**Residential Exemption Services and Housing Survey - Statistical Analysis of Housing Stress and Predicted Migration Decisions**

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Questions of Interest:

* Role of property taxation in reported housing stress
* Role of property taxation in predicted migration decisions

Household stress was sureyed using a categorial response question with five answers of increasing stress, reflecting an implied **ordinal** scale. Statistical estimation would best use of one two approaches:

* Treat household stress as a continuous variable with five point estimates, and use **ordinary least squares** (OLS) to predict changes on a continuous scale.

*This approach has obvious limitations, such as the fact that survey responses are truncated at a minimum and maximum value but a statistical model fits to a line.*

* Use an **ordinal logistic** model to reflect latent levels of stress with estimated thresholds which are associated with respondents selecting from five levels. (

*This method allows the thresholds to exist independently of one another, but has the disadvantage that confidence interval estimation is more complicated.*

We start the statistical process with OLS estimation because it easily estimates statistical significance, thereby allowing less significant variables to be omitted in model iterations. After settling on useful parameters, the final model was tested with an ordinal logsitic model. The ordinal logistic model did not offer additional insights and is not included here.

Included observations are initially limited to those (1239 of 1475) where the respondent is reported to own a home and be responsible for housing costs. Of these, only 1208 provided answers to the housing stress question, and 914 answered all statistically relevant questions.[[1]](#footnote-0)

Predicting relocation, we use response summary grouping “1”, which is the following categorical interpretation of survey responses:

* Definitely Not: 0
* Unlikely: 1
* Have not considered (or) Undecided - Possible: 2
* Likely: 3
* Definitely: 4

We elect to combine two codes which are seemingly neutral into code 2 as neither response lends itself to being more or less likely than the other, and both belong somewhere in the middle of this scale. The end result is that the relocation dependent variable is an ordinal variable with five levels (0-4), which higher levels indicating higher forecast propensity to migrate out of Lexington.

An OLS model predicting housing stress has a R^2 = 0.2, and seven significant explanatory variables. With this model, we can estimate the impact of a residential property tax exemption on housing stress levels as follows:

Assume a household has property taxes of $10,000 per year (roughly a $700,000 assessed value). For a range of monthly housing expenditures ($1000, $1500, … $4000) assume that the property tax were reduced $5000 (50% would be a very generous tax exemption) and calculate the change in monthly housing % and property tax % of monthly housing. Using this change and the coefficient, estimate what happens to the level of housing stress.

Not surprisingly, the findings indicate that the greatest impact of a $5000/year property tax reduction will be felt in households having the smallest (prior) monthly housing expenditures and therefore the greatest (prior) percentage of housing expenditures related to property taxes. A bit more surprising may be that the model indicates only a modest adjustment to stress with significant changes in property taxes. However, this modest relationship may be due to the fact that numerous other factors contribute to housing stress beyond the effect of property taxes.

|  |  |
| --- | --- |
| Prior Monthly Housing | Effect of 50% reduction of property taxes |
| $1,000 | -0.40 |
| $2,000 | -0.23 |
| $3,000 | -0.18 |
| $4,000 | -0.15 |

The model predicting relocation forecast has an r^2=0.12. While it seems that stress is among main drivers, and there may therefore be a direct and indirect property tax link, the statistical relationship is particularly weak. We can estimate that a stress change of 1.0 may be related to a 0.28 change in the scale for likelihood of moving, but as the 1.0 stress change is not estimated to occur through tax exemptions, it appears that this study does not find evidence that tax policy would directly affect migration. (For the non-statisticians, this does not mean that tax policy changes have no effect; it merely means that no material effect is *identified* with this data survey.)

A third model is used for relocation in which stress is excluded from the independent variables since it may mask direct relationships between property taxes and household costs and propensity to move. As the model overview below describes, the relationship appears largely consistent wiht the other findings. A weak model exists for propensity to move, and a large change in property taxes and housing costs for an individual could result in a change in propensity to move, but only to a fraction of one level on a categorical scale.

Because property taxation impacts household stress, and the latter impacts migration decisions, we have an “endogenous variable” problem which makes estimation of the impact of property taxation on migration more difficult. A common approach is to use instrumental variables. We have also estimated this third model without stress to take a view on how an explanatory model looks without this intermediate variable.

**Statistical Models**

OLS Model for Stress:

====================================================================  
Model: OLS Adj. R-squared: 0.200   
Dependent Variable: StressCode AIC: 2591.0511  
Date: 2018-11-25 21:39 BIC: 2629.5937  
No. Observations: 914 Log-Likelihood: -1287.5   
Df Model: 7 F-statistic: 33.59   
Df Residuals: 906 Prob (F-statistic): 1.05e-41   
R-squared: 0.206 Scale: 0.98833   
--------------------------------------------------------------------  
 Coef. Std.Err. t P>|t| [0.025 0.975]  
--------------------------------------------------------------------  
Income914 -0.0048 0.0004 -10.8862 0.0000 -0.0057 -0.0039  
MarketValue914 -0.0460 0.0094 -4.9003 0.0000 -0.0644 -0.0276  
Age914 -0.0136 0.0036 -3.7911 0.0002 -0.0207 -0.0066  
MonthlyHousing914 0.1538 0.0197 7.7935 0.0000 0.1151 0.1926  
HouseholdSize914 0.1602 0.0404 3.9631 0.0001 0.0809 0.2396  
PropertyTaxShare914 0.0080 0.0016 5.0903 0.0000 0.0049 0.0111  
AgeIncome914 -0.0001 0.0000 -2.1343 0.0331 -0.0001 -0.0000  
One 1.4879 0.0377 39.4321 0.0000 1.4138 1.5619  
--------------------------------------------------------------------  
Omnibus: 15.853 Durbin-Watson: 2.031   
Prob(Omnibus): 0.000 Jarque-Bera (JB): 10.355  
Skew: 0.115 Prob(JB): 0.006   
Kurtosis: 2.532 Condition No.: 1729   
====================================================================  
\* The condition number is large (2e+03). This might indicate  
strong multicollinearity or other numerical problems.

Monthtly housing costs, household size, and property tax share all increase reported housing stress.

Age, income, market value, and age\*income all decrease reported housing stress.

Note: Variables with suffix 914 are mean-adjusted version of the 914 original survey code responses. The new variable is obtained by subtracting the mean from the original 914 observations to create a new variable with mean=0.

OLS Model for Relocation:

==================================================================  
Model: OLS Adj. R-squared: 0.120   
Dependent Variable: RelocationStat1 AIC: 2671.5200  
Date: 2018-11-25 21:49 BIC: 2695.6091  
No. Observations: 914 Log-Likelihood: -1330.8   
Df Model: 4 F-statistic: 32.15   
Df Residuals: 909 Prob (F-statistic): 4.34e-25   
R-squared: 0.124 Scale: 1.0828   
------------------------------------------------------------------  
 Coef. Std.Err. t P>|t| [0.025 0.975]  
------------------------------------------------------------------  
Age914 0.0112 0.0029 3.9053 0.0001 0.0056 0.0169  
StressCode 0.2861 0.0315 9.0718 0.0000 0.2242 0.3479  
PropertyTaxShare914 0.0052 0.0016 3.2042 0.0014 0.0020 0.0083  
AgeIncome914 0.0001 0.0000 4.8003 0.0000 0.0001 0.0002  
One 1.7572 0.0607 28.9288 0.0000 1.6380 1.8764  
------------------------------------------------------------------  
Omnibus: 19.328 Durbin-Watson: 2.027   
Prob(Omnibus): 0.000 Jarque-Bera (JB): 10.633  
Skew: -0.017 Prob(JB): 0.005   
Kurtosis: 2.473 Condition No.: 2672   
==================================================================  
\* The condition number is large (3e+03). This might indicate  
strong multicollinearity or other numerical problems.

Age, stress, property tax share, and age\*incoe are all positively correlated with forecast of relocation. The overall r^2=0.12, so the relationship is fairly weak.

The strongest relationship is between stress and forecast relocation. A one level increase in stress corresponds roughly to a 0.3 level increase in propensity to move.

Property tax share not only directly impacts propensity to move, but also indirectly affects through its impact on stress.

Therefore we find that property tax burden is related to forecast relocation, however the effects appear in total to be small and most impactful on those for whom property taxes constitute the preponderance of monthly housing costs.

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Discussion of instrumental variables (solving endogeneity): <http://cameron.econ.ucdavis.edu/e240a/ch04iv.pdf>; Not applied here.

OLS Model for Relocaiton (without using Stress as a predictor):

===================================================================  
Model: OLS Adj. R-squared: 0.063   
Dependent Variable: RelocationStat1 AIC: 2729.8131  
Date: 2018-11-25 22:24 BIC: 2758.7201  
No. Observations: 914 Log-Likelihood: -1358.9   
Df Model: 5 F-statistic: 13.31   
Df Residuals: 908 Prob (F-statistic): 1.53e-12   
R-squared: 0.068 Scale: 1.1529   
-------------------------------------------------------------------  
 Coef. Std.Err. t P>|t| [0.025 0.975]  
-------------------------------------------------------------------  
Income914 -0.0020 0.0004 -4.4257 0.0000 -0.0028 -0.0011  
Age914 0.0047 0.0034 1.4057 0.1601 -0.0019 0.0114  
MonthlyHousing914 0.0537 0.0184 2.9163 0.0036 0.0175 0.0898  
PropertyTaxShare914 0.0070 0.0017 4.1991 0.0000 0.0037 0.0103  
AgeIncome914 0.0001 0.0000 4.3321 0.0000 0.0001 0.0002  
One 2.1881 0.0407 53.7323 0.0000 2.1081 2.2680  
-------------------------------------------------------------------  
Omnibus: 39.032 Durbin-Watson: 2.005   
Prob(Omnibus): 0.000 Jarque-Bera (JB): 17.049  
Skew: 0.041 Prob(JB): 0.000   
Kurtosis: 2.336 Condition No.: 1604   
===================================================================  
\* The condition number is large (2e+03). This might indicate  
strong multicollinearity or other numerical problems.

PropertyTaxShare914 has values as follows:

-4.811816 418  
-29.811816 203  
 20.188184 189  
 44.188184 100  
-42.811816 4

(This occurs because it is a mean=0 adjusted version of PropertyTaxShare)

A category jump on this scale is therefore about 20 points. So a full category jump (20) multiplied by the coefficient 20 \* 0.007 = 0.14; so it translates to about 1/6th of a jump in the predicted propensity to move scale.

This feels roughly consistent with the impact of property taxes on stress found in the first relationship. It is a weak relationship with limited substantive impact.

1. Imputation of income could add about 100 respondents, but we have not elected to do any imputation. [↑](#footnote-ref-0)