Consumer Ecoregions and the Geography of Automotive Brand Preference: An Analysis of Vehicle Registration Data

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This article analyzes regional variability in consumer automotive brand preferences using vehicle registration data from Oregon and Washington. Vehicle registration data are aggregated by county and per-capita ownership rates are calculated and analyzed to assess regional variability. Results indicate that Consumer Ecoregions may be more cohesive, in terms of homogenous ownership rates by automotive brand groups, than corresponding States. As such, Consumer Ecoregions may provide a more useful partition for understanding regional variability for a variety of business applications including the identification of sales and distribution territories or comparable applications where the geographical dimension of the supply chain is salient.

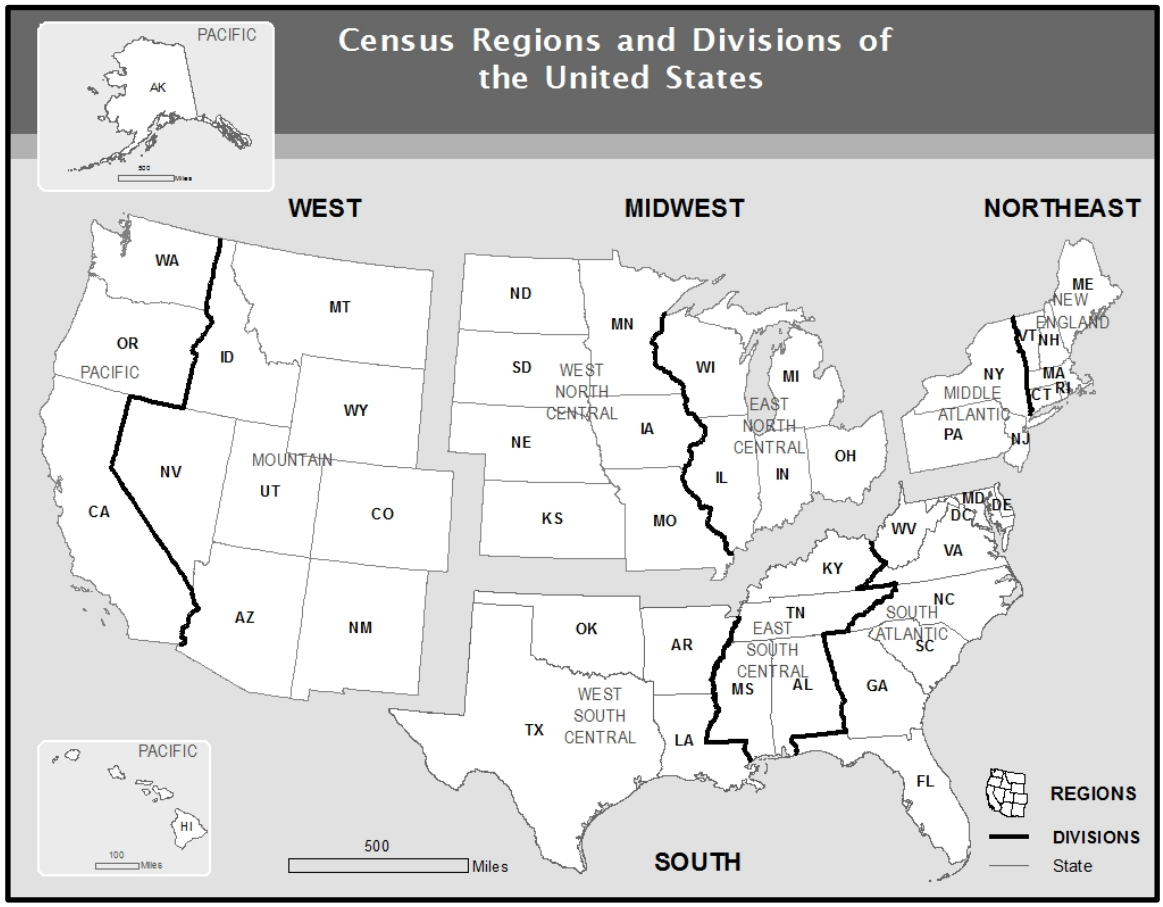
Keywords: geographic segmentation, spatial data aggregation, vehicles in operation (VIO), consumer demand

INTRODUCTION

To illustrate the utility of Consumer Ecoregions, as defined for the Western US (Holman 2020), this study examines the variability of per capita automotive brand ownership rates aggregated by county for the States of Oregon and Washington. This is part of a broader research effort to develop a geographic partition of Consumer Ecoregions (CERs) and to provide an alternative spatial data aggregation approach to enhance efforts to analyze patterns of regional economic activity and variability within the conterminous 48 United States.

A foundational element in business analytics involves the quantification and, almost always, the geographic aggregation of consumer demand metrics and other economic variables. Geographic data aggregation is typically based on State boundaries, US Postal Service ZIP Codes, County boundaries, or one of several US Census Bureau partitions. While Census Tracts, Block Groups, and Core-Based Statistical Areas (CBSA) provide adequate spatial resolution for neighborhood or metropolitan level analyses, partitions using Census Regions or Divisions are often inadequate, providing too few units of analysis for understanding regional patterns of variability in business data. There are only four (4) Census Regions and only nine (9) Census Divisions (See Figure 1).

FIGURE 1
CENSUS REGIONS AND DIVISIONS OF THE UNITED STATES (US CENSUS BUREAU)



The most frequently used, and often misused, geographic partition involves the aggregation of data using the political boundaries of the 50 States and Washington D.C. When applied to apolitical data, the utility of our State political partitions is rarely questioned, perhaps because this geographic lens is taught to the general populace beginning in Kindergarten. Unfortunately, these political borders are typically inappropriate for spatial data aggregation or analysis of geographic patterns of variability in demographic, economic, or business data. The use of State borders can be particularly problematic when an influential lurking environmental or cultural variable is present or when two or more distinct regions within a State are aggregated together, disguising the underlying variability.

To begin supporting the hypothesis that CERs provide a better partition for regional data aggregation and better represent distinct geographical segments of the American consumer than do the political boundaries of the 48 conterminous States, in this paper I analyze vehicles-in-operation (VIO) registration data, comparing county-level automotive brand ownership rates at the State level with CER aggregation. My objective here is to demonstrate that ownership patterns are more distinct and homogenous within CERs than they are within State borders.

LITERATURE REVIEW

The concept and study of brand loyalty in the automobile market first begins to appear significantly in academic literature in the 1980s and 1990s, during a sizeable shift in American consumer consumption from brands headquartered in the United States to foreign models. Researchers including Lave and Train

(1979), Manski and Sherman (1980), Mannering and Winston (1985), and Train (1986) set a precedent for quantifying a variety of influences on consumers' behavior, which helped the automobile industry understand the decline of interest in American models (Train & Winston 2007, p. 1473). Mannering and Winston (1991) built on these studies, defining brand loyalty as "consecutive purchases of the same brand of automobile independent of changes in price, quality, and so on," and arguing that it reflects the historical quality and value of the brand and strongly contributes to future performance (p. 70). Since then, brand loyalty and attachment have been evaluated and tested in a variety of ways (Wiedmann, Hennigs, Schmidt, & Wuesterfeld 2011, Talay, Townsend, & Yeniyurt 2015, Loureiro, Sarmento, & Bellego 2017, Long, Axsen, Miller, & Kormos 2019). Fetscherin and Toncar (2009) attempted to identify specific attributes of automobiles and how they were valued by consumers in order to explain the popularity of and loyalty to particular brands. Baltas and Saridakis (2010) found evidence to support the idea of a "brand-name premium," meaning that brand as an external factor impacted price across models and brands.

Although there have been many studies on automotive market share and brand preference there are very few studies, if any, looking at vehicle registration data to evaluate market share or brand preference. Fewer still have examined geographic variability in market share. In their research, Train and Winston (2007) explore the declining marketshare of the U.S. "Big Three" automakers and the concurrent increase in market share of foreign nameplates, especially the Japanese automakers Toyota and Honda, from 1970 to 2005. Train and Winston (2007) refer to the possibility of geographically disproportionate market share losses in specific regions of America but they dismiss this possibility based on the expansion of vehicle manufacturing facilities, stating:

> *"It may be believed that the industry's losses are confined to certain geographical regions of the country such as parts of the East and West Coasts and some affluent areas of the southwest. However, Japanese and European automakers have built manufacturing plants and research and development facilities in the mid-West and mid-South that have spurred local employment and helped increase market share in these areas because American consumers no long view auto "imports" as costing themselves or their friends a job. In addition, during the past decade Japanese automakers in particular have significantly expanded their dealer network in interior regions of the country."* (*p. 1470-1471)*

While analysis of consumer data through geography was introduced by this and similar research, actual analysis through the use of ecoregions has rarely been conducted in the field of automotive sales, despite decades of literature proving the effectiveness of such a study. According to the research of geographer Hart (1982), change over time, the environmental factors, and the behavior of humans in that area must all be considered when partitioning regional frameworks. Many different disciplines of study have worked to create geographic partitions to support their understanding of patterns in human action and often, apply that understanding to a specific framework of interpretation. One area of study that has undertaken these efforts is research in marketing and consumer data. Some psychographic systems for data analysis through geographic segmentation have emerged from these publications (Lesser & Hughes 1986; Kahle et al. 1992; Umesh 1987; Mitchell 1983). Some studies have attempted to define or validate market segments using statistical analysis (Horowitz 1981; Uri et al. 1985; Tonks 2009). However, none of these publications have attempted to definitively draw geographic segments or use data analysis to frame geographic partitions to serve as alternatives to political boundaries. There are a handful of studies that do attempt geographic segmentation using data analysis, but they are focused on answering a specific question, such as the distribution of labor markets in urban areas (Dash Nelson & Rae 2016). This contrasts with the focus here on utilizing CERs for broader application within the world of business economics, supply chain management, and marketing. Finally, ecoregions have frequently been developed and utilized in the fields of bioregionalism (McGinnis 1999; Scott Cato 2013; Fanfani and Ruiz 2020) and environmental protection (Omernik 1987; Bailey 1998; Omernik & Griffith 2014; McMahon et al. 2001; Loveland & Merchant 2004). In these fields, they are more often used to support and structure effective data analysis of environmental factors and ecological data to support local bodies in managing their resources.

DATA AND METHODS

This paper focuses on an analysis of vehicles-in-operation (VIO) data, essentially a census of registered automobiles, in Oregon and Washington. These data, provided by each State's respective Motor Vehicle divisions, include vehicle registration quantities for every unique Year, Make, Model combination (e.g., 2016 Honda Pilot or 2006 Ford F-150) for each of the 75 counties in the two states. This is, perhaps obviously, a large and complex data set where a quantity for every combination of county and vehicle year, make and model is represented. There are hundreds of "makes", many with multiple "models" dating back to the first half of the 20th century so the number of combinations of vehicles in each county, depending on the population of the county, can amount to several thousand unique vehicles.

The focus on Oregon and Washington is a matter of necessity as much as a matter of preference. Data from both states were made available at a reasonable cost by the respective Department of Motor Vehicles. Unfortunately, most States are not nearly as reasonable when it comes to providing vehicle registration data. Many States simply refused to provide the data on legal grounds, many others simply ignored repeated requests and others were only willing to provide data in exchange for ridiculously high fees (See Table 1).

TABLE 1
RESPONSE TO REQUEST TO PROVIDE VEHICLE REGISTRATION DATA AND, IF WILLING, PRICE QUOTED FOR STATEWIDE REGISTRATION AGGREGATED BY COUNTY

Refused	No Response	> $1M	> $100k	> $10k	> $1k	> $100	< $100
AR	AZ	AK	AL	NM	CT	MA	ID
DE	GA	CA	CO	ND	MO	SC	IN
HI	IL	NJ	FL		VT	SD	MN
KS	IA		KY		WI	TX	NY
ME	LA		MI			WA	OR
MD	MS		UT				WY
NE	MT						
NV	NC						
NH	OH						
PA	OK						
TN	RI						
VA							
WV							

To simplify and generate a set of analyzable data suitable for this paper, I chose to aggregate 24 well-known vehicle "makes" (manufacturing brands) into 3 groups based on the three major automobile producing regions: Europe, Japan, and the United States of America. The vehicle makes are listed below by region of origin.

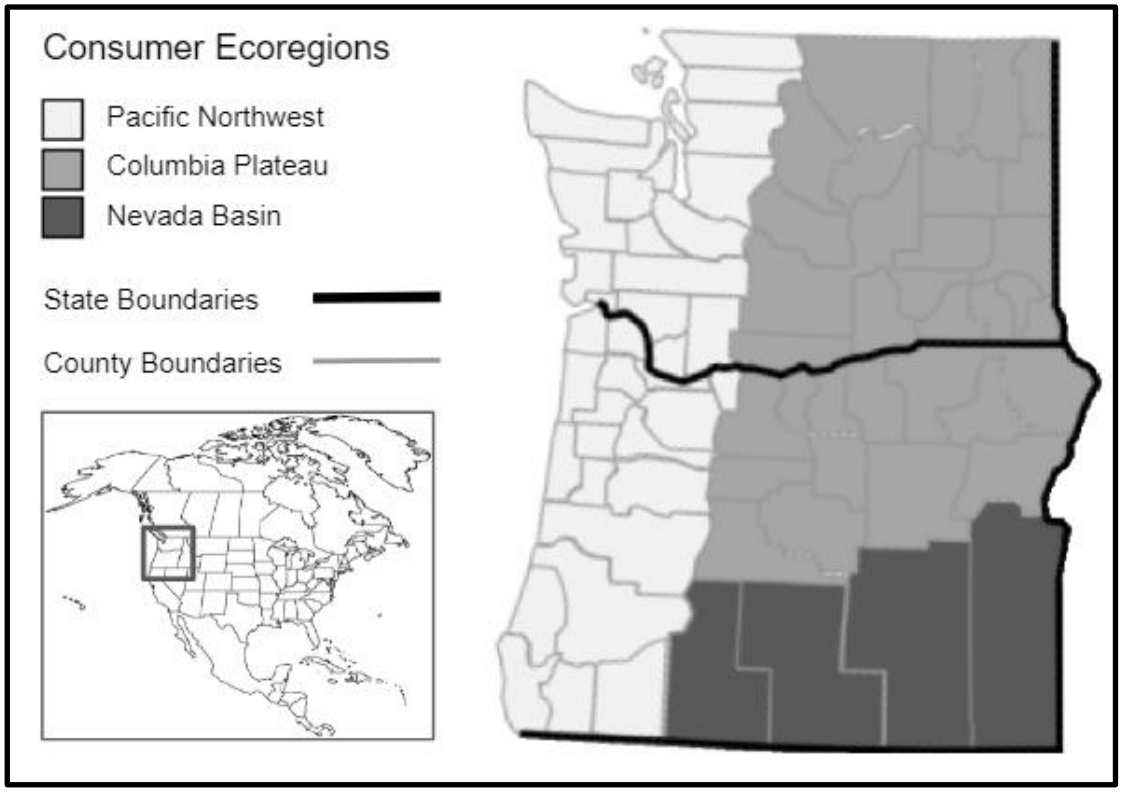
- European: Audi, BMW, Fiat, Mercedes-Benz, Mini, Porsche, Volkswagen, Volvo
- Japanese: Acura, Honda, Infiniti, Lexus, Mazda, Nissan, Subaru, Toyota
- American: Buick, Cadillac, Chevrolet, Chrysler, Ford, GMC, Jeep, Lincoln

To generate Per Capita rates for each regional group of makes, the total number of vehicles per group is divided by the population (US Census Bureau) and then multiplied by 1,000 to produce a "vehicles per 1,000" ownership rate for each county.

There are two geographic partitions compared to determine relative homogeneity in this study. Partition 1 includes the State of Oregon (OR) and the State of Washington (WA). Partition 2 includes three CERs defined in Holman (2020) as the Pacific Northwest (PN), the Columbia Plateau (CP), and the Nevada Basin

(NB). The two partitions are overlaid on top of one another in Figure 2 with State and County borders along with grayscale shading to indicate counties within each CER grouping.

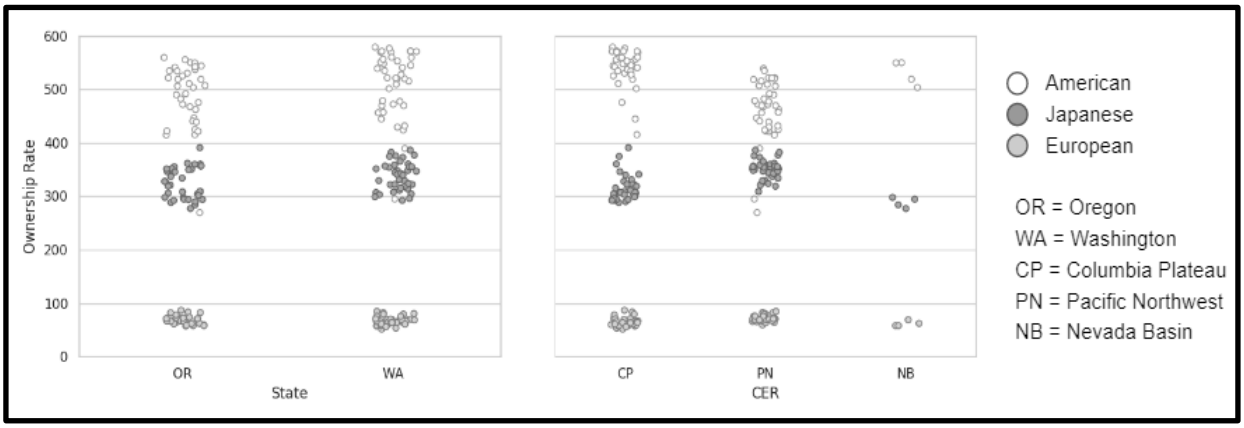
FIGURE 2
CONSUMER ECOREGIONS IN OREGON AND WASHINGTON



The map illustrates the county and state boundaries for Oregon and Washington state along with the three corresponding consumer ecoregions within the same geographic area.

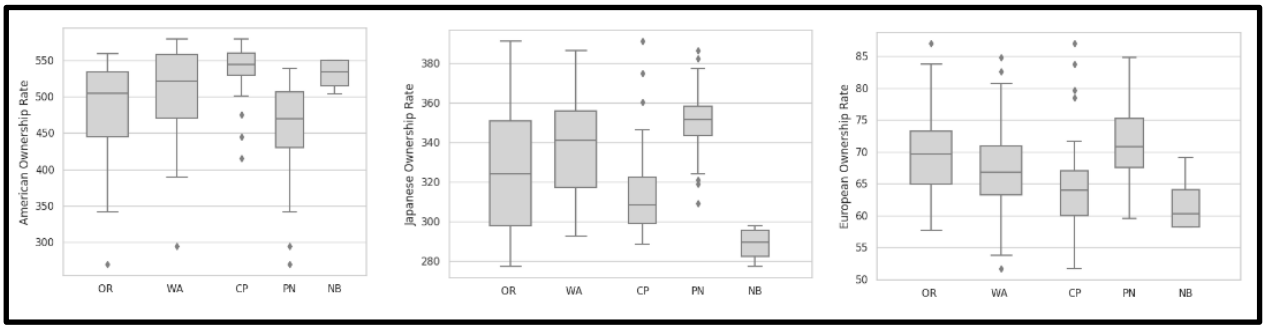
The distributions of county-level ownership rates for both States and for each CER are illustrated using stripplots from Seaborn, a Python data visualization library (Waskom 2021), in Figure 3. Ownership of American brands is highest among the three groups but also contains the most variability ranging from a low of 269.6 per 1,000 in Multnomah County, OR to a high of 579.0 in Adams County, WA. Japanese brand ownership ranges from a low of 277.2 in Lake County, OR to a high of 390.9 in Benton County, OR. European brands have the smallest market share and the lowest variability ranging from a low of 51.6 in Garfield County, WA to a high of 87.0 in Wheeler County, OR.

FIGURE 3
STRIPPLOTS ILLUSTRATING THE DISTRIBUTION OF VEHICLE OWNERSHIP RATES ("VEHICLES PER 1,000 POPULATION") FOR AMERICAN, JAPANESE, AND EUROPEAN AUTOMOTIVE BRANDS BY STATE FOR OREGON ("OR") AND WASHINGTON ("WA") AND BY CONSUMER ECOREGION ("CER") FOR THE COLUMBIA PLATEAU ("CP"), THE PACIFIC NORTHWEST ("PN") AND THE NEVADA BASIN ("NB")



In Figure 4, the distributions of ownership rates for each of the three vehicle groups within the two partitions are illustrated with boxplots, again using Seaborn (Waskom 2021), on separate scales for closer comparison. The graphic shows that the distribution of county-level American brand ownership rates is similar when aggregating by State but fairly distinct when aggregating by CER. The Pacific Northwest has significantly lower American ownership rates than the Columbia Plateau and the Nevada Basin. This pattern repeats itself for both the Japanese and European ownership rates but with the Pacific Northwest showing significantly higher rates of ownership in comparison to the Columbia Plateau and Nevada Basin.

FIGURE 4
BOXPLOTS ILLUSTRATING COUNTY-LEVEL OWNERSHIP RATES OF AMERICAN (LEFT), JAPANESE (MIDDLE), AND EUROPEAN (RIGHT) VEHICLE MAKES, DISPLAYED BY STATE FOR OREGON ("OR") AND WASHINGTON ("WA") AND BY CONSUMER ECOREGION FOR THE COLUMBIA PLATEAU ("CP"), THE PACIFIC NORTHWEST ("PN") AND THE NEVADA BASIN ("NB")



For each partition and region, the ownership rate mean, standard deviation, and coefficient of variation are calculated. The results of these calculations are shown in Table 2. To the extent that a lower coefficient of variation is an appropriate indicator of relative homogeneity, CERs appear to be more homogenous than States, at least in terms of vehicle brand ownership patterns. The average coefficient of variation across all

three vehicle brand groups (shown in the right-most column, "Mean CV" in Table 2) is substantially lower for the CER partition than it is for the State partition.

TABLE 2
VEHICLE OWNERSHIP VARIABILITY

Partition	Region	n	A mean	A std	A CV	E mean	E std	E CV	J mean	J std	J CV	Mean CV
State	OR	36	485.2	63.4	13.06%	69.5	7.5	10.79%	325.1	29.1	8.95%	10.93%
State	WA	39	510.1	61.8	12.12%	67.4	7.8	11.57%	338.1	26.2	7.75%	10.48%
CER	PN	38	459.2	60.7	13.22%	71.7	5.9	8.23%	350.0	17.4	4.97%	8.81%
CER	CP	33	539.1	36.5	6.77%	65.3	8.1	12.40%	316.2	24.5	7.75%	8.97%
CER	NB	4	530.5	23.0	4.34%	62.0	5.2	8.39%	288.5	9.6	3.33%	5.35%

The table displays the number of counties included ("n"), the mean ("mean"), standard deviation ("std"), and coefficient of variation ("CV") for vehicle ownership rates of American ("A") Japanese ("J") and European ("E") automotive brands by State ("OR"=Oregon, "WA"=Washington) and for each of the three Consumer Ecoregions ("PN"=Pacific Northwest, "CP"=Columbia Plateau, "NB"=Nevada Basin).

RESULTS AND DISCUSSION

Studies such as this one, which is intended to support automotive businesses in their understanding of regional vehicle ownership rates, depend on analysis of vehicles-in-operation (VIO) data. These data must be procured from a State's respective Motor Vehicle division. However, as mentioned previously, many States refused to share the data on legal grounds, or they were only willing to release the data for an exorbitant fee, some more than $1 million (see Table 1). This puts automotive industry analysts in a difficult position. There are two commercial providers of VIO data, IHS-Markit and Experian, who will happily license the data to you for $20k-$100k per year depending on the geographic resolution and the level of vehicle detail provided. Unfortunately, because of the market price among large manufacturers, distributors, and retailers in the automotive aftermarket, small companies, independent researchers, or academics without large budgets are, essentially, priced out of the market. It should be far easier and far less expensive to obtain these data, especially since their collection, storage, and distribution are paid for, ultimately, by the public.

After analysis of the data on hand through the lens of two different types of geographic partitions, the data demonstrate that vehicle ownership rates appear to be more homogeneous within CERs than within State borders. Additionally, while analysis by State did not show any significant differences in vehicle ownership trends between Oregon and Washington, the differences between the Pacific Northwest, the Columbia Plateau, and the Nevada Basin ecoregions were more distinctive. Though this is a small-scale study looking only at the Oregon and Washington areas, it likely applies in many other regions as well and indicates the effectiveness of CERs as a lens for geographical data analysis.

Accordingly, because the CERs proved advantageous in this kind of analysis, automotive and other consumer product businesses may want to consider the use of CERs for sales territory management, supply chain planning, and similar business purposes. By using CERs to interpret, analyze, and categorize VIO data, automotive businesses may gain new insights into consumer vehicle purchase patterns. This understanding may then guide their decision-making processes in order to improve operational efficiency.

CONCLUSION

When originally partitioning the conterminous United States, I intended CERs to be used for analyzing business and economic data aggregated by CERs rather than States to highlight differences in their utility. This paper is the first of such a study, in that it uses VIO data collected from Oregon and Washington and

compares trends in vehicle ownership when studied by State borders to those that arise when broken down by three CERs, the Pacific Northwest, the Columbia Plateau, and the Nevada Basin. The results demonstrate that ownership rates are more homogenous within CERs than within State borders, and the three CERs are more distinct from one another in consumer vehicle preference than the two states are from one another. Although relatively simplistic, this study demonstrates the problem with State aggregation and the potential benefit of CER aggregation.

Further similar studies will be necessary to more fully illustrate the utility of CERs. For example, in this study, the focal point of analysis and aggregation was whether vehicle make was American, European, or Japanese. A more specific study could examine individual makes such as Ford, Toyota, and Volkswagen both to test the utility of CERs and to provide useful data to automotive businesses about their region's brand preferences. Unfortunately, VIO data will not prove to be a feasible source for such a case study on a regional or nationwide basis due to data availability and cost. Additional sources must be found to perform this type of analysis and feedback in the future.

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