**Housing Wealth and Political Outcomes: A Multi-dimensional Analysis at the Local Level in South Korea**

Online Appendix

**Tables**

[Table A1. Dependent variables 2](#_Toc137467403)

[Table A2. Explanatory variables 2](#_Toc137467404)

[Table A3. Descriptive statistics 4](#_Toc137467405)

[Table B1. Shapley Additive exPlanations (SHAP) 7](#_Toc152368230)

[Table B2. Housing wealth and Conservative/Democratic vote proportion 9](#_Toc152368231)

**Figures**

[Figure B1. Wealth gini in Korea (1995-2021) 5](#_Toc152369217)

[Figure B2. National net wealth/National net income (1995-2021) 6](#_Toc152369218)

[Figure B3. Social Spending in OECD (2020) 6](#_Toc152369219)

[Figure B4. Average values of variables by cluster 6](#_Toc152369220)

[Figure B5. Optimal clustering (Hierarchical) 7](#_Toc152369221)

[Figure B6. Average impact on model output based on SHAP 10](#_Toc152369222)

**Appendix A**

**Table A1**. Dependent variables

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Variable | Description | Source | Website |
| 1 | 2022 Conservative vote | $$\frac{Votes for conservative party}{Qualified electors}$$ | National Election Commission | http://info.nec.go.kr/ |
| 2 | 2022 Democratic vote | $$\frac{Votes for democratic party}{Qualified electors}$$ | National Election Commission | http://info.nec.go.kr/ |

**Table A2**. Explanatory variables

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Variable | Description | Source | Website |
| 1 | Average price of APT/$m^{2}$ | Average price of APT/$m^{2}$ in 2022 by si-gun-guUnit: 10,000KRW | KB Real estate data hub | https://data.kbland.kr/ |
| 2 | Income and Wealth | Average Health Insurance PremiumsUnit: 10,000KRW | National Health Insurance Service | https://www.nhis.or.kr/nhis/together/wbhaec06900m01.do |
| 3 | Wealth Tax | Statistical Yearbook of Local TaxUnit: 10,000KRW | Ministry of the Interior and Safety | https://www.wetax.go.kr/main/?cmd=LPTIIA7R3 |
| 4 | APT ratio | Proportion of apartments in the housing type | Korean Statistical Information Service | https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT\_1JU1503&conn\_path=I3 |
| 5 | Home ownership | $$\frac{Households with their own houses}{Households}$$ | Korean Statistical Information Service | https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT\_1PE2008&conn\_path=I3 |
| 6 | Education | $$\frac{High education}{Low education}$$- High education: Population with 4-years university or higher- How education: Population with 2-years college or below | Korean Statistical Information Service | https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT\_1PM2001&conn\_path=I3 |
| 7 | Age | Average age of population | Korean Statistical Information Service | https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT\_1B040M5 |
| 8 | Sex | $$\frac{Male population}{Female population}$$ | Korean Statistical Information Service | https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT\_1B040A3 |
| 9 | Urbanization | $$\frac{Population living in urban area }{Population}$$ | Ministry of Land, Infrastructure and Transport of South Korea | https://kosis.kr/statHtml/statHtml.do?orgId=315&tblId=TX\_315\_2009\_H1001 |
| 10 | Voter turnout | Turnout of in the 2022 Presidential election | National Election Commission | http://info.nec.go.kr/ |
| 11 | CapitalRegion | Capital dummy = 1- Seoul city-Incheon city-Gyeonggi province |  |  |
| 12 | HonamRegion | Honam dummy = 1- Gwangju city- Jeollabuk province- Jeollanam province-Jeju island |  |  |
| 13 | YoungnamRegion | Youngnam dummy = 1- Busan city- Daegu city- Ulsan city- Gyeongsangbuk province- Gyeongsangnam province |  |  |
| 14 | GangwonRegion | Gangwon dummy = 1- Gangwon province |  |  |
| 15 | ChungcheongRegion | Chungcheong dummy = 1- Daejeon city- Chungcheongbuk province- Chungcheongnam province |  |  |

**Table A3.** Descriptive statistics

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | N | Mean | Std dev | Min | Median | Max |
| 2022 Conservative vote | 250 | 0.372 | 0.146 | 0.072 | 0.388 | 0.69 |
| 2022 Democratic vote | 250 | 0.369 | 0.159 | 0.115 | 0.336 | 0.727 |
| Average price of APT/$m^{2}$ | 239 | 502.66 | 438.45 | 33.62 | 326.36 | 2729 |
| Income and Wealth | 250 | 10.737 | 2.47 | 6.994 | 10.42 | 22.84 |
| Wealth Tax | 230 | 4.98e+06 | 6.53e+06 | 9.65e+04 | 2.87e+06 | 4.19e+07 |
| APT ratio | 250 | 0.51 | 0.25 | 0.002 | 0.57 | 0.92 |
| Home ownership | 250 | 0.66 | 0.4 | 0.31 | 0.62 | 0.66 |
| Education | 250 | 0.28 | 0.11 | 0.11 | 0.26 | 0.69 |
| Age | 250 | 46.7 | 4.98 | 37.7 | 45.4 | 58.5 |
| Sex | 250 | 1.57 | 0.005 | 0.88 | 0.99 | 1.32 |
| Urbanization | 250 | 76.95 | 26.48 | 7.76 | 91.61 | 100 |
| Voter turnout | 250 | 0.77 | 0.03 | 0.7 | 0.77 | 0.84 |

**Appendix B**



**Figure B1.** Wealth gini in Korea (1995-2021)

*Note*: Wealth gini based on net wealth

Source: World Inequality Database (https://wid.world/data/)



**Figure B2**. National net wealth/National net income (1995-2021)

Source: World Inequality Database (https://wid.world/data/)



**Figure B3**. Social Spending in OECD (2020)

*Note*: This indicator is measured as a percentage of GDP. Please see the below source for detailed explanation.

Source: OECD data (https://data.oecd.org/socialexp/social-spending.htm)



**Figure B4.** Average values of variables by cluster



**Figure B5.** Optimal clustering (Hierarchical)

To ensure the robustness of the findings from K-means++, this study also presents the results obtained from Hierarchical Clustering using the Ward linkage method. Hierarchical Clustering operates by starting with each data point as an individual cluster and iteratively merging similar points to create hierarchical clusters. In contrast to the distance-based approach of K-means++, the Ward linkage method is utilized in Hierarchical Clustering, combining clusters based on the within-group sum of squares. Unlike K-means++, Hierarchical Clustering does not require the pre-determination of the number of clusters, *K*. Instead, it generates a dendrogram, a tree-like structure that reveals the order in which objects are merged, enabling the analysis and interpretation of clustering results. The inclusion of Hierarchical Clustering results enhances the robustness and comprehensiveness of the study's findings.

In Figure B5, Hierarchical clustering is applied, and its results mirror those obtained from the K-means++ algorithm. This concordance in outcomes between different clustering approaches is significant. Despite their varied methodologies, both approaches consistently reveal similar patterns. This consistency is crucial as it mitigates any concerns about the potential impact of the chosen estimation methods on the results, thereby reinforcing the robustness of the findings.

**Table B1.** Shapley Additive exPlanations (SHAP)

|  |
| --- |
| Shapley Additive exPlanations (SHAP) allows an interpretation of how the variables work, which makes it a useful algorithm for interpreting results. SHAP is an approach based on game theory and SHAP values are numbers that indicate how much each variable contributed to the estimated outcome, with the goal of interpreting an algorithm’s estimated outcome. SHAP elaborates on the approach of additive feature attribution methods. The goal of SHAP is to calculate each variable’s attribution to the estimation, and to account for the result in a consistent manner. The explanatory model $g$ can explain such an approach as the linear function of a binary variable, as follows.$g\left(z^{'}\right)=ϕ\_{0}+\sum\_{i=1}^{M}ϕ\_{i}z\_{i}^{'}$ (1)In this equation, $g\left(z^{'}\right)$ is a local surrogate model of the original model *f*(x). Using this allows us to interpret the original model. In the case of $z^{'}=\{0, 1\}^{M}$, $M$ refers to the number of explanatory variables, $z\_{i}^{'}$ refers to the observation status of the variables, and $ϕ\_{i}$ refers to the attribution of $i$, $ϕ\_{i}\in R$ . Here, we are interested in $ϕ\_{i}$, and Equation 2 provides the method for its estimation.$ϕ\_{i}=\sum\_{S⊆N\\{i\}}^{}\frac{\left|S\right|!\left(M-\left|S\right|-1\right)!}{M!}(f\_{x}\left(S∪\left\{i\right\}\right)-f\_{x}(S))$ (2) Here, $N$ refers to the entire set of explanatory variables, and $S$ refers to a temporary subset that does not include *I,* $S⊂N$. $\frac{\left|S\right|!\left(M-\left|S\right|-1\right)!}{M!}$ is the added weight that calculates the number of subset $S$’s permutations, and $f\_{x}(S)$ is the expected output for a given $S$. Equation 3 allows for the calculation of the global importance of each variable. The size of this outcome determines the importance of variable $I\_{i}$. $I\_{i}=\frac{1}{N}\sum\_{j=1}^{N}\left|ϕ\_{i}^{(j)}\right|$ (3)We can estimate the importance of each variable via Equation 3, but this does not illustrate how it works for the output. In order to discover that, we use the SHAP summary plot. The SHAP summary plot utilizes $ϕ\_{i}^{(j)}$to deliver every aspect of the variable’s importance in an intuitive visual manner.  |



**Figure B6.** Average impact on model output based on SHAP

Through the analysis of mean impacts using the SHAP framework in Figure B6, it becomes evident that the influence of APT price on the outcome is significantly greater compared to other variables. This finding serves as an important supplement to the insights presented in Figure 11(c).

**Table B2.** Housing wealth and Conservative/Democratic vote proportion

|  |  |  |
| --- | --- | --- |
|  | DV: Conservative vote proportion | DV: Democratic vote proportion |
|  | (1) | (2) | (3) | (4) | (5) | (6) |
| APT price/$m^{2}$ | 0.00003\*\*(0.00001) |  |  | -0.00003\*\*(0.00001) |  |  |
| Income& Wealth |  | 0.01\*\*\*(0.003) |  |  | -0.009\*\*\*(0.003) |  |
| ln Wealth tax |  |  | 0.01\*\*(0.004) |  |  | -0.008\*\*(0.004) |
| APT ratio | -0.009(0.018) |  |  | 0.012(0.018) |  |  |
| Homeownership | -0.003(0.008) | -0.005(0.008) | -0.006(0.008) | 0.002(0.008) | 0.004(0.007) | 0.005(0.008) |
| Education | 0.005(0.007) | -0.002(0.008) | 0.011\*(0.006) | -0.003(0.007) | 0.001(0.007) | -0.011\*(0.005) |
| Age | 0.003\*\*(0.001) | 0.006\*\*\*(0.001) | 0.005\*\*\*(0.001) | -0.002\*(0.001) | -0.005\*\*\*(0.001) | -0.004\*\*\*(0.001) |
| Sex | 0.0001(0.0009) | 0.0003(0.0007) | 0.0005(0.0007) | -0.0002(0.0009) | -0.0004(0.0007) | -0.0006(0.0007) |
| Urbanization | -0.0002(0.0002) | -0.0001(0.0002) | -0.0001(0.0002) | 0.0002(0.0002) | 0.0001(0.0002) | 0.0001(0.0002) |
| Turn out | 0.611\*\*\*(0.161) | 0.583\*\*\*(0.158) | 0.79\*\*\*(0.164) | 0.399\*\*(0.159) | 0.422\*\*\*(0.157) | 0.231(0.163) |
| Capital | 0.012(0.05) | 0.013(0.049) | 0.027(0.051) | -0.008(0.049) | -0.011(0.049) | -0.025(0.051) |
| Honam | -0.268\*\*\*(0.05) | -0.277\*\*\*(0.05) | -0.278\*\*\*(0.051) | 0.277\*\*\*(0.049) | 0.286\*\*\*(0.049) | 0.287\*\*\*(0.051) |
| Youngnam | 0.15\*\*(0.05) | 0.142\*\*\*(0.05) | 0.156\*\*\*(0.051) | -0.149\*\*\*(0.049) | -0.143\*\*\*(0.049) | -0.155\*\*\*(0.051) |
| Chungcheong | 0.053(0.05) | 0.044(0.05) | 0.059(0.052) | -0.052(0.05) | -0.044(0.05) | -0.057(0.052) |
| Gangwon | 0.07(0.051) | 0.063(0.051) | 0.074(0.053) | -0.071(0.051) | -0.065(0.051) | -0.075(0.052) |
| Constant | -0.286(0.221) | -0.512\*\*\*(0.182) | -0.712\*\*\*(0.218) | 0.227(0.218) | 0.45\*\*(0.18) | 0.618\*\*\*(0.217) |
| $$R^{2}$$ | 0.89 | 0.89 | 0.89 | 0.90 | 0.89 | 0.91 |
| N | 239 | 250 | 230 | 239 | 250 | 230 |

\* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01.