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Final Paper

This summer, I worked alongside Dr. Wesley Sine, a professor of Entrepreneurship and Innovation in the Johnson College of Business, and his research team in order to analyze the effects of maquiladoras on local entrepreneurship and technological innovation in Mexico. Maquiladoras are manufacturing plants run by foreign companies that take raw materials and process them into finished products. These products are then exported to the company's home country. This process provides the benefit of allowing the factories to operate largely duty-free and tariff-free. The concept was created by the Mexican government in 1965 to help industrialize northern Mexico and attract foreign business investment.

Over the last few decades, maquiladoras have become an integral part of the Mexican economy. Foreign manufacturers, predominantly those from the United States, use maquiladoras for a number of reasons including; lower labor costs, relative ease of access compared to overseas options, exemptions from value-added tax on imports, and fewer environmental regulations. Some well-known companies that have operated maquiladoras include BMW, Canon, General Electric, General Motors, Hewlett Packard, Samsung, and Honeywell.

As for the maquiladora program's effect on Mexican citizens, maquiladoras provide over 500,000 jobs for Mexican workers, of which 50 percent are women that have few other employment opportunities. Also, regions in Mexico that have greater exposure to globalization and maquiladoras have higher labor income and lower incidences of wage poverty. Moreover, following changes that increased the competitiveness of maquiladoras, export trade increased by 99% from 2005 to 2017 and the poverty rate decreased by roughly 14% over the same period. Some studies have also shown that maquiladoras help employees build the skills and operational know-how that become the foundation of newly formed, local enterprises.

As a research team, we proposed the hypothesis that the introduction of maquiladoras into Mexico spurs entrepreneurship, marked by the formation of new businesses. To aid in this study, we had access to datasets from the Mexican Government agency INEGI. These datasets provided us with information for all municipalities in Mexico, including the number of new businesses being founded, literacy rates, crime rates, and many other socioeconomic variables. We also have access to data from Solunet-infomex.com, an industrial listing website that has information on the factories including the type of plant, the product being manufactured, location of the factory, and the name and location of the parent company.

My role in the research project was to clean the dataset and run the necessary analyses to identify trends. I was drawn to this role because I am incredibly interested in both entrepreneurship and data science. This project allowed me to combine these interests in order to conduct research that could advise policies that change lives for the better.

Starting off, I needed to clean the INEGI and Solunet datasets in order to combine their variables by the municipal level. I began by fixing mismatched labels and standardizing the location information. I quickly realized that the dataset had incorrect information about the

municipalities of a large portion of the maquiladoras. For example, the municipality for some maquiladoras was blank, while others listed a larger geographic area like Mexico City instead of one of its municipalities. The location of the factories was critical to analyze local effects and compare municipalities with maquiladoras to those without. The data points that had inaccurate municipality information still had information on the specific address of the maquiladoras. So, using the Google Maps Geocoding API, I was able to manipulate the address string to retrieve the municipality of the maquiladora.

After running the API, I manually fixed municipality names from the Solunet dataset to match those in the INEGI dataset and double-checked a subset of the data by using Google Maps to zoom in on an address and determine if there was actually a factory there. After all of the cleaning, we had roughly 15 thousand data points on maquiladoras from 2005 to 2011 (excluding 2010).

Next, I combined the INEGI and Solunet datasets at the municipal level by year. I then conducted exploratory analyses. The mean number of maquiladoras per municipality per year is 1.044 and the median is 0.000. This tells us that there are a large number of municipalities that have 0 maquiladoras. The maximum number of maquiladoras per municipality per year was 523 in Tijuana in 2005. In 2005, 2006, 2007, 2008, 2009, and 2011, there were 568,388 new firm foundations. The average number of firm foundations per municipality per year was 39.937 and the median was 0.000. This also shows that there were a large number of municipalities that had 0 new firm foundations in a given year. While this may seem strange, it is important to remember that INEGI only has data on new businesses that were registered with the government. In lots of areas of Mexico, there are many businesses that are small and unregistered. The maximum number of new firm foundations was 8,524 in Guadalajara in 2005. In that same year, Guadalajara had 38 maquiladoras.

In another exploratory analysis, I compared the average number of foundations for municipalities with and without maquiladoras. The municipalities without maquiladoras had 16.687 foundations in a given year, compared to an average 279.096 new firm foundations in municipalities with at least one maquiladora. This suggests that there may exist some relationship between the introduction of maquiladoras in a community and the number of new local companies being created.

Starting the analyses, I began with negative binomial regression, a regression model useful for overdispersed count outcome variables. Initially, I ran the regression comparing the number of foundations with the number of maquiladoras per municipality per year. This yielded the result that, without accounting for confounding variables, there was a statistically significant 17.71% average increase in the number of new foundations for every additional maquiladora. This result continued to show that there was a possible relationship between these maquiladoras and the foundation of new firms, so I factored potential confounding variables into my next analysis. The variables I looked at were population, income inequality represented by the Gini coefficient, rate of drug use, income, whether the municipality is next to the border, foreign direct investment, homicides per capita, and the year-over-year effect. The regression showed

that all of these factors were statistically significant. With the confounding variables accounted for, there is a statistically significant 2.03% average increase in the number of new firm foundations for every additional maquiladora in a municipality.

Next, I wanted to perform an analysis to determine if the number of maquiladoras in a municipality in one year affected the number of firm foundations in the following year. These analyses showed that accounting for confounding variables, for every additional maquiladora in the previous year, there is a 2.58% increase in the number of new company creations. Also, for every additional maquiladora 2 years earlier, there is a 2.55% increase in the creation of new companies.

The next set of analyses I ran involved fixing the municipality to determine the relationship between maquiladoras and entrepreneurship in each locale. These analyses showed maquiladoras having a much smaller effect on new firm creations. Without accounting for the other variables, an additional maquiladora corresponds with a 0.2% increase in new firm establishments and an additional maquiladora 2 years previously corresponds with a 0.8% increase. There wasn't a statistically significant relationship between a 1 year lag and the formation of new businesses. Accounting for the confounding factors, an additional maquiladora 2 years previously corresponds with a 0.76% increase in the number of new business conceptions.

Lastly, I utilized a matching model that grouped municipalities in given years by whether they were next to the border, their population size, their gini coefficient, their drug rate, their average income, and their homicides per capita. This found that the mean difference in new foundations between the untreated group (no maquiladoras) and treated group (>1 maquiladora) is 8.096.

After finishing these analyses, I created a presentation for my research group and presented the findings. All together, the results seem like a good starting point for us to continue to pursue trends and start discussing possible reasons why these trends appear. For example, the relationship between maquiladoras and new business creations could exist because maquiladoras introduce new technology and managerial skills into the community. This semester, I am going to continue to work with Dr. Sine and the research team to perform more analyses on the data and analyze new trends. One such analysis that I would like to examine is whether there is a "sweet-spot" for the number of maquiladoras in relation to encouraging entrepreneurship. This could be examined using a dose-response function.

During the research part of the summer, I developed my analytical, statistical, data science, and many other hard-skills that would aid me in my future endeavors. I also greatly developed as a leader. I learned how to have dialogue across a team, how to summarize my results, and how to present myself and my capabilities. I was also able to take initiative to reach out for help when I didn't know something, and I learned that to be a community-engaged leader you need to truly understand the communities that you are involved with. With this lesson, I always know at the front of my mind that the data points correspond to real businesses, run by actual people and policies that arise from my research can have palpable effects on their lives.

Overall, I think this summer was a fantastic opportunity to develop my skills and to realize how I would like to lead in the future. I am excited to continue the research this semester and to find out what opportunities are in store for next summer.