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You Can't Take it With You:
Appliance Choices and the Energy EfficieCT

You Can't Take It With You: Appliance Choices and the Energy E ciency Gap

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Abstract

The bene ts of an investment in an energy e cient durable good depend on the life of the investment. If the expected length of ownership is mis-estimated, this will bias calculations of the bene ts of energy e ciency, including estimates of the energy e ciency gap. This paper estimates how expected ownership length a ects household appliance choices. I leverage the fact that some types of appliances are expected to convey (be included) with the sale of a house, while other appliances may or may not convey depending on local customs that vary at the state level. An appliance that conveys will be left behind when a homeowner moves, while an appliance that does not convey may be kept until the end of its useful life. I estimate the e ect of an appliance conveying using a di erence-in-di erences across states and appliance types, allowing me to control for state-level trends using xed e ects. I nd that consumers purchase less expensive refrigerators and clothes washers when those appliances convey. I show that accounting for whether an appliance conveys can substantially reduce or eliminate apparent undervaluation of energy e ciency bene ts.

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1 Introduction

actual average energy savings experienced by homeowners. Relatedly, Sallee (2014) shows that to the extent that consumers do not fully evaluate future energy savings, this may re ect rational inattention, rather than an irrational bias.

One element of energy e ciency calculations that has not been considered in previous literature is the expected life of the investment[4]. The simplest approach for these calculations is to assume that energy savings continue for the entire useful life of the good. However, if the good has limited resale or scrap value and consumers tend to replace their goods before the end of life, this will overestimate the bene ts of energy e ciency. Similarly, useful life may itself be uncertain or mis-estimated, leading to a further bias.

In this paper, I estimate the impact of expected length of ownership on consumer appliance choices by exploiting a previously undocumented feature of the U.S. real estate market that creates exogenous variation in the expected length of ownership for certain types of appliances. U.S. real estate law requires that \ xtures" convey (be included) with a sale of real estate in the absence of a contract specifying otherwise. The de nition of a xture is su ciently vague that the status of certain major home appliances is unclear, in particular refrigerators, clothes washers and dryers. As a result, the default for whether one of these appliances conveys depends on local real estate norms that are consistent within states, but vary across states. For instance, a homeowner in California purchasing a new refrigerator can expect to keep it when moving to a new house, while homeowners in Maryland and Virginia almost always leave appliances with the house. In a perfectly e cient housing market we would expect the value of any appliance to be capitalized into the house price. However, given that even major appliances are a small fraction of the overall price of a house, there is reason to believe that additional spending on these goods might not be recouped when selling the house[5].

Using a rich survey dataset capturing more than 200,000 consumer appliance choices, I estimate the e ect of an appliance conveying by default on the price of the appliance chosen, estimated energy use, and the probability of choosing an EnergyStar certi ed appliance. I compare refrigerators and clothes washers, which convey in some states but not others, to dishwashers and water heaters, which always convey in all states. I use MLS real-estate listings to determine the proportion of home sales in each state where a

[4] Jacobsen et al. (2016) estimate that ignoring heterogeneity in the longevity of motor vehicles undermines the potential e ciency gains of regulating fuel economy. This paper di ers in its focus on individual choice, rather than policy optimality, although the two questions are closely related.

[5] Possible explanations of this include thin resale markets for appliances, di ering preferences for appliance characteristics, and \lumpy" prices for homes (e.g. house prices rounding to the nearest $5,000). Although there is a recent literature showing that energy e ciency improvements are fully capitalized (Harjunen and Liski, 2014; Aydin et al., 2015; Margaret Walls and Bak, 2016), these works are all in the context of major, expensive upgrades to heating or insulation systems.

refrigerator or clothes washer conveys. By using an always-conveying appliance type as a control group, I am able to estimate a continuous di erences-in-di erences model with the proportion conveying as the treatment variable. This approach essentially entails comparing across states and appliance types with exible controls for unobserved state-speci c level e ects and trends.

I estimate that having an appliance convey by default causes consumers to choose refrigerators that are 12% less expensive and clothes washers that are 7% less expensive. This is consistent with a shorter expected length of ownership when the appliances convey, and thus a lower return to investing in a model with lower per-period energy costs. The e ect on upfront costs does not directly translate into choosing less energy e ciency, however. When appliances convey by default, consumers choose refrigerators that are on averagemore energy e cient, with smaller e ects or zero e ect on chosen energy e ciency for clothes washers. I estimate the e ect of an appliance conveying on EnergyStar

2 Background: The Law of Fixtures in the U.S.

The variation in which home appliances convey with the sale of a house stems from a legal gray area known as the Law of Fixtures (Horowitz, 1952). The purchase contract for a the sale of a house will by default specify that it covers only real property and not personal property. Real property is generally de ned as land and things such as buildings and trees which are attached to the land, while personal property is everything else. Complicating matters, real property also includes objects which are attached to other real property. These are termed xtures, and would also be expected to convey with a sale. However there is no bright line separating xtures from personal property (Morris, 2010).

The legal test for whether an object is a xture and should convey is whether the object is attached to the real property in question, with the intention of permanently attaching the object, and the object is adapted to use with the real property. While a dishwasher or a water heater is clearly attached to a house and should be considered a xture, ranges are almost always considered xtures even if they are freestanding electric models that could in principle be unplugged and removed. Legal disputes between buyers and sellers of real estate over these issues are common, especially with items such as chandeliers, custom draperies, and built-in speakers. The status of refrigerators and clothes washers and dryers varies from state to state according to local laws, customs and circumstances.

Although the buyer and seller in a real estate transaction are free to include or exclude any item from the sale, regardless of the legal distinction, there is reason to believe that the norms governing whether refrigerators and clothes washers convey do in uence behavior. First, the law of xtures is such that in absence of a contract provision, the local regime will be binding and the seller could be legally liable if an appliance that normally conveys is removed. Second, the local regime determines the default that occurs if the buyer and seller do not specify particular items to convey or not. The behavioral economics literature clearly shows that the default option has a strong in uence on behavior.Third, there is anecdotal evidence that the defaults for which appliances convey are binding. For instance, one can nd national real estate forums online where a potential homebuyer asks

3 A Simple Model of Appliance Choice

I consider a simple model of consumer choice of an energy-consuming durable good, and use this to generate empirical predictions for the reduced form analysis in section 5. The basic outlines of the model are drawn from Allcott and Greenstone (2012), which is in turn a simplified version of the model of Allcott et al. (2014).

A consumer chooses between two models of a durable good, with an expected lifetime of T periods. Index the models by $j \in \{E, I\}$, where E denotes the more energy efficient model, and I a less energy efficient model. The consumer pays p^j up front, and then receives a stream of benefits b^j each period, while paying energy cost e^j.[8] By construction $e^E < e^I$, but b^E may be greater than or less than b^I. That is, the energy efficient model uses less energy, but may be more pleasant to use, less pleasant to use, or the same. For instance, a smaller capacity refrigerator will use less energy, but also provides a lower

4 Data

My data on consumer appliance choices comes from TraQline, a large consumer survey published and syndicated by the Stevenson Company. TraQline is a retrospective survey of consumers who have recently purchased durable goods. Stevenson Company contracts with a variety of internet research panel companies to conduct the surveys. The panel maintains a pool of around 9 million potential respondents, who are recruited online to o er their opinions in a variety of surveys, generally in exchange for small monetary rewards, entrance into a sweepstakes, or points toward larger prizes. While participation in the TraQline survey is voluntary, potential survey takers are sent a generic invitation e-mail which does not mention the subject of the particular survey. TraQline surveys 150,000 consumers each quarter about purchases of new durable goods in the previous quarter. TraQline is widely used by appliance manufacturers and retailers to track market shares and purchasing decisions.

The data cover purchases of refrigerators, clothes washers, dishwashers and water heaters, made from the third quarter of 2008 through the second quarter of 2013.[9] Each observation is a single appliance purchase by a particular household in a quarter. A small number of households purchase more than one of the four appliances in a given quarter, and in these cases each purchase has a separate observation.[10] Although TraQline uses repeat respondents, they are not tracked across multiple survey periods.

The TraQline survey contains a rich set of variables on consumers' purchase demographics. The data identify the consumer's geographic location down to the MSA, age, race, gender education, income, household size, homeownership status, home tenure, and whether the consumer is a rst time homeowner. To focus on appliance decisions where the local default is likely to determine whether the appliance conveys, I exclude renters and consumers who purchased the smallest size of refrigerator (i.e. mini fridges, which are universally treated as personal property). I also exclude consumers residing in Alaska and Hawaii due to small cell size. Table 1 shows the demographics of the TraQline sample.[11] Given that by construction TraQline respondants are recent purchasers of a major home appliance, it is no surprise that respondants are higher income, better educated and more

[9] Stevenson company sells extracts of the TraQline data in 5-year increments; this was the most recent available sample when the Federal Trade Commission purchased the data in September 2013.

[10]

likely to be married than the U.S. population as a whole.

In addition to demographics, TraQline has a wealth of information about the purchase decision. Importantly, consumers report the actual price paid for the appliance in question. A common challenge in studies of durable goods is that these products frequently have variable discounts, and rarely sell for list prices. Consumers report the brand of the product, and are allowed to select the brand freely, such that the survey identi es smaller brands that might otherwise be lumped into an \other" category. An important drawback of these data is that although they contain several product characteristics for each appliance type, such as size and con guration, consumers are not asked for model numbers, complicating the task of linking in additional features such as energy usage from other datasets.

TraQline does not contain any direct information on the energy e ciency of the appliances purchased.[12] In order to test how an appliance conveying by default a ects choices of energy e ciency, I link the TraQline data with publicly available energy usage data from the Federal Trade Commission, the U.S. Department of Energy and the California Energy Commission. Because TraQline respondents do not report model numbers, I link the energy usage data by brand, year and product characteristics, assigning the average energy usage of all matching models. I generate a probability of EnergyStar status in the same manner, determining the proportion of matching models which meet EnergyStar standards. Appendix A gives more details on how the energy variables are matched to the TraQline data.

considered a xture and required to convey with the real estate. Likewise, including some appliances in a listing but not others indicates that the unmentioned appliances are not attended to convey. Discussions with Move Inc., the company that runs Realtor.com for the NAR, con rm that any listing of appliances is informative as to which appliances the seller intends to convey.

MLS listings on Realtor.com have a unique listing number as part of the URL, and I use this to randomly sample listings. I rst produce a list of potential listing numbers by searching Realtor.com for listings in each of the 100 most populous U.S. cities. I then randomly select listing numbers in proportion to the relative populations of each city. I exclude listings which are short sales, foreclosures, condominiums or new construction, as these seemed likely to disregard the local default relating to xtures. For any listing that includes mention of appliances, I record whether the words \washer" or \refrigerator" are included. I continue sampling until there are at least 100 listings with appliances in each state, to ensure a su ciently large sample.

Figure 1 maps the likelihood that appliances convey, with states shaded to indicate the proportion of MLS listings that include refrigerators or clothes washers. The top panel shows the frequency that refrigerators convey, the middle panel shows the frequency that clothes washers convey, and the bottom panel shows the distribution of observations in the TraQline data. The average proportion of listings with clothes washers included is lower than for refrigerators, likely because some homes simply do not have a clothes washer, whereas refrigerator ownership is almost universal in the U.S. In general, refrigerators and clothes washers are less likely to convey on the west coast and in the south, while states in the midwest, northeast and mid-Atlantic regions typically have appliances conveying. Still there are exceptions in every region, and not every state with a high occurance of refrigerators conveying also has a high occurance of clothes washers conveying. I link the proportions of

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median U.S. homeowner moves within 7 years of purchase, while major home appliances typically last 10 years or more. Thus, if an appliance conveys the true discounted present

washers, regardless of the control used. None of the coe cients are statistically di erent from zero, all are small in magnitude, and the standard errors are small enough to reject even a modest change. However, I note that my EnergyStar variable is measured with substantial error, capturing only the proportion of potentially matching appliance models which are EnergyStar certi ed, and as such my coe cients will be biased toward zero.

In section 3, I showed that reducing the length of ownership can lead to increased demand for the energy e cient product if the energy e cient product has a lower utility of usage. This might occur if, when an appliance conveys, consumers are more likely to choose basic models without premium features. If premium features are associated with higher energy usage, we would expect to observe consumers choosing models that are coincidentally more energy e cient, such as smaller refrigerators. I cannot test this hypothesis explicitly with my di erence-in-di erences model, because the product features recorded in the TraQline data are not readily comparable between appliance types. However, I provide suggestive evidence through a simple di erence model that compares, for instance, refrigerator purchases in states where refrigerators convey to refrigerators in states where they do not convey.

Table 4 shows the results of these simple di erence regressions, with each cell showing the coe cient of a separate regression. The rst column shows the average marginal e ect of the appliance type conveying on the choice of each appliance feature, calculated using a probit regression. The second and third columns use OLS, and show the average change in normalized energy usage and log purchase price associated with each appliance feature. All regressions include state and calendar quarter xed e ects. I emphasize that this analysis is intended merely to be suggestive|without a control I cannot say that any results are caused by the appliances conveying.

I rst consider two features of refrigerators: capacity, and through-the-door ice dispensers. Both of these features likely enhance utility, and are associated with higher average energy usage and higher average prices. If consumers consider whether their refrigerator will convey when choosing a model, we would expect these features to be purchased less often in states where refrigerators convey. Indeed, as the rst two rows of table 4 show, the more refrigerators convey in a state, the less consumers in that state purchase large refrigerators and refrigerators with through-the-door ice dispensers. As such, my di erences-in-di erences results showing that consumers choose refrigerators with both lower purchase prices and lower energy usage when they expect the refrigerator to convey could be explained in part by consumers substituting away from premium features. It may be that consumers also substitute away from energy e cient models *ceteris paribus*, but the countervailing e ect of choosing more basic models dominates.

The case of clothes washers is less clear. The main premium feature in the TraQline data for clothes washers is loading direction. Front-loading clothes washers are generally seen as more desirable, and are also more energy e cient. However, the third row of table 4 shows that on average consumers are more likely to purchase front-loading models in states where clothes washers convey more often, even though front loaders use less energy and are more expensive. On the other hand, my di erence-in-di erences analysis shows that clothes washers conveying causes zero e ect on energy e ciency, rather than increasing energy e ciency as with refrigerators. In any event, the e ect of the clothes washers conveying by default on upfront expenditures on new clothes washers does not seem to be readily explained by consumers substituting away from front-loading models when clothes washers convey.

Finally, as a form of null test, I examine whether consumers purchase premium water heaters in states where refrigerators convey by default. Water heaters always convey and should not be a ected by the default governing refrigerators. The nal row of table 4 shows results for heat pump electric water heaters, a relatively new type of heater that is highly energy e cient. There is no statistically or economically signi cant di erence between the rate of purchasing heat pump water heaters across states where refrigerators convey more or less.

6 Length of Ownership and the Energy E ciency Gap

In section 5, I show that the consumers' choice of appliances are a ected by whether the appliance type conveys, leading consumers to purchase less expensive appliances. I now consider the implications of this result for attempts to calculate whether consumers undervalue future net bene ts of an investment. This type of undervaluation can be thought of as an \energy e ciency gap", but applies generally to the valuation of any stream of bene ts from a durable good.

Following Allcott and Greenstone (2012), I modify the decision rule from section 3 to allow consumers to under or overvalue the stream of net bene ts from energy e ciency. Consumers choosing between energy e cient model E and ine cient model I will choose E if and only if:

$$\sum_{t=0}^{T} (b^E - b^I) - (e^E - e^I)\,{}^t > (p^E - p^I) \quad ;$$

the appliance conveying on the upfront cost implies a corresponding decrease in the net present value of investing in the energy e cient good. For each value of per-period net bene ts, I calculate the reduction in the life expectancy of the appliance necessary to produce the implied reduction in net present value. I assume that the energy e cient good costs the average price for each appliance in my sample. For instance, the average price for a refrigerator in my sample is $1,015. If a refrigerator conveying lowers average willingness to pay by 12%, as in table 3, this means it must lower the DPV by $121. Thus, if the energy e cient good saves $40 per year in energy costs, a refrigerator conveying must lower the expected length of ownership from 16 years to 9.6 years. Finally, I re-compute the value of that rationalizes the maximum price di erential, given the \true" life expectancy.

Figure 2 shows the results of these calculations, plotting annual net bene ts on the horizontal axis and the resulting na•ve and adjusted on the vertical axis. In each plot I assume a price di erential of $200, and a discount factor of either 0.9 or 0.85.

For low to moderate levels of per-period net bene ts, accounting for refrigerators conveying substantially reduces the apparent undervaluation of future bene ts. For per-period bene ts leading to a na•ve of about 0.6 or higher, accounting for the e ect of the refrigerator conveying by default produces a consistent with full valuation. However, the importance of conveying shrinks as the na•ve calculation of undervaluation grows larger. As the per period bene ts of energy e ciency increase, the DPV of the energy e cient investment grows, while the e ect of the appliance conveying on the DPV stays constant. This means that the implied change in life expectancy is smaller in the scenarios with larger per-period bene ts, decreasing the relative importance of conveying by default. For around 0.4, accounting for refrigerators conveying reduces the undervaluation by about a third. For very large undervaluations, where consumers appear to be unwilling to pay $200 for an investment that saves $100 or more per year, the e ect of conveying on the expected length of ownership accounts for only a small portion of the apparent undervaluation.

Accounting for clothes washers conveying has less e ect on calculations of the energy e ciency gap for those appliances. Between the smaller e ect on upfront expenditure from clothes washers conveying and the shorter \na•ve" life expectancy, the smaller bias

7 Conclusion

Determining whether consumers undervalue energy e cient goods requires, among other things, correctly determining how long consumers expect to bene t from energy e ciency investments. One contribution of this paper is simply demonstrating that in many U.S. states, engineering estimates of the useful life of an appliance will overestimate the true life of an investment, because consumers will necessarily transfer it when they move houses. More broadly, this paper adds to a recent literature nding that engineering estimates may overstate the bene ts of investing in energy e ciency appliances and home improvements. Previous works have shown that the per-period savings from energy e ciency investments can be overstated. I show that changes in the expected length of ownership can also a ect consumer choices, and failing to correctly account for the length of ownership can lead to overestimating the size of an energy e ciency gap.

My results focus on the e ect of the local regime for which appliances stay with a house when the house is sold. However, there are other ways that the e ective life of an energy e ciency investment could be overstated. If consumers simply replace their appliances before the product completely breaks down, this will also reduce the length of ownership if there is no practical market for secondhand appliances. Likewise, engineering estimates of the life of an appliance generally assume proper and regular maintenance. If consumers do not maintain their appliances, this will reduce the e ective life of the investment.

It is also worth noting that besides the major appliances used in this study, most energy e ciency investments by homeowners necessarily convey. Insulation, high-e ciency windows and most HVAC improvements will always convey with the sale of the house. As such, failure to account for the length of ownership will bias estimates of consumers' valuation of future energy savings.

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Table 1: Demographics of TraQline Sample

	Percent	Count
High School Dropout	0.028	6,931
High School Diploma	0.521	130,823
BA or More	0.451	113,375
Single	0.304	76,319
Married	0.696	174,869
Less than $50K	0.372	88,487
$50K-$100K	0.402	95,858
$100K-$200K	0.193	46,030
More than $200K	0.033	7,796
Employed	0.607	152,560
Retired	0.193	48,472
Other Not-Employed	0.200	50,152
Less than 1 Year at Address	0.188	43,626
1-5 Years at Address	0.201	46,733
5+ Years At Address	0.612	142,269

Table 2: TraQline Price, Conveyance and Energy Characteristics

	All	Refrigerators	Dishwashers	Clothes Washers	Water Heaters
Price Paid	708.4	1015.9	506.9	583.3	572.7
	(496.5)	(640.3)	(232.0)	(272.3)	(468.6)
Proportion Convey	0.580	0.481	1	0.260	1
	(0.362)	(0.262)	(0)	(0.187)	(0)
P(EnergyStar)	0.628	0.590	0.796	0.754	0.131
	(0.365)	(0.327)	(0.202)	(0.321)	(0.289)
Observations	260817	85181	50938	88615	36083

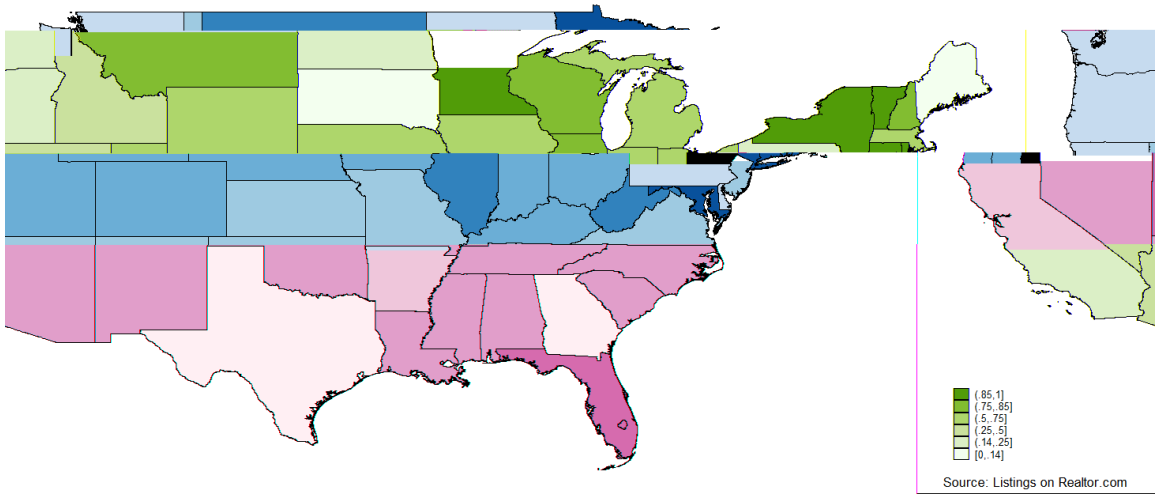
mean coe cients; sd in parentheses

Table 3: Conveyance Customs and Appliance Choices

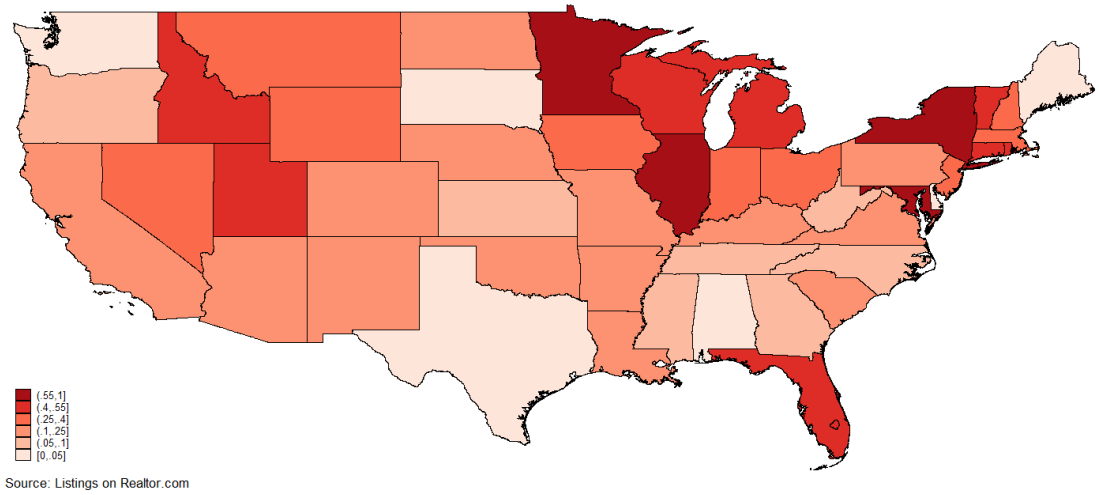
	Panel A: Price			
	Dishwasher Control		W. Heater Control	Both
Refrigerator Convey	-0.0892		-0.140	-0.122
	(0.0371)		(0.0868)	(0.0500)
Clothes Washer Convey		-0.0381	-0.155	-0.0708
		(0.0240)	(0.0729)	(0.0285)
Refrigerator	0.722		0.700	0.735
	(0.0203)		(0.0446)	(0.0254)
Clothes Washer		0.193	0.189	0.209
		(0.00946)	(0.0260)	(0.0110)
Water Heater				0.0422
				(0.0163)
	Panel B: Normalized Energy Use			
	Dishwasher Control		W. Heater Control	Both
Refrigerator Convey	-0.239		-0.325	-0.286
	(0.0976)		(0.272)	(0.138)
Clothes Washer Convey		0.0312	-0.326	-0.0704
		(0.0396)	(0.329)	(0.111)
Refrigerator	0.157		0.176	0.178
	(0.0591)		(0.115)	(0.0683)
Clothes Washer		-0.0780	0.0705	-0.0262
		(0.0151)	(0.0858)	(0.0316)
Water Heater				-0.00367
				(0.0695)
	Panel C: P(EnergyStar)			
	Dishwasher Control		W. Heater Control	Both
Refrigerator Convey	-0.0100		-0.0257	-0.0103
	(0.0136)		(0.0378)	(0.0249)
Clothes Washer				

Table 4: E ect of Conveyance on Choice of Appliance Features

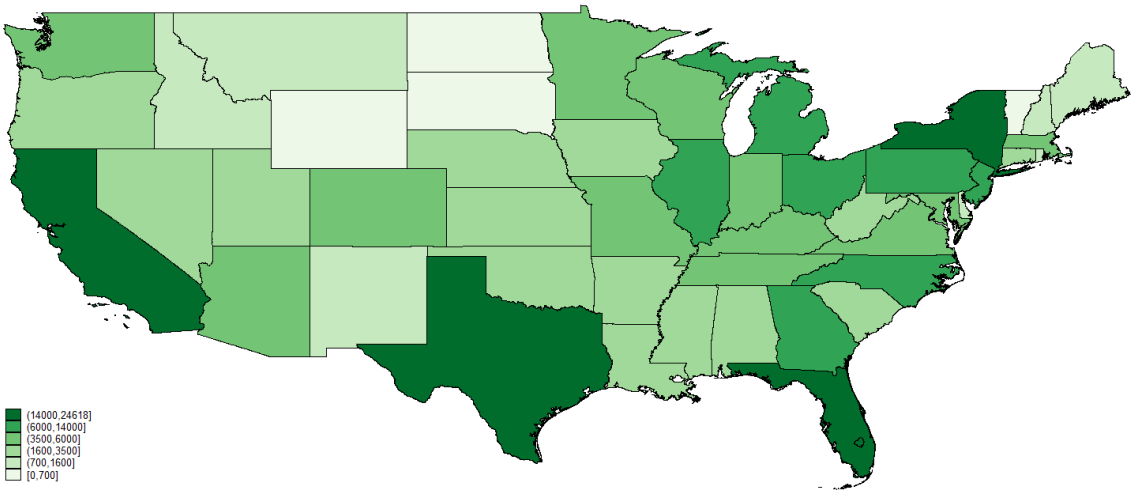
		E ect of...		
Feature		Convey on Feature	Feature on Energy	Feature on Price
Refrigerator; Capacity	23.5 ft^3	-0.433	0.814	0.460
		(0.461)	(0.0159)	(0.00581)



(a) Proportion of Listings Where Refrigerators Convey



(b) Proportion of Listings Where Clothes Washers Convey



(c) Count of Traqline Respondents 2008{2013

Figure 1: Proportion of Appliances Conveying and TraQline Respondents by State

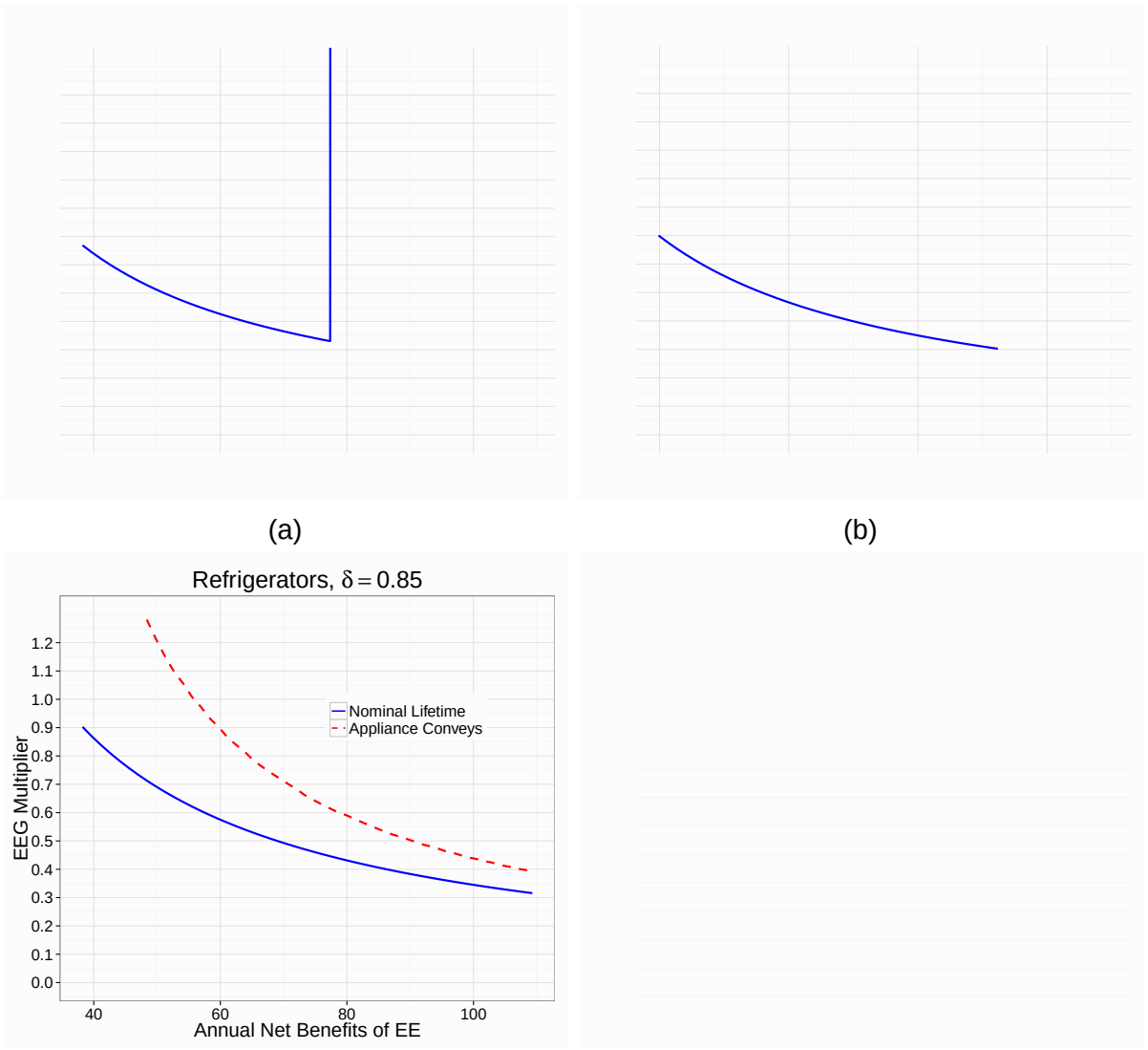


Figure 2: Implications of Appliances Conveying for an Estimated Energy E ciency Gap

Appendix

A Energy Usage Matching

This appendix describes the process used to match energy usage and EnergyStar information to the TraQline survey data.

A.1 Refrigerators

All data for refrigerators comes appliance energy usage data that appliance manufacturer's submitted to the U.S. Federal Trade Commission[18]. The energy usage data is given at the model level, and in addition to average annual electricity cost in dollars, the data indicate the refrigerator's con guration, capacity in cubic feet, whether it has manual or automatic defrost, and whether it has a through-the-door icemaker. The data contain an observation for each year between 2008 and 2012, and I match energy usage information from a given year to TraQline observations taken in the same year, using 2012 information for TraQline observations from the rst two quarters of 2013. I join the energy usage data to the TraQline survey data in three stages, aggregating at a higher level each time. First I match refrigerators in TraQline to the average energy usage by models with the same brand, year, con guration, manual defrost, icemaker and capacity bin. I then link TraQline observations with no match to the average by brand, year, con guration, manual defrost and icemaker. Remaining observations with no match are linked to the average by brand, con guration, and manual defrost.

Using the standard that applied during the study period, a refrigerator must have annual energy usage of 80% or less of the minimum e ciency standard. The minimum e ciency standard is a function of the con guration of the refrigerator, whether the model has a through the door icemaker, and a measure of adjusted capacity. Adjusted capacity is equal to 1.63 times freezer volume, plus total fresh volume. I assume that freezer capacity is 34.5% of total capacity for top and bottom refrigerators, and 42.5% of total capacity for side-by-side refrigerators.[19]

[18] These data are now maintained by the Department of Energy, since 2013

[19] These fractions were determined using data scraped from the websites of appliance retailers such as Best Buy. 34.5% and 42.5% represent the average ratio of freezer volume to total capacity. I am grateful

A.2 Dishwashers

Data for dishwashers comes from submissions to the Federal Trade Commission, and proceeds in the same manner as refrigerators. First, the data only indicate brand and whether the model is compact, and so the matching is done in one stage, by brand, year and compact status.

For EnergyStar status, a model is considered EnergyStar if it's annual energy usage in KwH is less than 335 (for models before 2010), 324 (for 2010 and 2011 models) or 295 (for 2012 and 2013).

A.3 Clothes Washers

Data from Clothes Washers comes from the California Energy Commission. These data indicate the modi ed energy factor and water factor for each model, as well as the brand, manufacturer, and loading direction. I link energy usage to TraQline in three steps. In the rst step I link to the average energy factor by brand, manufacturer, year and loading direction. For non-matching observations I then link to the average by brand, manufacturer and loading direction. Remaining observations are matched to the average by brand and loading direction.

EnergyStar status is determined by the modi ed energy factor and the water factor, with the standard becoming tighter with each year.

A.4 Water Heaters

The publicly available water heater data is much less clean than for the other three appliance types. I combine data from the California Energy Commission, the Federal Trade Commission, and the Department of Energy. Each dataset has a somewhat di erent list of models, and slightly di erent variables. Where the same model is present in multiple datasets, I take the every energy usage across the datasets. The data indicate for each model the energy factor, as well as brand, manufacturer, fuel type (electric or gas), capacity and electric type (for heat pump water heaters). I link the average energy usage in several stages, starting with all characteristics, and then aggregating more and more.

EnergyStar status is only available for heat pump electric water heaters, instantaneous gas water heaters, and conventional gas water heaters with energy factors of 0.67 and higher.