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Length of residency and water use in an arid urban environment

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ABSTRACT

Southwestern arid cities face growing pressure on their available water supplies due to a rapidly increasing population and the impacts of climate change. We evaluate the behavioral effect that the length of residency has on residential water demand in the cities of Reno and Sparks, Nevada. We find that the length of residency has a significant positive effect on households' water consumption: customers that have lived in the area longer consume higher volumes of water, on average. Additionally, social norms, as measured by neighbors' water use, and compliance with outdoor water regulations also significantly and positively influence households water consumption. Moreover, the effect of social norms on outdoor water use is persistent among households with varying length of residency. We discuss the implications of our findings for future water demand and conservation policies.

1. Introduction

Southwestern arid urban regions have the highest per capita residential water usage in the United States. For example, while the national average is 88 gallons per day, in the State of Nevada daily per capita consumption amounts to 134 gallons [23]. Landscape irrigation accounts for the majority of this higher than average water use [37].

A well-known problem affecting the southwestern states is the pressure that an increasing population poses on water supplies (Fort, 2002). During the period from 1993 to 2008, the states of Arizona, Texas, Nevada and Colorado were among the top ten states with the highest net immigration flows from other US states [12]. Nationwide, six of the ten cities with the highest total population increase in 2012 are located in arid or semi-arid western states: Houston, San Antonio, Austin, Phoenix, Dallas and Fort Worth [34]. More importantly, the population in states with the highest per capita residential water usage is expected to continue to rise [36,39]. This stress on water resources will likely be intensified by the concomitant change in climatic conditions. Future global warming is believed to result in an increase in temperature, increased evaporation, and more pronounced drought in the region [38].

Inevitable questions arise within government agencies and water utilities concerned about the potential increase in future water demand: What are the water consumption habits of this incoming population? Do households that arrive to the Southwest consume higher volumes of water than native residents or households that have lived in the area longer? Do they use water less carefully? How much do they know about and how much do they comply with water conservation policies in their new arid urban environment?

Very little research has been conducted comparing new residents' water consumption to that of long-time residents. Remarkably, this scant literature seems to be reaching a rather counterintuitive conclusion: homeowners tend to

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increase outdoor water consumption the longer they have lived in an arid city. Moreover, the length of residency (LOR, hereafter) appears to have a negative effect on households' attitude towards outdoor water conservation behaviors and policies (e.g. [28,1,21,31,43,7,10,19]).

Of existing studies, Agthe et al. [1] and Harlan et al. [7] are the only ones that use data on water consumption to quantify the effect that the LOR has on water demand. The former find that an additional year of tenancy in Tucson, Arizona increases households' monthly summer water usage by 35.5 cubic feet. The latter estimate that households with more than 5 years of residency in the city of Phoenix, Arizona consume on average 10.5% more water than newer residents. In spite of this, the reasons explaining why families increase their water consumption after moving into an arid city are less clear.

Our paper analyzes the effects of LOR on water consumption in the metropolitan area covering the cities of Reno and Sparks in the state of Nevada. We use daily metered water consumption at the household level observed for 63 consecutive days in the summer of 2008. Apart from evaluating the specific Reno-Sparks' case study, the main contributions of our research to the existing literature are threefold:

First, ours is the first study to quantify the behavioral effect of LOR controlling for both unobserved neighborhoods' characteristics, and social norms and regulations. In doing so, we are able to show that the LOR significantly explains variation in water consumption within relatively homogeneous areas (neighborhoods) that usually share common property and yard characteristics. Additionally, the LOR has a positive effect on water use that can neither be explained by the influence of social norms within close neighborhoods nor by outdoor watering regulations effective in the period of analysis. We conclude that this increasing use with LOR is due to private changes in preferences over time as opposed to the effect that social norms or regulations have on water consumption.

Second, we identify that households living near one another significantly influence the volume of water used by each other. While several studies have noted the relevance of community norms on new residents' water consumption, Harlan et al. [7] are the only to include proxy variables for social norms in their analysis. These variables are survey responses that summarize concern about water supply, trust in that others conserve water, and belief that a collective solution is efficient to improve the quality of the neighborhood. However, probably because households' stated preferences did not directly translate into changes in their actual behavior, these regressors were not significant in explaining water consumption. In our study, we calculate the average water consumption of households living within 50 yards of each property to measure how households' outdoor watering behavior influences water used by nearby households. Spatial correlation on residential water demand, however, can also be associated with other structural and sociodemographic factors, for example, a tendency of individuals with similar sociodemographic characteristics to cluster together in similar properties with homogeneous yards and landscaping [22]. Neighborhoods with varying exposure to climatic variables, such as wind, are also associated with different water consumption patterns [4]. This geographic heterogeneity may confound the identification of purely social interaction effects among nearby households. We control for these unobserved spatial effects by including in our empirical model spatial fixed effects at the neighborhood level.

Third, once we isolate the effect of LOR from the effect that social norms and regulations have on water use, we investigate the interaction between them. We find that the effect of social norms on outdoor water use is invariant to the length of residency. Newer households, as well as households that have lived in the arid Southwest for a longer period of time, tend to have water use that is in similar fashion with that of close neighbors. On the other hand, we find that losses due to strict compliance with outdoor water restrictions decrease with LOR, and that long-time residents may have learned how to use water more efficiently in their arid environment while still adhering to the official schedule (for instance by shifting watering from wind-prone afternoons to calm mornings on assigned days).

The remaining sections of the paper introduce the theoretical model of analysis. This is followed by a description of the data set and the empirical model. We then discuss the main findings and their policy implication. The last section summarizes the central conclusions of the study.

2. Households' adaptation to the arid Southwest

Individuals that move from their original society in order to settle in a new host society undergo an acculturation process that involves the learning of new socio-cultural skills (e.g., making friends, getting used to local foods, complying with local rules and regulations, coping with the climate, understanding the local value system) [5,40]. Researchers have found that this process of "cross-cultural adaptation" follows a learning pattern characterized by an initial rapid learning rate (culture shock) over the first few months followed by a final settling stage once the culture-learning process has been completed [40].

Three opposing theories have been proposed to explain the adaptation process of households that move to Southwestern arid cities with respect to their outdoor water use:

(1) *Human capital accumulation*: In this case, outdoor water demand changes over time as the result of an increase in knowledge and awareness about local environmental concerns. For instance, long time residents to the Reno-Sparks area may be aware of the pressure that the cities' water demand exerts on the Truckee River's natural inflows to Pyramid Lake (regarded as one of the United States' most beautiful desert lakes, host of endangered fish species, and economic center to the Paiute Tribal Reservation). Over time, households may also learn how to efficiently use water in their new climatic conditions (e.g.,