

The Real Estate Problem

ADVANCED QUANTITATIVE METHODS FOR BUSINESS

A stylized city skyline graphic at the bottom of the slide, composed of various colored blocks representing buildings. The colors transition from red on the left, through orange and yellow in the center, to teal and blue on the right. The names of the individuals are printed in white on the colored blocks.

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Agenda

- Introduction
- Executive Summary
- Problem Statement
- Motivation
- Data
- Problem
- Recommendations
- Insight



Introduction

Real Estate Company

Would you like to live in a place with high air quality?

Would you prefer a place where a car is not needed?

How about a place with low taxes?

We specialize in finding your dream location!



Executive Summary

- **Who?**
 - Real estate company that has environmentally conscious clients
- **What?**
 - Seeking optimal way to locate housing areas for clients
- **Why?**
 - Home buyers do not have sufficient information when purchasing a home
- **How?**
 - Solutions found through advanced quantitative optimization techniques



Problem Statement

Locate the 10 best housing areas in the United States

Factors:

- **CO2 Levels**
- Housing Values
- Income Per Household
- Elevation
- Income Tax
- Property Tax
- Vehicle Miles
- Population Density



Motivation

Business perspective

- Speedier housing search process
- More details for customer
- Easily adjust concerns to allow for new location options

Providing these features will increase revenue



Data Sources

Data gathered from the following sources:

- UC Berkeley Research (CoolClimate)
 - Mapped the average CO2 amount by zip code
 - Study findings
 - Areas with high/low CO2 Levels
- State Tax Rates
- Property Tax Averages



Data Pre-Processing

Cleaning, Filtering and Scaling of data

The data obtained from CoolClimate required some pre-processing before we could build the model:

- **Cleaning:** Reduced dataset from 28 columns to 11 columns
- **Filtering:** Chose top 50 zip codes based on lowest CO2
- **Scaling:** Made factors comparable by decimal scaling

Data usability improved by cleaning, filtering and scaling the data

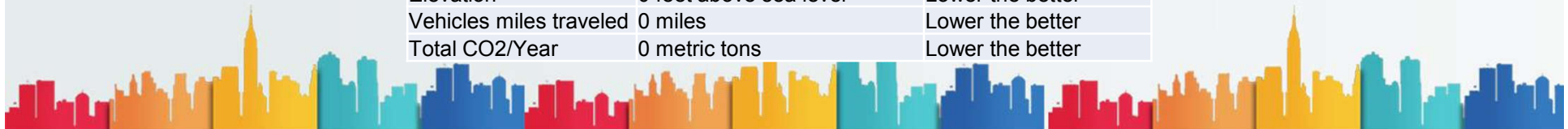


Problem Formulation

Optimization problem with the following characteristics

- **Decision variables:**
 - Every Zip Code
 - Value of 1 given to those selected
 - Select exactly 10
- **Cost Function:**
 - Gives cost(penalty) associated with each zip code
 - Minimizes total cost
 - Sums weighted values of the 8 different factors
- **Factors/Values**

Factor	Optimum Value	Remarks
Population density	4000 persons/sq. mile	Non-linear relation
Average House Value	\$100,000	Non-linear relation
Income	\$50,000 yearly	Non-linear relation
Income Tax	0.0%	Lower the better
Property Tax	\$0	Lower the better
Elevation	0 feet above sea level	Lower the better
Vehicles miles traveled	0 miles	Lower the better
Total CO2/Year	0 metric tons	Lower the better



Solution Method – Business Perspective

Formulating the cost function by weighting each factor

- Evaluate importance of each factor from a customer's perspective
- Prioritize factors based on their relative importance
- Assign a weight between 1 and 10, to each factor, based on its importance
- Carbon dioxide (most important) - weight of 10
- Elevation (least important) - weight of 1

FACTORS	WEIGHTS
Carbon dioxide	10
House price	8
Population density	7
Income	6
Income tax	5
Property tax	4
Vehicle mile travel	3
Elevation	1



Solution Method – Technical Perspective

- Cost function – Non linear function:

$$\text{Cost} = \text{Decision Variable (Binary)} * (7 * \text{Population Density} + 8 * \text{Average House Value} + 6 * \text{Income} + 5 * \text{Income Tax} + 4 * \text{Property Tax} + 1 * \text{Elevation} + 3 * \text{Vehicles Miles Travelled} + 10 * \text{CO2/Year})$$

- Optimization technique – Non linear programming
- Constraints
 - Decision variables are binary
 - Exactly 10 decision variables will have values equal to 1
- Application used to solve : MS Excel Solver
- Optimization technique : GRG Non-linear Programming

Nonlinear Optimization by minimizing total weighted cost of factors



Results

Based on our Optimal solution, the following cities were chosen

State	City	Zip code
New York	Rochester	14604
Alaska	Takotna	99675
Alaska	Nikolai	99691
Pennsylvania	Scranton	18503
Ohio	Akron	44308
Alaska	Arctic Village	99722
Alaska	Juneau	99850
Florida	Jacksonville	32202
Washington	Tacoma	98402
Tennessee	Chattanooga	37402



Results

Area Statistics

ZipCode	StateFullName	City	popden	AverageHouseValue	IncomePerHousehold	Income Tax	Property Tax	Elevation	Vehicle miles traveled	Total (tCO2e/yr)	CostFunction
99691	Alaska	NIKOLAI	1	75000	14500	0	2796	0	8,365	19.82	300.222
44308	Ohio	AKRON	1,865	95000	8676	4.7	1834	989	6,621	21.13	302.595
37402	Tennessee	CHATTANOOGA	3,214	82700	10562	0	1041	685	8,058	23.46	302.684
99722	Alaska	ARCTIC VILLAGE	8	106800	20250	0	2796	0	7,889	22.05	303.61
99675	Alaska	TAKOTNA	3	65000	14583	0	2796	0	7,494	19.79	305.2535
18503	Pennsylvania	SCRANTON	2,294	59200	11341	3	2092	754	6,735	20.02	308.4385
99850	Alaska	JUNEAU	0	108900	16250	0	2796	0	8,074	22.26	310.001
98402	Washington	TACOMA	4,363	129800	15847	0	2127	46	9,762	23.03	311.5975
14604	New York	ROCHESTER	4,978	137500	9692	7.9	3736	513	6,406	18.43	315.475
32202	Florida	JACKSONVILLE	2,489	59100	9904	0	1619	8	7,321	22.4	315.792



Sensitivity Analysis

Income
Tax

ZipCode	State	City	Incom Tax	1	2	3	4	5	6	7	8	9	10
20006	DC	WASHINGTON	8.5	1	1	1	1	0	0	0	0	0	0
14604	New York	ROCHESTER	7.9	1	1	1	1	1	0	0	0	0	0
99675	Alaska	TAKOTNA	0	1	1	1	1	1	1	1	1	1	1
99691	Alaska	NIKOLAI	0	1	1	1	1	1	1	1	1	1	1
18503	Pennsylvania	SCRANTON	3	1	1	1	1	1	1	1	1	1	1
12207	New York	ALBANY	7.9	1	1	1	0	0	0	0	0	0	0
44308	Ohio	AKRON	4.7	1	1	1	1	1	1	1	1	1	0
78205	Texas	SAN ANTONIO	0	0	0	0	0	0	0	1	1	1	1
99722	Alaska	ARCTIC VILLAGE	0	1	1	1	1	1	1	1	1	1	1
99850	Alaska	JUNEAU	0	0	0	1	1	1	1	1	1	1	1
32202	Florida	JACKSONVILLE	0	0	0	0	0	0	1	1	1	1	1
17101	Pennsylvania	HARRISBURG	3	1	1	0	0	1	1	0	0	0	0
98402	Washington	TACOMA	0	0	0	0	1	1	1	1	1	1	1
37402	Tennessee	CHATTANOOGA	0	1	1	1	1	1	1	1	1	1	1
99724	Alaska	BEAVER	0	0	0	0	0	0	0	0	0	0	1

Vehicles
Miles
Travelled

ZipCode	State	City	VMT	1	2	3	4	5	6	7	8	9	10
20006	DC	WASHINGTON	4965	0	0	0	0	1	1	1	1	1	1
14604	New York	ROCHESTER	6406	0	0	1	1	1	1	1	1	1	1
99675	Alaska	TAKOTNA	7494	1	1	1	1	1	1	1	1	1	1
99691	Alaska	NIKOLAI	8365	1	1	1	1	1	1	1	1	1	1
18503	Pennsylvania	SCRANTON	6735	1	1	1	1	1	1	1	1	1	1
12207	New York	ALBANY	6383	0	0	0	0	0	0	0	0	0	1
44308	Ohio	AKRON	6621	1	1	1	1	1	1	1	1	1	1
99722	Alaska	ARCTIC VILLAGE	7889	1	1	1	1	1	1	1	1	1	1
99850	Alaska	JUNEAU	8074	1	1	1	1	1	1	1	1	1	0
32202	Florida	JACKSONVILLE	7321	1	1	0	0	0	0	0	0	0	0
17101	Pennsylvania	HARRISBURG	7110	1	1	1	1	1	1	1	1	1	1
98402	Washington	TACOMA	9762	1	1	1	1	0	0	0	0	0	0
37402	Tennessee	CHATTANOOGA	8058	1	1	1	1	1	1	1	1	1	1

ZipCode	State	City	Income	1	2	3	4	5	6	7	8	9	10
14604	New York	ROCHESTER	9692	1	1	1	1	1	1	1	1	1	1
99675	Alaska	TAKOTNA	14583	1	1	1	1	1	1	1	1	1	1
99691	Alaska	NIKOLAI	14500	1	1	1	1	1	1	1	1	1	1
18503	Pennsylvania	SCRANTON	11341	1	1	1	1	1	1	1	1	1	1
44308	Ohio	AKRON	8676	1	1	1	1	1	1	1	1	1	1
99722	Alaska	ARCTIC VILLAGE	20250	1	1	1	1	1	1	1	1	1	1
99850	Alaska	JUNEAU	16250	1	1	1	1	1	1	1	1	1	1
32202	Florida	JACKSONVILLE	9904	1	1	1	1	1	0	0	0	0	0
17101	Pennsylvania	HARRISBURG	20315	0	0	0	0	0	1	1	1	1	1
98402	Washington	TACOMA	15847	1	1	1	1	1	1	1	1	1	1
37402	Tennessee	CHATTANOOGA	10562	1	1	1	1	1	1	1	1	1	1

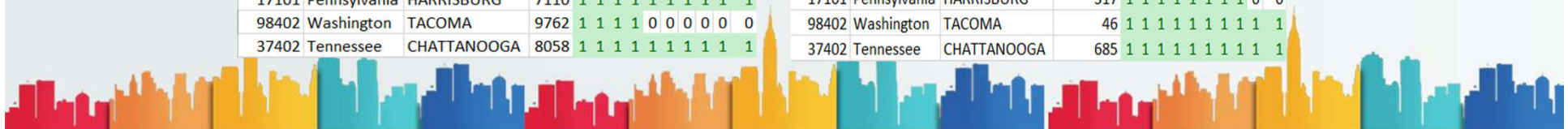
Income

☒ 1 Selected

☐ 0 Not Selected

Elevation

ZipCode	State	City	Elevation	1	2	3	4	5	6	7	8	9	10
20006	DC	WASHINGTON	0	0	0	0	0	0	0	0	0	1	1
14604	New York	ROCHESTER	513	1	0	0	0	0	0	0	0	0	0
99675	Alaska	TAKOTNA	0	1	1	1	1	1	1	1	1	1	1
99691	Alaska	NIKOLAI	0	1	1	1	1	1	1	1	1	1	1
18503	Pennsylvania	SCRANTON	754	1	1	1	1	1	1	1	1	1	1
44308	Ohio	AKRON	989	1	1	1	1	1	1	1	1	1	1
99722	Alaska	ARCTIC VILLAGE	0	1	1	1	1	1	1	1	1	1	1
99850	Alaska	JUNEAU	0	1	1	1	1	1	1	1	1	1	1
32202	Florida	JACKSONVILLE	8	0	1	1	1	1	1	1	1	1	1
17101	Pennsylvania	HARRISBURG	317	1	1	1	1	1	1	1	1	0	0
98402	Washington	TACOMA	46	1	1	1	1	1	1	1	1	1	1
37402	Tennessee	CHATTANOOGA	685	1	1	1	1	1	1	1	1	1	1



Sensitivity Analysis (contd.)

House
price

ZipCode	State	City	Houseprice	1	2	3	4	5	6	7	9	10
89824	Nevada	HALLECK	12500	1	1	1	1	1	1	1	0	0
20006	DC	WASHINGTON	52800	1	0	0	0	0	0	0	0	0
14604	New York	ROCHESTER	137500	1	0	0	0	0	0	0	0	0
99675	Alaska	TAKOTNA	65000	1	1	1	1	1	1	1	1	1
99691	Alaska	NIKOLAI	75000	1	1	1	1	1	1	1	1	1
18503	Pennsylvania	SCRANTON	59200	1	1	1	1	1	1	1	0	1
99754	Alaska	KOYUKUK	9999	1	1	1	0	0	0	0	0	0
12207	New York	ALBANY	95000	0	0	0	0	0	0	0	0	1
44308	Ohio	AKRON	95000	0	0	0	0	0	0	0	0	1
78205	Texas	SAN ANTONIO	58600	0	1	1	1	1	1	1	1	0
99722	Alaska	ARCTIC VILLAGE	106800	0	1	1	1	1	1	1	1	1
99850	Alaska	JUNEAU	108900	0	0	0	1	1	1	1	1	1
32202	Florida	JACKSONVILLE	59100	1	1	1	1	1	1	1	1	0
17101	Pennsylvania	HARRISBURG	68300	0	0	0	0	0	0	0	0	1
98402	Washington	TACOMA	129800	1	1	1	1	1	1	1	1	1
37402	Tennessee	CHATTANOOGA	82700	1	1	1	1	1	1	1	1	1
99724	Alaska	BEAVER	80000	0	0	0	0	0	0	0	1	0

Property
Tax

ZipCode	State	City	Property Tax	1	2	3	4	5	6	7	9	10
14604	New York	ROCHESTER	3736	1	1	1	1	1	1	0	0	0
99675	Alaska	TAKOTNA	2796	1	1	1	1	1	1	1	1	1
99691	Alaska	NIKOLAI	2796	1	1	1	1	1	1	1	1	1
18503	Pennsylvania	SCRANTON	2092	1	1	1	1	1	1	1	1	1
12207	New York	ALBANY	3736	1	0	0	0	0	0	0	0	0
44308	Ohio	AKRON	1834	1	1	1	1	1	1	1	1	1
99722	Alaska	ARCTIC VILLAGE	2796	1	1	1	1	1	1	1	1	1
99850	Alaska	JUNEAU	2796	1	1	1	1	1	1	1	1	1
32202	Florida	JACKSONVILLE	1619	0	0	0	0	0	0	1	1	1
17101	Pennsylvania	HARRISBURG	2092	0	1	1	1	1	1	1	1	1
98402	Washington	TACOMA	2127	1	1	1	1	1	1	1	1	1
37402	Tennessee	CHATTANOOGA	1041	1	1	1	1	1	1	1	1	1

ZipCode	State	City	Pop densitiy	1	2	3	4	5	6	7	8	9	10
89824	Nevada	HALLECK	1	1	1	0	0	0	0	0	0	0	0
14604	New York	ROCHESTER	4978	0	0	0	0	0	1	1	1	1	1
99675	Alaska	TAKOTNA	3	1	1	1	1	1	1	1	1	1	1
99691	Alaska	NIKOLAI	1	1	1	1	1	1	1	1	1	1	1
18503	Pennsylvania	SCRANTON	2294	1	1	1	1	1	1	1	1	1	1
44308	Ohio	AKRON	1865	1	1	1	1	1	1	1	1	1	1
78205	Texas	SAN ANTONIO	1470	1	0	0	0	0	0	0	0	0	0
99722	Alaska	ARCTIC VILLAGE	8	1	1	1	1	1	1	1	1	1	1
99850	Alaska	JUNEAU	0	1	1	1	1	1	1	1	1	1	0
32202	Florida	JACKSONVILLE	2489	0	1	1	1	1	1	0	0	0	1
17101	Pennsylvania	HARRISBURG	3819	0	0	0	0	0	0	1	1	1	1
98402	Washington	TACOMA	4363	0	0	1	1	1	1	1	1	1	1
37402	Tennessee	CHATTANOOGA	3214	1	1	1	1	1	1	1	1	1	1
99724	Alaska	BEAVER	4	1	1	1	1	1	0	0	0	0	0

Population
density

1 Selected
0 Not Selected

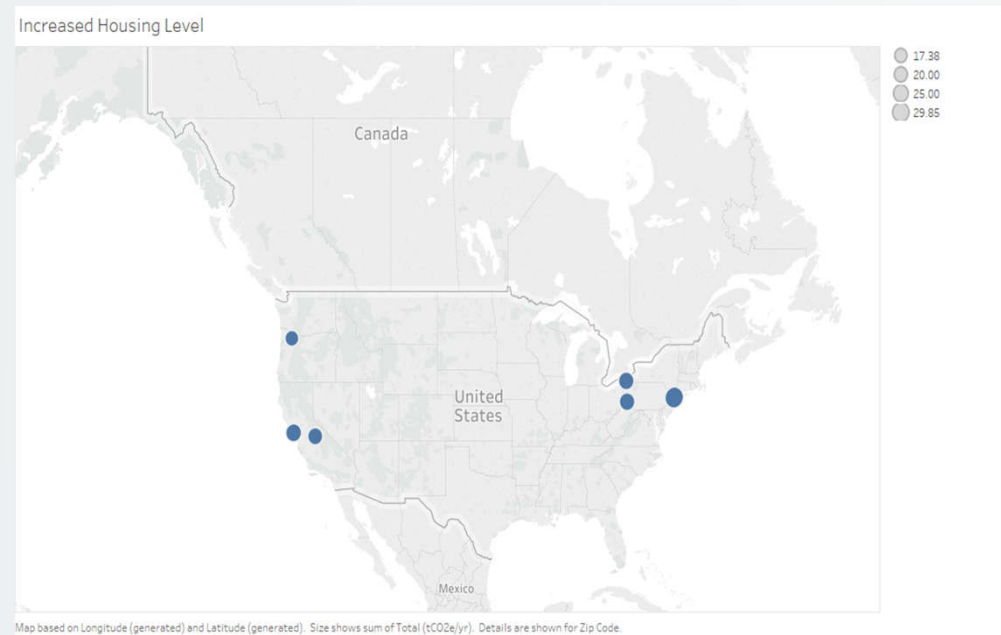
Total
CO2
Emission

ZipCode	State	City	Total CO2	1	2	3	4	5	6	7	8	9	10
14604	New York	ROCHESTER	18.43	0	0	0	0	0	0	0	0	0	1
99675	Alaska	TAKOTNA	19.79	0	0	1	1	1	1	1	1	1	1
99691	Alaska	NIKOLAI	19.82	1	1	1	1	1	1	1	1	1	1
18503	Pennsylvania	SCRANTON	20.02	0	0	0	0	0	1	1	1	1	1
44308	Ohio	AKRON	21.13	1	1	1	1	1	1	1	1	1	1
78205	Texas	SAN ANTONIO	22.02	1	1	0	0	0	0	0	0	0	0
99722	Alaska	ARCTIC VILLAGE	22.05	1	1	1	1	1	1	1	1	1	1
99850	Alaska	JUNEAU	22.26	1	1	1	1	1	1	1	1	1	1
32202	Florida	JACKSONVILLE	22.4	1	1	1	1	1	1	1	1	1	0
17101	Pennsylvania	HARRISBURG	23.01	1	1	1	1	1	1	1	1	1	1
98402	Washington	TACOMA	23.03	1	1	1	1	1	1	1	1	1	1
37402	Tennessee	CHATTANOOGA	23.46	1	1	1	1	1	1	1	1	1	1
99724	Alaska	BEAVER	23.51	1	1	1	1	1	0	0	0	0	0

Further Insights

Average House Value

- House value range
 - \$200K to \$ 1 million
- Increased CO2 levels
- Increased Average Income
- Decreased Vehicle Miles



Further Insights

Income Based Analysis

- Analysis on top 50 cities having an income between 75,000 – 125,000 sorted based on lowest CO2
- General Observations and Comparative analysis:
 - Higher CO2 values
 - Higher population density



Trade off - Higher income may mean higher CO2!



Impact

- Provides customers with a useful instrument to make correct real estate investing decisions
- Focus on environmentally conscious customer and their views about evaluating a buying decision
- Tool to assign different weights by how important different are factors in their real life and as a real estate company, providing more reasonable suggestions

Provide customers with information to make an educated choice



Sources

UC Berkeley Data

<http://coolclimate.berkeley.edu/>

Income Tax Rates & Property Tax average

<http://modernsurvivalblog.com/retreat-living/lowest-to-highest-taxes-by-state/>





Thank You

Questions?