Final Literature Review

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### **Energy Efficiency**

The Mayor of New York has signed an executive order (EO 26), to commit to the principles of the Paris Climate Agreement, the first Paris Agreement-compliant plan from any major city in the world. The new action plan called, “1.5°C: Aligning New York City With the Paris Climate Agreement,” lists actions the City will take in coordination with the Mayor’s Office of Sustainability (MOS), municipal agencies and the private real estate sector, to accelerate greenhouse gas (GHG) reductions and put the city on a path to deep de-carbonization over the next three years. [1]

Under the auspices of the Greener Greater Buildings Plan (GGBP), New York City has a self-reported annual building energy benchmarking law for buildings over 50,000 square feet in total conditioned floor area adopted under Local Law 84. Starting in 2018, buildings between 25,000-50,000 square feet will be required to annually benchmark. The energy data is comprised of all energy and water usage and inputted in the Environmental Protection Agency’s (EPA), ENERGY STAR Portfolio Manager. This tool compares similar buildings typologies across the nation and is normalized for weather and usage to designate a score based on ranking within the percentile of the building population. [2]

The newest report released for NYC building energy and water use, relies on the annual data collected under Local Law 84 and 87. For The first time municipal buildings have their benchmarking data incorporated. There is also the ENERGY STAR rankings for multifamily buildings, the largest building sector type by aggregated square footage. The Greenhouse gas emissions have The significant takeaways are: energy use is down 14% citywide (mostly from grid production and infrastructure upgrades), large buildings are 30% of GHG emissions, reductions have not been consistent and an acceleration of reductions are needed to reach NYC goals.[3]

### **Property Valuation**

One of the only places where environmental quality is traded on explicit markets is real estate. There are several techniques that can be used to study the effects of environmental quality on property values and infer willingness to pay for improvements. The most commonly used method is the hedonic model. [4] The hedonic model is a revealed preference method of estimating demand or value. It breaks down the item being researched into its constituent characteristics, and obtains estimates of the contributory value of each characteristic. And the hedonic model has various forms, including Linear, Semi-Log, Log-Log, Box-Cox Linear, Quadratic, Box-Cox Quadratic etc. Different form of the model applies to different situations since it is essential to control the errors which in estimating marginal attribute prices are calculated by comparing each consumer’s equilibrium marginal bid vector with the gradient of the hedonic function. When all attributes are observed, linear and quadratic Box-Cox forms produce lowest mean percentage errors; When some attributes are unobserved or are replaced by proxied, linear and linear Box-Cox functions perform best.[5] However, Cassel and Mendelsohn (1985) advocated the use of simpler functional forms because of the concern that if the interest was in a minor characteristic such as air quality, the transformation might be determined largely by other more important characteristics and the wrong transformation of the environmental variable could have a large impact on the environmental welfare measures. [6]

### **Efficiency v.s. Price Premium**

Former studies have already found that energy efficiency could influence residences and office buildings’ sale and rental premiums but not with the Energy Star label, which is also consistent with the perspective of regular economic theories. From the demand side, people are willing to get more efficient in that this could help save money in space conditioning expenditures. Additionally, from the supply side, property developers or residence owners would also expect a higher price because of additional costs on efficiency.

However, in Hassett, K. A., & Metcalf, G. E. (1997) ‘s research, it turned out that technically calculated discount rate on energy savings is often underestimated, resulting in the fact that knowledgeable consumers might well be convinced that their future realized savings on energy would be far below these estimates, thus expecting a lower housing price. [7] What’s more, DeCanio, S. J., & John, A. (1997) found that due to unobserved transaction costs, myopia, informational barriers, uncertainty about benefits, market failures and other factors, that kind of profit might not happen. Accordingly, it would be very hard to appraise value of residences based on its inherent efficiency discount rate.[8]

We found that there are quite a few former literature utilizing hedonic method focusing on parties providing with a direct house price valuation changes resulting from improvement in energy efficiency and drew a conclusion that energy efficiency could improve housing capitalization to some degree, while due to the weakness and limits most of them haven’t measured the specific magnitude.

Halvorsen, R., & Pollakowski, H. O. (1981) examined the effect on house prices of changes in the prices of space-heating fuels since the 1973 oil embargo has abruptly shifted the energy prices, analyzing a sample of 269 homes in a single neighborhood in Seattle, Washington between 1970 and 1975. [9] It turned out that the fuel price changes have resulted in significant changes in house prices but it was not a priori and disappeared after natural gas prices finally rose. So in our research, we are considering taking types of fuel into account.

Dinan, T. M., & Miranowski, J. A. (1989) did a typical hedonic model including selling price, structural characteristics and location variables on a sample of 234 residences sold in Des Moines, Iowa between January and June, 1982. To measure energy efficiency, they used fuel expenditure of the residences in the sample. They also considered alternate functional forms for the hedonic equation such as linear, log-linear, semi-logarithmic and Box-Cox models. Then they applied a likelihood ratio test which is usually used to determine which model fits the best, and they figured that linear, semi-logarithmic and log-linear models differed significantly from the Box-Cox model which indicated an increase in residence price of $11.63 for every $1 decrease in fuel expenditures.[10]

Corgel, J. B., Geobel, P. R., & Wade, C. E. (1982) used a sample of 100 residences in Lubbock, Texas between 1978 and 1979 by applying a similar hedonic model, where the dependent variable was the selling prices and nine structural features were set as independent variables. From them, the energy efficiency factor was valuated from aerial infrared photography (categorical variable). They seemed to be quite significant in the regression model and has a marginal impact of $3,416 premium. But there are a variety of factors that they didn’t count like location factors.[11]

Johnson, R. C., & Kaserman, D. L. (1983) used a sample of 1,317 residences in Knoxville, Tennessee and performed a hedonic method, which shows that a decrease of $1 per year in a utility bill would increase the market value of a residence by $20.73.[12]

These studies all contain a common disadvantage which is that they relied too much on self-reported utility bills instead of construction characteristics such as how efficient a residence is which could have a big measurement error.

In the Energy Star home brochure, it was quoted by the EPA that a current Energy Star homeowner said “My biggest selling point for buying an Energy Star home was resale value. I would highly recommend Energy Star to anyone because it will definitely save them money in the long run.” [13] Therefore, based on the fact that efficiency could stimulate housing prices, it would be useful and important to measure the marginal value this program brings to residences.

In our proposal, we planned to quantify what are the property market valuation increase caused by unit increase of energy star scores and the obtaining of LEED status, identifying patterns in the valuation increase. The stimulation with Energy Star program hasn’t been examined until Eichholtz, P., Kok, N., & Quigley, J. M. (2010) found that Energy Star and LEED office buildings have a a 16% sale premium and a 3% rent premium compared to regular office buildings. [14] Bloom, B., Nobe, M., & Nobe, M. (2011) also found that Energy Star residences in Colorado have a sale premium of $8.66 per square feet. [15] Kahn, M. E., Kok, N., & Quigley, J. M. (2013) similarly concluded that Energy Star, LEED and GreenPoint Rated residences in California have a 4% sale premium. [16]

Bruegge, C., Carrión-Flores, C., & Pope, J. C. (2016) did a research on homeowners’ marginal willingness to pay a premium for the Energy Star residences in Gainesville, Florida, using a hedonic method. [17] They claimed to be the first to test the resale price premium associated with the Energy Star label, using repeat sales data, in order to control for time-invariant home characteristics that could potentially bias cross-sectional estimates.

### **Methodology**

Basically all of former studies applied the hedonic method to appraise the residences’ market value but with various models such as linear, semi-log, log-log, Box-Cox linear, quadratic or Box-Cox Quadratic which could be mighty different. Additionally, they were using different independent variables. A richer control for building and neighborhood characteristics could help estimate the magnitude of the housing efficiency impact.

After doing all models, we would apply a likelihood ratio test to examine which model fits our data the best.

### **References**

[1] ALIGNING NEW YORK CITY WITH THE PARIS CLIMATE AGREEMENT. (n.d.). Retrieved October 23, 2017, from <http://www.bing.com/cr?IG=3807FA1FD9F640069112F256048DF7F2&CID=255D20200ADC62F813D92B050BDA630C&rd=1&h=HKM18kjIurW_NugPJT-_7q51pREDnxDB14qKVUcShlA&v=1&r=http%3a%2f%2fwww1.nyc.gov%2fassets%2fsustainability%2fdownloads%2fpdf%2f1point5-AligningNYCwithParisAgrmt%2520(1).pdf&p=DevEx,5064.1>

[2] NYC Local Law 84 of 2009: Benchmarking Instructions ... (n.d.). Retrieved October 23, 2017, from <http://www.bing.com/cr?IG=6622D25B99A94F70ABAF2D15C79C982F&CID=2788108ADB446DCC2B841BAFDA426C3D&rd=1&h=AUKlWwBsd1k5ENmYcK9dEIeKagBdCDfE74hhLN6ee5Y&v=1&r=http%3a%2f%2fhome.nyc.gov%2fhtml%2fgbee%2fdownloads%2fpdf%2f2016_ll84_submission_instructions.pdf&p=DevEx,5063.1>

[3] *New York City’s Energy and Water Use 2014 and 2015 Report*. www.bing.com/cr?IG=19CD31A5D4FB40898508C75B9D92A64D&CID=15745AA938F36C1F05BE518C39F56D4B&rd=1&h=BYREu5xB4JNVV4fby0SOW57UEYYrJwDBpk4rfd2iXnI&v=1&r=http%3a%2f%2furbangreencouncil.org%2fsites%2fdefault%2ffiles%2fenergy\_and\_water\_use\_report\_spreads.pdf&p=DevEx,5064.1.

[4]Palmquist, Raymond B. (2005). “Chapter 16 Property Value Models”. In *Valuing Environmental Changes* , Handbook of Environmental Economics2005 2:763-819

[5]Maureen L.Cropper, Leland B.Deck and Kenneth E. McConnell\* (1988). “On the choice of functional form for hedonic price functions”. The Review of Economics and Statistics. 70(4):668-675

[6]Cassel, E., Mendelsohn, R. (1985). “The choice of functional form for hedonic price equations: comment”. Journal of Urban Economics 18, 135–142.

[7] DeCanio, S. J., & John, A. (1997). Modeling technological change in energy demand forecasting: A generalized approach. *Technological Forecasting and social change*, *55*(3), 249-263.

[8] Hassett, K. A., & Metcalf, G. E. (1997). *Measuring the energy savings from home improvement investments: evidence from monthly billing data*. National Bureau of Economic Research.

[9] Halvorsen, R., & Pollakowski, H. O. (1981). The effects of fuel prices on house prices. *Urban Studies*, *18*(2), 205-211.

[10] Dinan, T. M., & Miranowski, J. A. (1989). Estimating the implicit price of energy efficiency improvements in the residential housing market: A hedonic approach. *Journal of Urban Economics*, *25*(1), 52-67.

[11] Corgel, J. B., Geobel, P. R., & Wade, C. E. (1982). Measuring energy efficiency for selection and adjustment of comparable sales. *The Appraisal Journal*, *50*(1), 71-78.

[12] Johnson, R. C., & Kaserman, D. L. (1983). Housing market capitalization of energy‐saving durable good investments. *Economic Inquiry*, *21*(3), 374-386.

[13] ENERGY STAR Certified Manufactured Homes Brochure. (n.d.). Retrieved October 22, 2017, from <https://www.energystar.gov/newhomes/tools-and-resources/energy-star-certified-manufactured-homes-brochure>

[14] Eichholtz, P., Kok, N., & Quigley, J. M. (2010). Doing well by doing good? Green office buildings. *The American Economic Review*, *100*(5), 2492-2509.

[15] Bloom, B., Nobe, M., & Nobe, M. (2011). Valuing green home designs: A study of ENERGY STAR® homes. *Journal of Sustainable Real Estate*, *3*(1), 109-126.

[16] Kahn, M. E., Kok, N., & Quigley, J. M. (2013). *Commercial building electricity consumption dynamics: The role of structure quality, human capital, and contract incentives* (No. w18781). National Bureau of Economic Research.

[17] Bruegge, C., Carrión-Flores, C., & Pope, J. C. (2016). Does the housing market value energy efficient homes? Evidence from the energy star program. *Regional Science and Urban Economics*, *57*, 63-76.