Gi) using Euclidian distance as a distance method. This analysis indicates where high or low values, in this case percentage change in location quotient between 2004 and 2015, cluster spatially. Percent change in location quotient from 2004 to 2015 was calculated as ((2015LQ-2004LQ)/2004LQ)*100) for each industry.*



Animated Maps:

All maps are available at:

http://www.prism.gatech.edu/~JCunningham60/

These maps are assembled as gifs at two frames per second of the block level location quotient for the transport and warehousing sector (NAICS 48 and 49), retail trade sector (NAICS 44-45), and manufacturing sector (NAICS 31-33) for Nogales, AZ, Douglas, AZ, Calexico, CA, San Diego, CA. It should be noted that the map for San Diego, CA is restricted to the southern portion of the city, San Ysidro, which was chosen to allow for a similar scale to the other maps. Within this online directory the R code developed for these maps is available. Below is an example of five maps that make up the first five years of the animated map for Nogales, AZ.

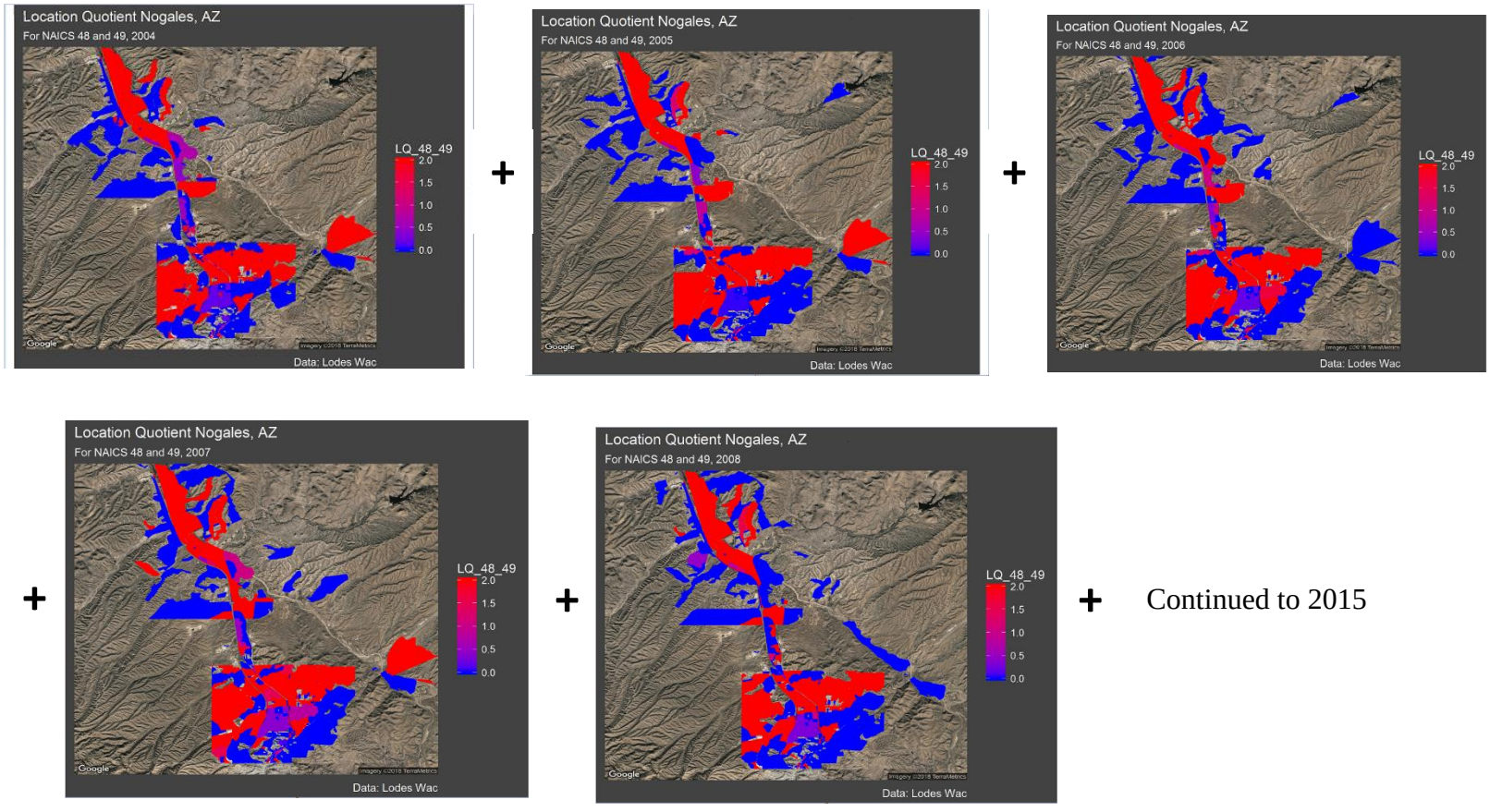


Fig 16: LEHD Origen-Destination Employment Statistics Workplace Area Characteristics, US Census Bureau

Regression Analysis:

	Dependent variable:		
	LQPct_TransportWarehousing	LQPct_RetailTrade	LQPct_Manufacturing
	(1)	(2)	(3)
Urban Area	1.355***	3.545***	1.754***
	(0.361)	(0.475)	(0.383)
Within 20mi of US/MX border	-0.170	0.152	-1.400*
	(0.763)	(1.004)	(0.809)
Constant	-0.013	0.254	0.022
	(0.248)	(0.326)	(0.263)
Observations	241,666	241,666	241,666
R^2	0.0001	0.0002	0.0001
Adjusted R^2	0.0001	0.0002	0.0001
Residual Std. Error (df = 241663)	88.302	116.124	93.650
F Statistic (df = 2; 241663)	7.055***	28.119***	11.530***
Note:			*p**p***p<0.01

Table 5. OLS results for all census blocks in Arizona, the dependent variables are the percent change in location quotient between 2004 and 2015 for Transport and Warehousing, Retail Trade, and Manufacturing.

	Dependent variable:		
	LQ04_TransportWarehousing	LQ04_RetailTrade	LQ04_Manufacturing
	(1)	(2)	(3)
Urban Area	0.134***	0.174***	0.083***
	(0.005)	(0.003)	(0.002)
Within 20mi of US/MX border	0.011	-0.003	-0.018***
	(0.011)	(0.006)	(0.005)
Constant	0.009**	0.006***	0.007***
	(0.004)	(0.002)	(0.002)
Observations	241,666	241,666	241,666
R^2	0.003	0.016	0.005
Adjusted R^2	0.003	0.016	0.005
Residual Std. Error (df = 241663)	1.319	0.684	0.597
F Statistic (df = 2; 241663)	313.771***	1,938.170***	583.077***
Note:			*p**p***p<0.01

Table 6. OLS results for all census blocks in Arizona, the dependent variables are 2004 location quotients for Transport and Warehousing, Retail Trade, and Manufacturing.

	Dependent variable:		
	LQ15_TransportWarehousing	LQ15_RetailTrade	LQ15_Manufacturing
	(1)	(2)	(3)
Urban Area	0.204***	0.206***	0.111***
	(0.008)	(0.003)	(0.004)
Within 20mi of US/MX border	0.077***	-0.007	-0.030***
	(0.016)	(0.007)	(0.008)
Constant	0.028***	0.021***	0.020***
	(0.005)	(0.002)	(0.003)
Observations	241,666	241,666	241,666
R^2	0.003	0.015	0.004
Adjusted R^2	0.003	0.015	0.004
Residual Std. Error (df = 241663)	1.848	0.842	0.915
F Statistic (df = 2; 241663)	387.314***	1,802.516***	442.872***
Note:	*p**p***p<0.01		

Table 7. OLS results for all census blocks in Arizona, the dependent variables are 2015 location quotients for Transport and Warehousing, Retail Trade, and Manufacturing.

	Dependent variable:		
	LQPct_TransportWarehousing	LQPct_RetailTrade	LQPct_Manufacturing
	(1)	(2)	(3)
Urban Area	0.348	6.108***	2.142***
	(0.361)	(0.872)	(0.627)
Within 20mi of US/MX border	-0.601	0.108	1.072
	(0.665)	(1.604)	(1.154)
Constant	0.356	-0.030	-0.052
	(0.307)	(0.742)	(0.533)
Observations	420,548	420,548	420,548
R^2	0.00000	0.0001	0.00003
Adjusted R^2	-0.00000	0.0001	0.00003
Residual Std. Error (df = 420545)	105.384	254.275	182.859
F Statistic (df = 2; 420545)	0.835	24.611***	6.421***
Note:	*p**p***p<0.01		

Table 8. OLS results for all census blocks in Southern California, the dependent variables are are the percent change in location quotient between 2004 and 2015 for Transport and Warehousing, Retail Trade, and Manufacturing.

	Dependent variable:		
	LQ04_TransportWarehousing	LQ04_RetailTrade	LQ04_Manufacturing
	(1)	(2)	(3)
Urban Area	0.185***	0.311***	0.145***
	(0.007)	(0.004)	(0.003)
Within 20mi of US/MX border	0.020*	0.023***	-0.047***
	(0.012)	(0.008)	(0.005)
Constant	0.039***	0.016***	0.022***
	(0.006)	(0.003)	(0.002)
Observations	420,548	420,548	420,548
R^2	0.002	0.014	0.006
Adjusted R^2	0.002	0.014	0.006
Residual Std. Error (df = 420545)	1.918	1.194	0.856
F Statistic (df = 2; 420545)	400.009***	2,907.140***	1,236.132***
Note:	*p**p***p<0.01		

Table 9. OLS results for all census blocks in Southern California, the dependent variables are 2004 location quotients for Transport and Warehousing, Retail Trade, and Manufacturing.

	Dependent variable:		
	LQ15_TransportWarehousing	LQ15_RetailTrade	LQ15_Manufacturing
	(1)	(2)	(3)
Urban Area	0.237***	0.317***	0.135***
	(0.008)	(0.005)	(0.004)
Within 20mi of US/MX border	-0.037***	0.019**	-0.061***
	(0.014)	(0.008)	(0.007)
Constant	0.066***	0.034***	0.044***
	(0.007)	(0.004)	(0.003)
Observations	420,548	420,548	420,548
R^2	0.002	0.012	0.003
Adjusted R^2	0.002	0.012	0.003
Residual Std. Error (df = 420545)	2.284	1.322	1.075
F Statistic (df = 2; 420545)	458.574***	2,460.866***	700.366***
Note:	*p**p***p<0.01		

Table 10. OLS results for all census blocks in Southern California, the dependent variables are 2015 location quotients for Transport and Warehousing, Retail Trade, and Manufacturing.

	Transport/Warehousing	Retail Trade	Manufacturing
LQ % Change from 2004 to 2015 AZ	-0.170	0.152	-1.400*
LQ % Change from 2004 to 2015 CA	-0.601	0.108	1.072
LQ 2004 AZ	0.011	-0.003	-0.018***
LQ 2004 CA	0.200*	0.023***	-0.047***
LQ 2015 AZ	0.077***	-0.007	-0.030***
LQ 2015 CA	-0.037***	0.019**	-0.061***

*Note:**p**p***p<0.01

Table 11. Coefficients summary from the above regressions for census blocks within 20 mi of the US/MX border, as controlled by census Urban Area. These coefficients represent the impact of the proximity to the US/MX border on the location quotients of the described categories.

The summary statistics indicate that Arizona border cities, Douglas and Nogales, had a decrease in location quotient for manufacturing and retail trade, but a 41% and 98% increase in location quotient for transport/warehousing between 2004 and 2015 respectively. Both Arizona cities showed that across time, manufacturing remained below state averages, and retail trade was above state averages. While the transport/warehousing industry grew in both cities, in Douglas the location quotient remained slightly below 1, indicating a level below state average, while in Nogales this value rose from an already high 2.65 to 3.74. The mapping portion of the analysis for these cities generally confirm this pattern at a higher spatial resolution, particularly with there being cold spots in both Douglas and Nogales for the percent change in location quotient for manufacturing and hot spots for transport/warehousing location quotient growth.

For California cities, only Calexico showed a drop in the location quotient for the manufacturing and retail trade industries, with San Diego showing a slight growth in sectors. In Calexico, manufacturing and retail trade represented values far below state averages for these

industries, while in San Diego these values were approximately equal to the state average. Unlike Arizona, both California cities showed a slight decrease in transport/warehousing location quotient, with these values ultimately dropping or remaining below state average from 2004 to 2015. The mapping portion of the analysis for these cities also generally confirmed this pattern at a higher spatial resolution. In instances where there were city-level drops in location quotient, but a lack of cold spots on the map, it is assumed there is a spread out spatial distribution of the blocks experiencing a drop in location quotient, and a clustering of blocks with increased location quotient. This provides further spatial information on how each border city has changed.

The regression analysis, which seeks to compare the location quotient of all census blocks within 20 miles of the US/MX border to the rest of each state, shows that there is a negative and significant relationship between the percent change in the manufacturing sector in Arizona between 2004 and 2015. When only looking at the relationship between the location quotient per California block in 2004 and border proximity, there was a positive significant relationship for in the transport/warehousing and retail trade sectors. Alternatively, in 2004 there was a negative significant relationship in both Arizona and California for the manufacturing sector. When only looking at the relationship between the location quotient per California block in 2015 and border proximity, there was a significant negative relationship with the transport/warehousing sector and manufacturing sector, with a significant positive relationship with retail trade. The relationship between the location quotient per Arizona block in 2015 and border proximity showed a positive significant relationship with the transport/warehousing sector and a negative significant relationship with the manufacturing sector.

Discussion:

This project sought to answer two central questions, the first being *how have the transport/warehousing, retail trade, and manufacturing industries in US cities that share a border with Mexican cities changed as the result of the continuing industrialization of Mexico's northern border*? Studies from 1978-2006 demonstrated that several US border cities showed an increased amount of job growth, particularly among jobs relating to transport and warehousing, manufacturing, and retail trade, the three US industries most directly related to the growing export economy of Mexican border cities (Davila et al. 1984, Patrick 1990, Ladman et al. 1972, Holden 1984, Cañas et al. 2013). Following this same logic and knowing that maquiladora growth has continued at a steady pace over the time period of this study, 2004 to 2015 (Doroki et al. 2014), it was hypothesized that the trends existing prior to 2004 would continue, such that the location quotient for transport and warehousing, manufacturing, and retail trade sectors would show growth across all cities in this study.

This was not the case however, with considerable differences among cities. Notably, across three cities, both manufacturing and retail trade showed a negative percent change in location quotient between 2004 and 2015, suggesting a general decrease in importance compared to state levels. These findings directly oppose the established theories that manufacturing levels in Mexican border states also lead to an increase in US border city manufacturing employment (Hanson 1996), and that retail trade is bolstered by maquiladora workers looking for deals in the US, where many items are often cheaper (Davila et al. 1984). It is possible that as Mexican manufacturing plants continue to grow and mature, there is less need for complimentary manufacturing facilities to in the US, especially as more high end technologies are integrated into existing maquiladoras. With the economic and legal freedoms given to US companies like

Continental, Acer, and Canon to operate in a much cheaper Mexico, one may expect that US border manufacturing will continue to decline in the near future as companies continually push to avoid the much higher US production and labor costs. To account this unexpected decrease in retail trade, new theories need to be considered for how Mexican shoppers currently interact with US border cities. For example, with the very recent construction of major US chains such as Walmart and Home Depot in numerous Mexican border cities, there may be continually less incentive for Mexican shoppers to make the time intensive and inconvenient trip to these same stores in the US. While there are more maquiladora workers now than ever, their spending habits may not reflect those of the late 1990s and early 2000s.

Further, the time period of this study, 2004-2015, partially covers the post 9/11 period of increased US/MX border security and an increased militarization of the entire border region. During this time, many US border cities implemented laws and infrastructure to slow the traffic of Mexicans into the US often with excruciating security inspections. This is likely to have served as a disincentive for Mexican shoppers looking for better prices in the US. San Diego was the only city that saw location quotient growth in these the manufacturing and retail trade sectors, however San Diego is unique in this study as it represents the largest and most diverse economy. It is likely that large shifts in economic characteristics are buffered by the city's size, with the diversity of manufacturing and retail options preventing location quotient changes from going in any one direction. The same cannot be said for Calexico, Nogales, and Douglas which are far smaller cities and did experience far greater economic shifts. Incorporating one border city of larger size helped to interpret the impacts of city size on the trends in question.

Increases in the location quotient for transport and warehousing were divided along state lines. The very strong increase in location quotient in the two Arizona border cities reflected the

accepted theory that an increased Mexican export sector will result in more US trucking and warehousing jobs. However, this was not the case for the California cities, with a heavy decrease in Calexico and a minor decrease in San Diego. This may be due to California specific restrictions on the trucking industry or the increased cost of storage compared to Arizona. Further, Arizona may serve as a more convenient trucking route to the Midwest and other large population centers. Perhaps in recent years maquiladora exports are more often routed through or produced in the Mexican state of Sonora, then sent up through Phoenix and around the county, a complimentary analysis of Mexican state level exports would help add to this argument.

The project concludes by asking, *how have these same industries in US cities that share a border with Mexican cities changed compared to cities that do not share a border with Mexico?* US and Mexican border towns are described by economists as "binational regional production centers" or "city-pairs" (Hanson 1996) to account for their intimately linked economies. As mentioned, there is abundant evidence that maquiladoras and industrialization in northern Mexico are related to employment in many US sectors, but most reliably in retail, manufacturing, and transport/warehousing. The predominant hypothesis put forward by the literature is that US cities with proximity to the border will experience economic changes that are unique to that area. It is implied that there would be a significant positive or negative effect of border proximity on location quotient because of this unique border economy. This study partially confirms these ideas as multiple significant relationships were recorded, most notably it was found that border proximity related negatively to the manufacturing sector in both Arizona and California in 2004 and 2015, agreeing with the summary statistics, and suggesting that manufacturing has shown consistent loss across the border region. Retail and transport/warehousing varied by year and by state, but often showed a significant positive

relationship with border proximity. In can be concluded that the border region does often allow for a unique economy to develop, however differences among states and among sectors will likely exist. There is no stable significant benefit or loss of being close to the border in Arizona and California across 2004 to 2015, other than for the loss of manufacturing. Such studies looking across time and geography are notoriously difficult to provide consistent findings due to the influence of regional, national, and international business cycles (Fullerton 1998), suggesting that this loss in manufacturing is a truly relevant and important result.

Ultimately this project was able to produce an investigation into the changes in three major economic sectors in four US border cities using a location quotient analysis that involved summary statistics, open source mapping, and a regression analysis. By focusing on three sectors indicated by the literature to be the most connected to the Mexican export economy in an understudied time period, novel conclusions were reached regarding how maquiladoras are continuing to impact the US border economy. This new time period exposed how several previous economic trends have shifted, primarily in the unanimous drop in the manufacturing industry, and also how many shifts often only exist on a city-wide level, and lesser extent across multiple states. These findings contrast previous hypotheses that suggest the border economy is constantly growing in relation to continued Mexican border city growth. This study also highlights the nuances of comparing border cities. Disparities among cities are likely due to how each city and region responds to both domestic and international changes, as well as to local policy and consumption culture. To further expand on these findings, a potential next step would be to dig into the impacts of local policies and trade policy amendments, evaluating each for both city and region wide impacts. Further, a qualitative analysis of maquiladora workers, managers,

and local politicians would help to give context to the findings put forth in this study and help give predictions into changes occurring even after 2015 and into the future.

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