Team Control Number: 7037

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2016

19th Annual High School Mathematical Contest in Modeling (HiMCM)

Summary Sheet

(Please make this the first page of your electronic Solution Paper.)

Team Control Number: 7037

Problem Chosen: B

Please paste or type a summary of your results on this page. Please remember not to include the name of your school, advisor, or team members on this page.

Summary

Below is a list of Variables and their corresponding definitions used in this project:

Variable	Definition
P_O	Population in area outside of state of warehouse
P_I	Population in area inside of state of warehouse
T	Sales tax in the state of warehouse
S_R	Raw Score
S_F	Final Score
C	Clothing tax in state of warehouse
n	Total number of warehouses

i	Warehouse number
T_i	Total in-state population of warehouse
R	Total in-state population of the map
C_i	Clothing tax of the state the warehouse is located in
μ_T	Average clothing tax

Online shipping is a major booming business that is becoming a natural phenomenon through the increase of electronics in the United States. One of the major industries that has become proficient in this area of industry is UPS. At first, the team's goal was to determine the minimum amount of warehouses needed to provide efficient one-day coverage throughout the continental United States. Some assumptions had to be made, particularly regarding seasonal weather conditions as well as traffic consistencies in the highway system. The time of the worst weather conditions was chosen, but that assumes no extraordinary events could slow down distribution. To accomplish this goal, certain criteria was needed to determine the location of the warehouses. The criteria used for the location was that optimal area covered by zipcode in one day (to meet the requirement of the one-day ground shipping with United Parcel Service), that the warehouse is located in a city with a major intersection of roads and highways, and that there was an overlap of one-day shipping capability reduced to a minimum. Using this criteria, it was determined that 28 warehouses was needed to effectively reach all the populated areas in the continental United States. Next, the team had to evaluate the effect of sale taxes on the amount of people with sale taxes based on the location of the warehouses. An equation was then created to score each of the 28 warehouses: $S_R=P_o/(P_I)(T)$. Using this equation, the warehouses with a score below the first quartile was found inefficient and was then attempted to be replaced with an another location. After solving this problem, clothing tax was factored into the location of the warehouses and so the equation changed to be $S_R=P_o/(P_I)(C)$. Using this equation, the locations that scored under the first quartile, 3.959, were determined to be inadequate and new locations were considered. The equation $\mu_T = \sum_{i=1}^{n} ((T_i / R)(C_i))$ was used to determine which map should be used as the basis for the third map model. It was found that the second map was overall more efficient than the first and thus was used as the canvas for the clothing tax issue. The strengths for these models were that you could compare different warehouses and effectively determine efficiency. It also provides an accurate display of the ratios' correspondence to the sales tax. Some weaknesses include its inaccuracy regarding warehouses with no taxes or out of state population. In such situations the score will be ∞ or 0 respectively and thus do not fully account for the other variables and their ratios.

Mr Company President,

After 36 hours of intense computation and analyzation of your situation, our team has discovered a solution that seems to account for the three most important factors of deciding where the warehouses go using the minimum amount to cover the entire continental United States with one-day shipping, sales tax of states with warehouses, and clothing taxes of states with warehouses. The laws of demand show that it is always preferable to minimize the price of the items for the customers. Because private profits will not be gained from any state tax, it is the most preferable to put make as many warehouses as possible to satisfy everyone in the continental United States with one day, out of state shipping, while applying the minimum tax possible. However, due to the overwhelming funding needed for this, it was deemed only necessary to change the worst warehouses that had the worst ratio of out-of-state population to the in state population times the state tax rate. The reason this ratio was used was to find whether it was worth it to have a warehouse in a state and have the people in that state pay the taxed in order to access more customers out of the state, since they would not have to pay taxes. As an extreme example, if there was a state with a population of two people, and they had to pay a tax rate of 6%, it would be valuable to have them pay the tax rate if 30,000,000 people outside of the state were given a 0% tax rate because they are purchasing online from out of the state. All of the ratios were compared for the sales tax, and the warehouses with the lowest seven values were attempted to be moved. The finalized locations for the whole entire country can be seen in the Appendix[1]. To make these finalized changes, the following factors were compared, in order from least to most important: the minimum number of warehouses needed to give everyone in the continental United States with one-day shipping (determined by the United Parcel Service Ground Time-in-Transit Map Website[2]), the ratios for each warehouse of the total out of state population to the in state populations times the sales tax, and the ratios for each warehouse of the total out of state population to the in state population times the clothing tax.

A similar method was used in dealing with sales tax per state as was used in clothing taxes. As you may or may not know, customers outside of the state of the warehouse do not have to pay state taxes, while customers inside the state do. Therefore, it was calculated whether or not to have the customers in the state of the warehouse pay the state taxes in order to access more customers with shipping they did not have to pay state taxes for. These factors were used to determine if the seven warehouses with the worst ratios could be changed and relocated to have better ratios, which was done for both sales and clothing taxes. The result were finalized and are given in the appendix. Our resources were limited due to the UPS one-day shipping calculator used, but we are confident that we came up with some of the most accurate results for where to locate the warehouses when including the previously mentioned factors.

Sincerely,
Your Employees

[1] See Appendix Table 4.1
[2] See Cited Sources 3

Title Page

Problem B: Shop and Ship

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Solution to Part I

In order to cover the whole Continental United States with one day shipping times, multiple cities were tested and compared to find the best cities for coverage. The date that was entered onto the United Parcel Service Ground Time-in-Transit Maps Calculator was estimated to be the most during the most trying weather conditions and thus provides a worst case scenario for delivery. The criteria the team used to determine where to place a warehouse is:

1) Optimal area covered by zipcode in one day (to meet the requirement of the one-day ground shipping with United Parcel Service)
2) Warehouse is located in a city with a major intersection of roads and highways
3) Overlap of one-day shipping capability reduced to a minimum

From there, the team discovered the cities where UPS should place their warehouses. The minimum number of warehouses needed was found to be 27, plus the headquarters in New Hampshire[3]. Some shipping areas overlapped, but were necessary for covering specifically remote areas that had less access to major highways. Reference Image 1 to see the domain of where each of the 28 warehouses reach in one day. The new warehouses were located in 27 different cities interspersed throughout the country, found through the criteria above. Through the team's research, there was several obstacles that stood in the way to finding efficient one day routes to all 48 states. For example, one major problem that was found was that the western part of Texas was difficult to reach in one day due to the lack of connection of two major interstates: Interstate 20 and Interstate 40. Therefore, the western part of Texas had to be split in two in order to cover all parts of Texas efficiently.

[3] See table 1.1 in appendix

Solution to Part II

2.1: Purpose of Minimizing Tax Liability

A scoring system was established in order to rate each warehouse based on their efficiency of reaching customers with the least amount of population having the higher sales taxes and the most amount of population having the lower or no sales taxes. The goal of the company is to have the least amount of people pay the least amount of taxes while still maximizing the amount of people that can receive the shipment within one day, for the maximum convenience of the consumer. In order to score the efficiency of each individual warehouse, there was a need to create a scoring system that would prove whether or not a warehouse would be beneficial to both the company and to the consumers. In order to benefit the company, the warehouse would need to be able to reach the maximum amount of people and to benefit the consumer, it would have to minimize the taxes that the consumers of our products face. At first, the research team was thinking of ranking the the 28 locations based on population and replacing the bottom 25% of the ranks. However, this method was found null due to the inefficiency to evaluate the effect of the sales tax on the population. And so, the method to discover the efficiency of the warehouses based on the surrounding area's sales taxes was discovered to be scoring each of the locations and then using statistics to discover which locations need to be changed due to the sales taxes of the state.

2.2: Developing a Scoring System

Variable	Definition
P_O	Population in area outside of state of warehouse
P_I	Population in area inside of state of warehouse
T	Sales tax in the state of warehouse
S_R	Raw Score
S_F	Final Score

The goal of the scoring system was to compare each warehouse area, and whether it was worth it to have the customers inside of the state to pay the tax in order to access a higher population outside of the state. For example, if a warehouse resides in a state that has a high sales tax, low internal population, and a high population of customers outside of the state then it would still get an adequate score. An adequate score would be given because the high outer population that is not being taxed greatly outweighs the small inner population having to face the sales tax of that state. A ratio was necessary to complete this goal of comparing each warehouse. Comparing each warehouse would give the ability to decide if some of the warehouse should be moved out of the state they are in so that less people would have to pay taxes. The ratio used was

$$S_R = P_O / (P_I T)$$

which counted for the different variables that would show if the warehouse is appropriate in relation to the tax liability. In this way, the ratios of the different warehouses could be compared to each other, and statistical analysis could be tested to show which warehouses were the worst and best in relation to tax liability. Using this ratio, each location would be placed in a positive number that would be further evaluated based on the statistics of the entire data. Furthermore, states without any sales tax , which are Montana, Delaware and New Hampshire, would have an indeterminate form (a number divided by zero), which was discovered to be the best score possible. An undefined result is the best form because of the zero sales tax within the state of the warehouse in addition to the zero sales tax to the population outside of the state as well. It ranks the warehouses based on their importance to change, such that the lowest scores are most important to fix and the highest are least important to alter.

2.2.1: Finding the Population in Specific Areas

To complete and solve for S_R the population of the specific areas, P_O and P_I, had to be calculated. An interactive website was used to calculate the areas in a state and out of a state by creating the similar borders as the map of warehouse areas contained[4]. The interactive website has a polygon tool that helps to find the population of an area of any shape, which was needed due to the many curves and sharp edges in the range of the one day shipping of each warehouse. If an entire state was covered by an area, the whole state population was used instead, which was found by the US Census[5]. All the values of P_O and P_I were recorded and used to calculate the ratios[6]. The ratio was then calculated through an excel spreadsheet to a decimal format, which was then rounded to three decimal places.

2.2.2: Finding and Using the Sales Tax of Each Warehouse

The tax rates used were calculated using the whole number instances. For example, since Virginia's tax rate is 5.3%, the number used to find the ratio was 5.3. The ratio was not calculated using 0.053. All state tax rates were determined by using a tax rates database[7].

2.3: Interpreting the Scoring System

[4] See Cited Sources 8
[5] See Cited Sources 1
[6] See Appendix Table 2.1
[7] See Cited Sources 5

After scoring all of the individual warehouses and applying it to the following equation

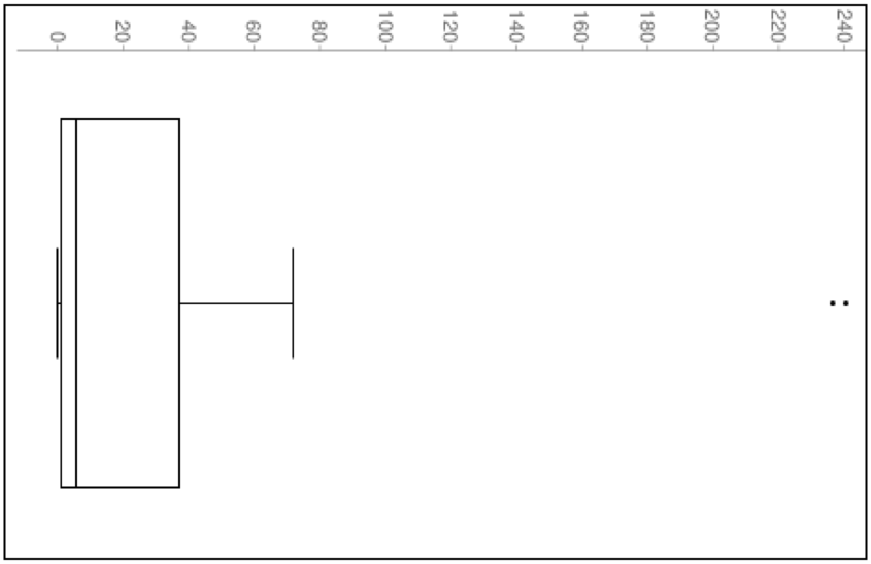
$$S_F = (S_R)(100),$$

the final score was obtained. This equation was created to convert the values to more comparable and readable answers. The median of these data points was 5.352. The statistical analysis showed that the range of Quartile 1 was from 0 to 0.991. The range of Quartile 3 was 5.352 to 37.032. It was determined that any warehouse with a S_F in the first quartile range was unfit to provide services to the customers. Using this exclusion the warehouses numbered 1, 10, 12, 22, 24, 25, and 27 were deemed inadequate[8]. By being inadequate, these warehouses was discovered to be inefficient and needed to be changed if possible due to the high population of sale taxes within the state being significantly greater than the low population having no sales taxes of the states outside of the state of the warehouse. The upper outliers are warehouses that were especially efficient for tax liability and thus were kept[9]. The upper outliers were wearhouse numbers HOME BASE, 11, 13, and 14. HOME BASE and 14 had no sales tax and thus had an infinite S_F. Therefore, because this is the best possible score attainable, these locations were left alone. Through the ratios, the higher the number the better, while the lower numbers were determined to be worse. In context, this means that the lower the score there is a higher population that has sales tax, while the higher score means that there is a higher population of people who do not have sales taxes. The following graph is a box-and-whisker plot that shows the distributions of the scores of the 28 warehouses as well as the first and third quartiles, the median, and the outliers.

[8] See Appendix Table 1.1 and Table 2.1

[9] See Appendix Table 2.2

Warehouse's Scores Statistics



The two dots in the graph above represent the outliers discussed above. These two outliers outside of the graph is to the right. There were also two other outliers with the amount of infinity. These two scores do not have actual S_F values because their taxes were 0, so their values were some constant divided by 0. These were especially preferable because their taxes were 0%. They were still calculated into the box-and-whisker plot as an extremely high value, but not graphed. The graph above shows a huge skew towards the right of the data, which is beneficial to the efficiency of the amount of sale taxes because of the greater percent of higher scores. The median is towards the left of the data, which is inadequate because of the fact that a half of the data is lower than 5.352. It was then attempted to bring the median up by changing the warehouse locations, and thereby their respective scores, of the warehouses that are lower than the first quartile.

2.4: Analyzing and Moving Inadequate Warehouses for Improved Tax Liability

The locations of warehouse numbers 1, 10, 12, 22, 24, 25, and 27 were deemed unsatisfactory because they were found to have very low S_F values in comparison to the other S_F values[10]. Other locations, preferably with low instate populations and high out of state populations, also with low sales tax rates, would result in a higher S_F value. Multiple locations were tested using United Parcel Service Ground Time-in-Transit Times[11] and their ratios were calculated. These new ratios were then compared to the previous ratios. Once a location with a significantly higher ratio was found, it was recorded and

[10] See Appendix Table 2.1
[11] See Cited Sources 3

the warehouse location was changed. In all, four of the seven warehouses was changed, while the other three warehouses were unable to be changed due to various reasons. In addition, two more warehouses changed locations to create a better ratio of population who do not have sale taxes to the population who do have sales taxes. To see the difference for the domain of the changes of warehouses from part 1 to part 2, reference Image 1 and Image 2 in the Appendix.

2.4.1: Finding the Best Method Excluding Costs of Building and Managing Warehouses

Theoretically, it would be the best option to only manage warehouses that only deliver out of state. Performing this would require lots of management and funds, but when only considering lowering tax liability to customers, it would be the best option. Using the formula for finding the ratio S_F, it would be the best to make P_I be as small as possible. It would be possible to service almost every part of the continental United States with out-of-state shipping, and to not have any warehouses ship in-state. However, when considering the price of making enough warehouses to service every state with out-of-state one day shipping, it would be impractical to supply and fund enough warehouses just to avoid sales tax. The additional increase in demand because of the lower price due to no sales tax would most likely not repay the warehouses, let alone increase profits. Therefore it was concluded as appropriate to only fix the warehouses with the lowest S_F values.

2.4.2: Unmovable Warehouses

There were seven locations where the score of the individual warehouses was below the first quartile. After going through each individual score, it was determined that four locations were impossible to change due to various reasons. The first location that could not be changed was warehouse 1 in Jonesborough, Maine[12]. This area was in the upper corner of Maine[13] is unable to be accessed in any other place because UPS already has a warehouse in New Hampshire. Warehouse 12, which was in Houston, TX, had a high S_F value. This was because it only covered in-state customers, so all customers from this warehouse would be required to pay state tax. The dominant purpose for being unable to relocate warehouse 12 was because of the large area that needed to be covered in Texas was inaccessible by any major highways. Warehouse 22, which was in Los Angeles, CA, had a similar reason for not being able to be relocated. Warehouse 25 covers the southeastern area of Texas, and could not be changed to lower tax rates because it was the only one that covered the area with one-day shipping.

[12] See Appendix Table 2.1
[13] See Appendix Image 1.1

2.4.3: Moving Warehouse Locations

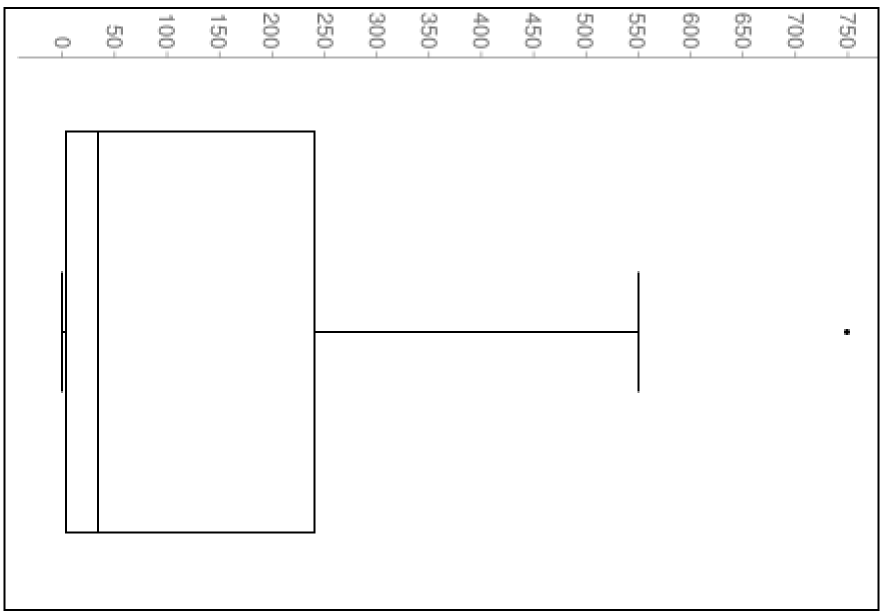
Many warehouses had locations that covered the same area and gave a better ratio. The warehouses that were attempted to be changed were the ones who had S_F values in the 1st quartile. The warehouse numbers whose locations changed were warehouses 10, 16, 20, 21, 24, and 27[14]. The location for warehouse 10 was moved from Minot, ND to Fargo, ND. This location change is more beneficial as the out of state population that the warehouse could reach increased by 14,458.807% and the number of people residing within North Dakota that would receive their package. Since the numerator increases by such a high percentage and the denominator decreases, that warehouse's score will increase, enough to make it a desirable location for the warehouse. The location for Warehouse 21 was changed from Phoenix, AZ to Needles, CA. This is because the two cities cover roughly the same area, meaning they reach the roughly the same number of people, but the number of people that would have to face taxes in California, if the warehouse is located in Needles is a lot less than the number of people that would have to face taxes in Arizona, were the warehouse placed in Phoenix, despite the fact that the residents of California would have to face a higher tax. The same major roadways intersect Needles as they do Phoenix, and the two cities are relatively close, so the same distances will be travelled in about the same time. The people that had to face sales tax actually decreases by a whole 98.122%, greatly reducing the number in the denominator. Since the same number of people are being reached, the entirety of Arizona no longer has to face a tax, so the number of people out of state being serviced by the warehouse greatly increases, meaning that the numerator will increase. This creates a completely new ratio that favors a much larger score, which is advantageous for the company and the consumer. The location for Warehouse 27 was changed from Wichita Falls, TX to Guymon, OK. Before this location change, no out of state residents could have been reached within a day, but afterwards, the same number of residents who could be serviced in state in Texas could be serviced out of state in Texas from Oklahoma. The number of in state residents of Oklahoma reached by the warehouse after the location change is significantly lower than were in state in Texas prior to the location change, having a much lower denominator, resulting in a higher score, especially since there was actually an out of state population. Warehouses 24, 20, and 16 all had their locations changed together. Warehouse 24 had its location changed from Sacramento, CA to Reno, NV. Not only is the sales tax lower in Nevada, but the number of people that can receive one day shipping in California from Reno is actually greater than can receive in California from Sacramento by more than two million people, and a warehouse placed in Sacramento could not even service out of state customers. On top of that, about seven million people less people will have to face the state sales tax from a warehouse placed in Reno than if it were placed in Sacramento, all of these things resulting in the score of Warehouse 24 increasing from 0 to 75.75. Since Warehouse 24 was now covering a lot more land, Warehouse 20 could be moved to a more advantageous location without having to worry about missing land in California, thus Warehouse 20 was moved from Weed, CA to Portland, OR. An obvious improvement of choosing Portland over Weed

[14] See Appendix Tables 2.1 & 2.3

was that Oregon has no sales tax at all, giving it a huge edge over the California location. Portland also reached a lot more people with one day shipping than Weed, which gives our company an easy way to ship to our consumers. The final warehouse placement for Warehouse 16 was changed from Seattle, WA to Missoula, MT. Once again, this location is more beneficial, despite the fact that it reaches less people within a day, because Montana has no sales tax compared to Washington's 6.5% sales tax. In addition, the people not covered by Missoula that were covered by Seattle with one day shipping could already be reached by Warehouse 20 being placed in Portland.

2.4.4: Analyzing Graph after Change to Warehouses

Below is the box-and-whisker plot of the scores of the individual warehouses after manipulation of the scores below the first quartile range.



The two dots in the graph above represent the outliers discussed in Table 2.4. However, there were four outliers that are not represented above due to their value not being able to fit on the graph (infinity). Again, these four dots do not have actual S_F values because their taxes were 0, so their values were some constant divided by 0. These were especially preferable because their taxes were 0%. They were still calculated into the box-and-whisker plot as an extremely high value, but not graphed. The graph above shows a huge skew towards the right of the data, which is beneficial to the efficiency of the amount of sale taxes because of the greater percent of higher scores. This skew is also consistent with the plot before the change, although with the greater change. The median is towards the left of the data; however, this median is significantly greater than the scores before the changes to the locations of the warehouses. The median changed from 5.352 to 34.854, which was one of the goals for the change to the warehouses to accomplish. This means that the scores of the warehouse rose in general, causing the efficiency of sales taxes to less people greater. In addition to the median having a greater change, the range of the data increased from 240.787 to 748.436. In context, this represents that the greatest score increased significantly by almost 300%. As explained above, the higher score signifies a greater amount of population (the population out of the state where the warehouse is located) getting no sales tax as well as lower amount of population (the population in the state where the warehouse is located) getting sales tax.

Solution to Part III

3.1: Calculating and Analyzing the Average Clothing Tax

Variable	Definition
n	Total number of warehouses
i	Warehouse number
T_i	Total in-state population of warehouse
R	Total in-state population of the map
C_i	Clothing tax of the state the warehouse is located in
μ_T	Average clothing tax

To analyze the clothing tax that the customers would have to pay, the average tax that all customers that have to pay clothing tax was calculated. In order to do this, a weighted average was needed for only the taxpayers. First, the following equation,

$$R = \sum_{i=1}^{n} (T_i),$$

was used to find the total population of taxpayers, which is the same as the total in-state population. Then, to find the weighted average of clothing tax for all the taxpayers, the equation

$$\mu_T = \sum_{i=1}^{n} ((T_i / R)(C_i))$$

was calculated for both map one of part one and map two of part two. The average clothing tax counted states that had no or limited tax, and they were counted as having 0% tax rates.

3.1.1: Calculating the Average for Map One of Part One

First, the total number of taxpayers, R, was calculated to be 167,336,683 total taxpayers. The above equation for finding weighted average tax that taxpayers had to pay, μ_T, was calculated to find an average of 5.38%[15]. The data used was found from the website of The Comprehensive Sales Tax Guide[16].

3.1.2: Calculating the Average for Map Two of Part Two

First, the total number of taxpayers, R, was calculated to be 150,140,309 total taxpayers. The above equation for finding weighted average tax that taxpayers had to pay, μ_T, was calculated to find an average of 5.07%[17]. The data used was found from the website of The Comprehensive Sales Tax Guide [18].

3.1.3: Concluding Remarks

The weighted averages of the clothing taxes of part one and part two were found to be 5.38% and 5.07%, respectively. The main goal was then concluded to be to lower this average tax. The lower this tax went, the better it was for the customers. The less the customers have to pay for clothing taxes, the more they are probable to buy. Therefore, it is preferable to keep μ_T as low as possible. The main purpose of this calculation was to conclude whether or not to start solving problem 3 with Map 1 or Map 2[19], and it was concluded to start with map 2 because it had the lower average.

3.2: Developing a Scoring System

Variable	Definition
P_O	Population in area outside of state of warehouse
P_I	Population in area inside of state of warehouse
C	Clothing tax in state of warehouse
S_R	Raw Score
S_F	Final Score

It was found necessary to calculate which warehouses were most important to change. To execute this, a ratio of outside population to the inside population multiplied by the clothing tax was formed

[15] See Appendix Table 3.1
[16] See Cited Sources 4
[17] See Appendix Table 3.2
[18] See Cited Sources 4
[19] See Appendix Image 1 and 2

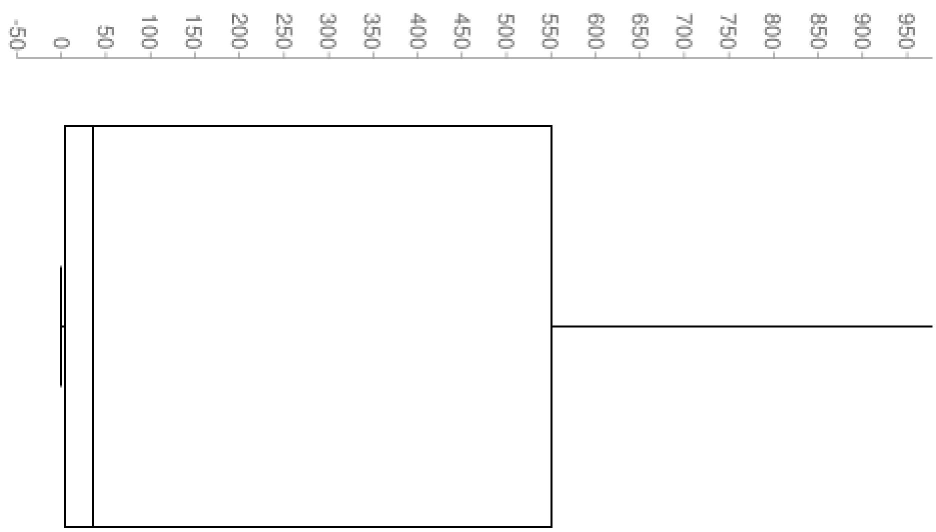
$$S_R = P_O / (P_I C)$$

in order to rank the warehouses of importance to change.

3.2.1: Calculating the Ratios

The ratios were calculated and graphed using a box-and-whisker plot.

Warehouse Scoring after Clothing Taxes Applied



The box-and-whisker plot cuts off because the ratios were divided by a clothing tax which were counted as extremely high numbers. Realistically, they did not exist, but were counted as extremely high values for the purpose of finding the lowest S_F values. Anything below the first quartile value, which was 3.96, was counted as being necessary to replace.

3.2.2: Changing the Warehouse Location

The locations for Warehouses 1, 12, 22, and 25 are not possible for the reasons previously mentioned in Section 2.4.2. The warehouse in Jacksonville, FL[20], Warehouse 9, was unable to be optimized because the peninsular nature of the state prevents warehouses located in other states from reaching all of Florida. Warehouse 23, originally located in Denver CO, did not have a better location because it

[20] See Appendix Table 2.1

did not have an out of state location that covered the same amount of area. Warehouse 23, however could be moved from Albuquerque, NM to Vaughn, NM[21]. This location change is much better for the company as Vaughn reaches the same area within the state as Albuquerque, reaching the entire population, yet out of state it reaches 1,103,701 more people than Albuquerque did. This is because Vaughn was actually able to take up the same area as Albuquerque within one day shipping as well as the entire area for Warehouse 27, getting rid of the need for an entire warehouse, meaning the company does not need to spend nearly as much money on funding the construction of the warehouses.

[21] See Appendix Table 3.4

Appendix

Image 1: Warehouse domain for one-day shipping

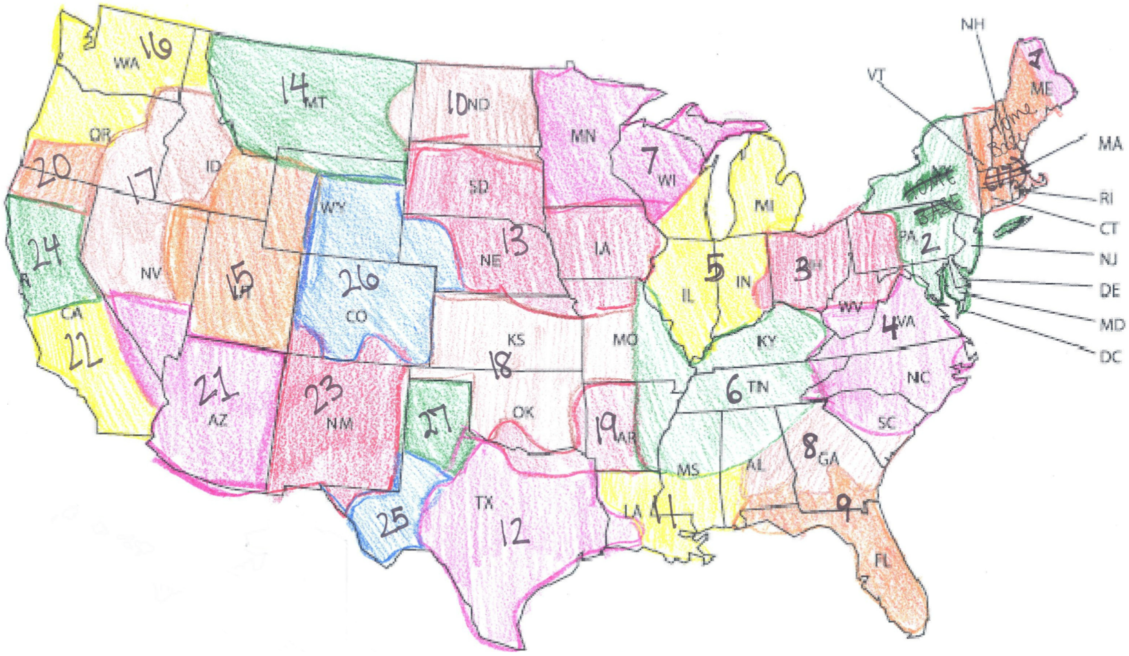


Image 2: Warehouse domain for one-day shipping after changes from part 2

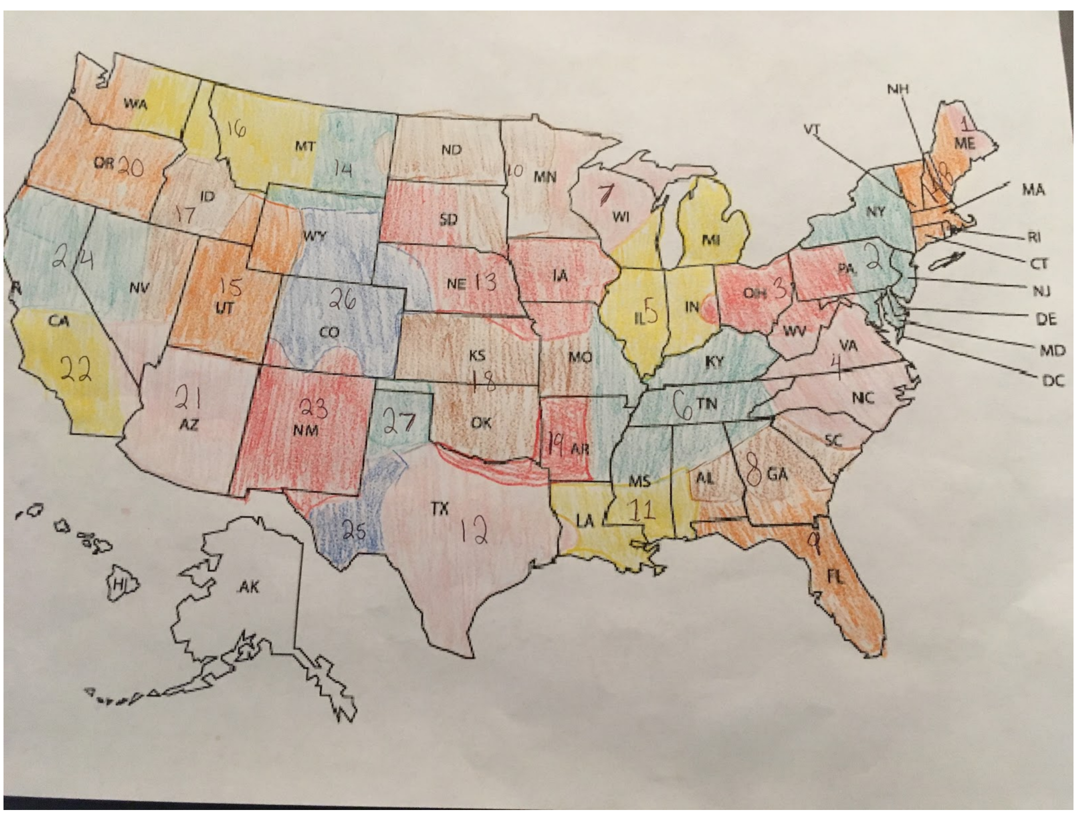


Table 1.1: Location and Number of Warehouses

Number	City	State	Zipcode
HOME BASE	Concord	NH	03301
1	Jonesborough	ME	04648
2	Honesdale	PA	18431
3	Cladwell	OH	43724
4	Midlothian	VA	23112
5	Portage	MI	49023
6	Barwell	KY	42023
7	Altoona	WI	54720
8	Waynesboro	GA	30830
9	Jacksonville	FL	32207
10	Minot	ND	58701
11	Birmingham	AL	35205
12	Houston	TX	77004
13	Sioux Falls	SD	57108
14	Billing	MT	59101
15	Salt Lake City	UT	84115
16	Seattle	WA	98118
17	Boise	ID	83202
18	Wichita	KS	67214
19	Texarkana	TX	75501
20	Weed	CA	96094
21	Phoenix	AZ	85003
22	Los Angeles	CA	90006

23	Albuquerque	NM	87102
24	Sacramento	CA	95883
25	Odessa	TX	79766
26	Denver	CO	80222
27	Wichita Falls	TX	76301

Table 2.1: Scoring Warehouse System Results

Number	City	State	Tax	Population in State	Population out of State	Final Ratio
HOME BASE	Concord	NH	0	1,330,608	12,497,732	∞
1	Jonesborough	ME	5.5	126,119	0	0
2	Honesdale	PA	6	8,544,249	36,969,111	72.113
3	Cladwell	OH	5.75	11,536,504	5,252,436	7.918
4	Midlothian	VA	5.3	8,326,289	9,668,941	21.910
5	Portage	MI	6	10,307,490	23,027,880	37.234
6	Barwell	KY	6	4,339,367	14,041,940	53.932
7	Altoona	WI	5	2,624,919	4,780,723	36.425
8	Waynesboro	GA	4	7,310,864	1,743,469	5.961
9	Jacksonville	FL	6	19,893,297	1,378,084	1.154
10	Minot	ND	5	756,927	35,625	0.941
11	Birmingham	AL	4	620,772	5,978,968	240.787
12	Houston	TX	6.25	20,643,180	848,177	0.657
13	Sioux Falls	SD	4	699,665	6,627,491	236.809
14	Billing	MT	0	914,349	117,153	∞
15	Salt Lake City	UT	5.95	2,763,885	682,302	4.148

16	Seattle	WA	6.5	6,775,647	3,718,160	8.442
17	Boise	ID	7	797,655	264,796	4.742
18	Wichita	KS	6.5	2,183,382	4,723,659	33.283
19	Texarkana	TX	6.25	6,354,051	1,572,420	3.959
20	Weed	CA	7.5	373,446	657,322	23.468
21	Phoenix	AZ	5.6	6,731,000	1,636,208	4.340
22	Los Angeles	CA	7.5	25,568,090	0	0
23	Albuquerque	NM	5.13	2,086,000	121,877	1.138
24	Sacramento	CA	7.5	9,530,034	0	0
25	Odessa	TX	6.25	561,175	0	0
26	Denver	CO	2.9	4,534,018	384,160	2.921
27	Wichita Falls	TX	6.25	1,103,701	0	0

Table 2.2: Scoring Warehouse System Statistics

Population Size	28
Median	5.352
Minimum	0
Maximum	240.787 (ignoring warehouses residing in states with no sales tax)
First Quartile	0.991
Third Quartile	37.032
Interquartile Range	36.041
Outliers	240.787, 236.809, ∞, ∞

Note: the two ∞'s represent the two warehouses that reside in states with no sale taxes.

Table 2.3: City Ratio Change Results

Number	New City	New State	New Zip Code	Population in state	Population out of State	Sales Tax	New Final Ratio
10	Fargo	ND	58102	739,482	5,186,575	5	140.276
16	Missoula	MT	59802	879,361	1,356,740	0	∞
20	Portland	OR	97201	4,013,845	5,960,838	0	∞
21	Needles	CA	92363	126,435	7,097,139	7.5	748.436
24	Reno	NV	89502	2,218,320	11,511,220	6.85	75.75
27	Guymon	OK	73942	44,505	1,103,701	4.5	551.099

Table 2.4: Scoring Warehouse System Statistics after Changes

Population Size	28
Median	34.854
Minimum	0
Maximum	748.436 (ignoring warehouses residing in states with no sales tax)
First Quartile	4.006
Third Quartile	239.793
Interquartile Range	235.786
Outliers	748.436, ∞, ∞, ∞, ∞

Note: the four ∞'s represent the two warehouses that reside in states with no sale taxes.

Table 3.1: Clothing Taxes in Relation to the Warehouses Used in Map 1

State	Clothing Tax	Instate Populations
NH	0	1,330,608
ME	5.5	126,119
PA	0	8,544,249
OH	5.75	11,536,504
VA	4.3	8,326,289
MI	6	10,307,490
KY	6	4,339,367
WI	5	2,624,919
GA	4	7,310,864
FL	6	19,893,297
ND	5	756,927
AL	4	620,772
TX	6.25	20,643,180
SD	4.5	699,665
MT	0	914,349
UT	4.7	2,763,885
WA	6.5	6,775,647
ID	6	797,655
KS	6.5	2,183,382
TX	6.25	6,354,051
CA	6.25	373,446
AZ	5.6	6,731,000
CA	6.25	25,568,090

NM	5.125	2,086,000
CA	6.25	9,530,034
TX	6.25	561,175
CO	2.9	4,534,018
TX	6.25	1,103,701

Table 3.2: Clothing Taxes in Relation to the Warehouses Used in Map 2

State	Clothing Tax	Instate Populations
NH	0	1,330,608
ME	5.5	126,119
PA	0	8,544,249
OH	5.75	11,536,504
VA	4.3	8,326,289
MI	6	10,307,490
KY	6	4,339,367
WI	5	2,624,919
GA	4	7,310,864
FL	6	19,893,297
ND	5	756,927
AL	4	620,772
TX	6.25	20,643,180
SD	4.5	699,665
MT	0	914,349

UT	4.7	2,763,885
MT	0	914,349
ID	6	797,655
KS	6.5	2,183,382
TX	6.25	6,354,051
OR	0	4,013,845
CA	6.25	126,435
CA	6.25	25,568,090
NM	5.125	2,086,000
NV	4.6	2,218,320
TX	6.25	561,175
CO	2.9	4,534,018
OK	4.5	44,505

Table 3.3: Ratios of Clothing Taxes Found in Warehouses from Map 2

Number	Internal Population	Outside Population	State	Clothing Tax	Final Ratio
HOME BASE	1,330,608	12,497,732	NH	0	∞
1	126,119	0	ME	5.5	0
2	8,544,249	36,969,111	PA	0	∞
3	11,536,504	5,252,436	OH	5.75	7.918058455
4	8,326,289	9,668,941	VA	4.3	27.00591981
5	10,307,490	23,027,880	MI	6	37.23486513
6	4,339,367	14,041,940	KY	6	53.93236694
7	2,624,919	4,780,723	WI	5	36.42568018

8	7,310,864	1,743,469	GA	4	5.961911615
9	19,893,297	1,378,084	FL	6	1.154563101
10	739,482	5,186,575	ND	5	140.2758958
11	620,772	5,978,968	AL	4	240.7876
12	20,643,180	848,177	TX	6.25	0.6574002649
13	699,665	6,627,491	SD	4.5	210.4972777
14	914,349	117,153	MT	0	∞
15	2,763,885	682,302	UT	4.7	5.252412394
16	879,361	1,356,740	MT	0	∞
17	797,655	264,796	ID	6	5.532801357
18	2,183,382	4,723,659	KS	6.5	33.28399562
19	6,354,051	1,572,420	TX	6.25	3.95947719
20	4,013,845	5,960,838	OR	0	∞
21	126,435	7,097,139	CA	6.25	898.1233361
22	25,568,090	0	CA	6.25	0
23	2,086,000	121,877	NM	5.125	1.140022917
24	2,218,320	11,511,220	NV	4.6	112.8078515
25	561,175	0	TX	6.25	0
26	4,534,018	384,160	CO	2.9	2.921668276
27	44,505	1,103,701	OK	4.5	551.0996268

Table 3.4: Moved Warehouse

Number	New City	New State	New Zip Code	Inner Population	Outer Population	Clothing Tax	New Final Ratio
23	Vaughn	NM	88353	2,086,000	1,225,578	5.125	11.464

27	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 4.1: Final Locations

Number	City	State	Zipcode
HOME BASE	Concord	NH	03301
1	Jonesborough	ME	04648
2	Honesdale	PA	18431
3	Cladwell	OH	43724
4	Midlothian	VA	23112
5	Portage	MI	49023
6	Barwell	KY	42023
7	Altoona	WI	54720
8	Waynesboro	GA	30830
9	Jacksonville	FL	32207
10	Fargo	ND	58102
11	Birmingham	AL	35205
12	Houston	TX	77004
13	Sioux Falls	SD	57108
14	Billing	MT	59101
15	Salt Lake City	UT	84115
16	Missoula	MT	59802
17	Boise	ID	83202
18	Wichita	KS	67214
19	Texarkana	TX	75501
20	Portland	OR	97201

21	Needles	CA	92363
22	Los Angeles	CA	90006
23	Vaughn	NM	88353
24	Reno	NV	89502
25	Odessa	TX	79766
26	Denver	CO	80222

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