Do thermostat settings reflect differences in temperature preferences by sex?

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January 18, 2020

Abstract

The choice of a thermostat setting reveals an individual's optimal temperature for thermal comfort. This paper examines the extent to which males and females choose different thermostat settings using thermostat-setting data from single-occupant homes in the United States. Thermostat settings for heating and cooling at night, at home, and when away from home are rigorously tested for behavioral differences between the sexes. In general, single-occupant males and females choose the same thermostat settings on average. The lack of differences between sexes is robust to controlling for demographic characteristics and environmental variables that differ systematically between the samples using both regression and decomposition approaches. These findings have important implications for thermostat settings and thermal comfort in shared spaces.

Keywords: Temperature, thermostat, sex differences, thermal comfort, occupant behavior, heating, cooling

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1 Introduction

A 2015 *Nature* article claims that the standards used to set thermostats in shared spaces rely on exclusively-male resting metabolic rates in methods developed in the 1960s and explained in Fanger's (1970) authoritative textbook *Thermal Comfort* (Kingma and van Marken Lichtenbelt, 2015). Indeed, Fanger argues that there is likely no practical difference between preferred temperatures for males and females; however, modern U.S. and international standards suggest using metabolic rates appropriate for the sexes of the occupants (ASHRAE, 2009, 2013; ISO, 2004, 2005). Nevertheless, in experimental settings, females are consistently more thermally uncomfortable than males at all temperatures and are particularly adversely affected by cold temperatures (e.g., Beshir and Ramsey, 1981; Griefahn and Knemund, 2001; Parsons, 2002; Pellerin and Candas, 2003; Chang and Kajackaite, 2019). Are thermostats set too low for females?

This article examines whether actual thermostat settings by males and females reflect laboratory-measured differences in temperature preferences. If males and females have meaningfully different temperature preferences as measured in the lab, then males and females should choose different thermostat settings on average. This article examines data on thermostat settings from 494 single-occupant males and 786 single-occupant females from the United States Energy Information Administration's Residential Energy Consumption Survey. Respondents report their winter heating temperature and summer cooling temperature when they are at home, at night, and when they leave the home. The data show that none of the mean thermostat settings differ either statistically or practically by sex. The average thermostat setting for females is less than 0.3° Celsius [0.5°F] warmer than the average thermostat setting for males in each case. In addition, single-occupant females choose *colder* thermostat settings than single-occupant males on average at night during the winter.

Regression and econometric decomposition approaches are used to analyze the differences between male and female thermostat settings and control for potentially confounding differences between single-occupant males and females.[1] When controlling for demographics and

[1] The decomposition approach is commonly called the Oaxaca-Blinder decomposition and is the standard

heating-environment variables in the regression approach, the differences in mean thermostat settings shrink practically to zero. When decomposing the differences in the mean into the difference due to sample composition and the difference due to fundamental physiological and behavioral differences between the sexes, the analysis shows no evidence suggesting that single-occupant females prefer higher temperatures than single-occupant males on average. In fact, the decomposition suggests that if single-occupant females had the same age, race, education, income, and heating equipment as single-occupant males, the average preferred heating temperature of single-occupant females would be colder than that of single-occupant males. For cooling, the decomposition suggests that the physiological and behavioral difference is less than 0.08°C [0.15°F].

Many studies have examined and found statistically-significant sex differences in thermal comfort, but very few have examined whether these differences are practically significant. Laboratory experiments typically expose uniformly-dressed subjects to researcher-set temperatures and have subjects rate their subjective comfort on a seven-point scale.[2] In the laboratory, females are more comfortable in warmer conditions (Parsons, 2002), are more sensitive to cold, windy drafts in wind tunnels (Griefahn and Knemund, 2001), are more uncomfortable in both extreme cold and heat (Beshir and Ramsey, 1981), and perform worse on cognitive tests at cold temperatures relative to males (Chang and Kajackaite, 2019). Field research focuses largely on temperatures in office buildings and is less conclusive–the relative preferences of males and females differ depending on the context.[3] Karjalainen (2012) and

method for estimating wage differences between males and females (Oaxaca, 1973; Blinder, 1973).

[2]The seven-point scale is similar to a likert scale: -3 (cold), -2 (cool), -1 (slightly cool), 0 (neutral), 1 (slightly warm), 2 (warm), 3 (hot).

[3]Cena and de Dear (2001) find that in the hot climate of Western Australia that while females and males do not have significantly different temperature preferences that females are more dissatisfied with their thermal comfort than males are. Karjalainen (2007) finds that Finnish females are less satisfied with the temperature than males during all seasons and that females report preferring a higher temperature than their spouse as well as having less control of the thermostat than their spouse. When conducting a hypothetical experiment about changing the thermostat, Karjalainen (2007) did not find any differences between males' and females' preferences. In office buildings in the United States, high temperatures were correlated with negative physical symptoms for males, but not with females (Reynolds et al., 2001). Females in an office building in Italy complained of being too hot more often than males (Muzi et al., 1998). Indraganti et al. (2015) find that in India and other Asian countries, males are more dissatisfied with temperatures than females are. In a study of a naturally ventilated building and an air-conditioned building in Brazil, Maykot et al. (2018) estimate that the mean preferred temperature for males is 23.2°C [73.8°F] whereas the mean

Wang et al. (2018) review the literature on thermal comfort differences by sex, coming to similar conclusions. Karjalainen (2012) finds in a meta-analysis that females are 1.74 times more likely to be dissatisfied with the temperature, but that males' and females' neutral temperatures are not statistically distinguishable. Wang et al. (2018) conclude that females are consistently more sensitive to temperature differences across the literature, but that many other differences between the sexes do not generalize.

The approach in this paper is novel because it is the only study to interpret real choices of thermostat settings in the field as statements of individuals' preferred temperatures. When choosing a thermostat setting, an individual optimizes their subjective thermal comfort subject to the constraints of the environment. Thus, choices of thermostat settings reflect information about individual preferences for thermal comfort. Prior work either focuses on temperatures in the laboratory or subjective ratings of comfort in the field.[4] If the actual thermostat settings of males and females differ, this would be strong evidence that laboratory-measured sex differences translate into meaningful differences in behavior that should be addressed by engineers and building managers, particularly when designing and managing shared spaces.

2 Thermostat-setting data

The thermostat-setting data come from years 2009 and 2015 of the United States Energy Information Administration's Residential Energy Consumption Survey, a large cross-sectional survey of United States households. In the Residential Energy Consumption Survey, household heads answer questions about their homes and energy-using behavior. The survey is designed to form a nationally-representative sample of United States households.[5] This

preferred temperature for females is 24°C [75.2°F].

[4]Wang et al. (2018) describes the tradeoffs between lab and field studies and the tradeoffs between revealed-preferred temperature and subjective rating of comfort. Conditions in the laboratory are not necessarily externally valid, but allow for much better randomization and control than conditions in the field. Analyzing revealed temperatures is often not feasible in the field, but a subjective rating of comfort does not reveal an individual's optimal temperature.

[5]The 2009 survey was administered from February to August (primarily during the heating season) and the 2015 survey was administered from August to April (primarily during the cooling season). The study includes

Thermostat setting (° C)	(1) Males (s.d.)	(2) Females (s.d.)	(3) Difference (p val)
Heating temperature at home	21.26	21.36	0.10
	(2.21)	(2.12)	(0.43)
Heating temperature when gone	19.59	19.82	0.24
	(3.24)	(3.04)	(0.19)
Heating temperature at night	20.34	20.07	-0.27
	(2.83)	(2.78)	(0.09)
Cooling temperature at home	22.73	22.98	0.25
	(2.47)	(2.45)	(0.07)
Cooling temperature when gone	23.92	23.95	0.03
	(2.86)	(2.85)	(0.85)
Cooling temperature at night	22.42	22.64	0.22
	(2.62)	(2.71)	(0.16)
Observations	494	786	1,280

Table 1: Differences in mean heating and cooling temperatures chosen by single-occupant males and females.

study examines only single-occupant households so that any thermostat-setting choices reflect either a male's or a female's preferences only.[6] In addition, individuals from the sample whose responses used in the study are imputed or missing are dropped. The final sample includes 494 single-occupant males and 786 single-occupant females.[7]

Table (1) displays the sample means and standard deviations of thermostat settings for single-occupant males and females for both heating and cooling when at home, away, and at night. Mean heating temperatures for both sexes are around 21°C [70°F] when at home during the day, 20°C [67°F] when away, and 20°C [68°F] when at home during the night. Mean cooling temperatures for both sexes are around 23°C [73°F] when when at home during the day, 24°C [75°F] when away, and 23°C [72°F] when at home during the night. None of the differences between sexes is statistically or practically significant. In fact, the largest

controls for the year to account for this difference. In any survey-based study, subject memory and recall is a concern; however, so long as males and females do not misreport thermostat settings in systematically different ways, the difference between mean male and female thermostat settings will accurately reflect the average differences (i.e., under the classical measurement errors assumption).

[6]Karjalainen (2007) asks married individuals which spouse prefers the higher temperature, finding that females prefer higher temperatures than males, but the broader within-household choice of thermostat setting is an under-studied area.

[7]All heads of household in the 2009 and 2015 Residential Energy Consumption Survey are labeled as either male or female.

	(1)	(2)	(3)	(4)	(5)	(6)
	Males (s.d.)		Females (s.d.)		Difference (p val)	
Age (years)	54.02	(17.43)	62.11	(16.46)	8.10	(0.00)
Non-white (%)	0.16	(0.37)	0.15	(0.36)	-0.01	(0.59)
High school or less (%)	0.30	(0.46)	0.34	(0.47)	0.04	(0.11)
College (%)	0.69	(0.46)	0.73	(0.44)	0.04	(0.14)
Graduate degree (%)	0.16	(0.36)	0.14	(0.35)	-0.01	(0.47)
Income < 20k (%)	0.21	(0.41)	0.26	(0.44)	0.05	(0.05)
Income 20k-40k (%)	0.27	(0.44)	0.34	(0.47)	0.07	(0.01)
Income 40k-60k (%)	0.22	(0.41)	0.20	(0.40)	-0.02	(0.33)
Income 60k-80k (%)	0.12	(0.33)	0.10	(0.30)	-0.02	(0.17)
Income 80k-100k (%)	0.09	(0.29)	0.04	(0.20)	-0.05	(0.00)
Income 100k-120k (%)	0.03	(0.18)	0.03	(0.17)	-0.00	(0.75)
Income > 120k (%)	0.05	(0.23)	0.03	(0.18)	-0.02	(0.04)
Unemployed (%)	0.42	(0.49)	0.55	(0.50)	0.13	(0.00)
Rents (%)	0.35	(0.48)	0.27	(0.44)	-0.08	(0.00)
Landlord pays heat (%)	0.06	(0.24)	0.07	(0.26)	0.01	(0.38)
Landlord pays ac (%)	0.05	(0.22)	0.06	(0.23)	0.01	(0.57)
Natural gas heat (%)	0.46	(0.50)	0.46	(0.50)	-0.01	(0.85)
Electric heat (%)	0.45	(0.50)	0.48	(0.50)	0.02	(0.38)
Central air (%)	0.86	(0.34)	0.91	(0.29)	0.05	(0.01)
Natural gas bill (USD)	329.21	(403.33)	321.03	(388.49)	-8.18	(0.72)
Electric bill (USD)	1104.04	(575.49)	1112.03	(616.70)	7.99	(0.82)
Heated square meters	137.35	(77.59)	144.68	(83.71)	7.33	(0.12)
Cooled square meters	125.44	(80.26)	136.15	(85.61)	10.71	(0.03)
Heating degree days (18)	2017.96	(1152.16)	2007.50	(1176.47)	-10.46	(0.88)
Cooling degree days (18)	1031.61	(648.12)	1049.42	(666.08)	17.81	(0.64)
Observations	494		786		1,280	

Table 2: Sample means and standard deviations for single-occupant males and females.

difference between the sexes is the heating temperature at night, which is 0.27°C [0.49°F] *colder* for females relative to males on average—opposite of the prediction of laboratory studies. Table (1) provides no compelling evidence that thermostat settings are different for single-occupant males and females on average. The rest of the paper focuses on thermostat settings when at home during the day and at night because these are the most relevant to thermal comfort.

The sample mean thermostat settings of single-occupant males and females reflect both the differences due to physiological and behavioral differences between the sexes as well as the differences in confounding factors due to sample composition. For example, if younger people have higher metabolic rates than older people and single-occupant males are younger than single-occupant females, the mean thermostat settings of single-occupant males will be lower due to age differences alone rather than due to differences between the sexes. Table (2) displays summary statistics for each group. In this sample, single-occupant males are younger, higher income, more likely to be employed, more likely to be renters, and less likely to have central air conditioning than single-occupant females. Each of these differences between the sample groups may influence the sample mean thermostat settings and be confounded with the differences due to physiological and behavioral differences between the sexes.

It is possible that the lack of differences in mean thermostat settings between males and females is due to offsetting differences in the sample composition. Individual characteristics that potentially affect the choice of temperature fall roughly into two groups: demographic characteristics (such as age, income, race, education, etc.) and environmental characteristics (such as size of home, price of energy, season, type of heating and cooling equipment, outdoor temperature, etc.). In the following sections, two methods are used to control for differences in the sample composition of single-occupant males and females and to distinguish the composition effect from fundamental physiological and behavioral differences between the sexes.

3 Regression approach

The first approach uses a linear regression with an intercept shift for females to estimate the difference in thermostat settings for single-occupant males and females while controlling for observed differences in individual characteristics. For an individual i, let the thermostat setting T_i be a function of observed individual characteristics X_i, sex $g_i \in \{m, f\}$, and mean-zero individual temperature-preference heterogeneity ε_i. Thus, the population conditional expectation function for thermostat setting is $E[T_i|X_i, g_i]$ and

$$T_i = E[T_i|X_i, g_i] + \varepsilon_i. \tag{1}$$

The first approach estimates the equation

$$T_i = \beta_0 + \mathbb{1}(g_i = f)\delta + X_i'\beta_1 + \epsilon_i, \tag{2}$$

using ordinary least squares, controlling for demographic characteristics and then environmental characteristics. Under the assumption that the differences in thermostat settings between males and females can be represented as an intercept shift so that $E[T_i|X_i, g_i] = \mathbb{1}(g_i = f)\delta + E[T_i|X_i]$, the ordinary-least-squares estimate $\hat{\delta}$ is an estimate of the mean difference in thermostat settings controlling for differences in the characteristics X_i.[8]

Tables (3) and (4) contain the heating and cooling estimates of equation (2). Model 1 is a regression of thermostat setting on an indicator for being female with no controls—the estimate of the coefficient on the indicator variable is mechanically equal to the difference in means in table (1). Model 2 includes controls for demographics such as age, race, education, and income. When controlling for demographics, the estimated coefficient on the indicator for being female decreases in all cases, changing sign for the daytime heating regression. The coefficient on the indicator for being female from the nighttime heating regression increases in magnitude to -0.33 and is statistically different from zero. This coefficient implies a mean nighttime heating thermostat setting of 0.33°C [0.60°F] colder for females relative to males when holding demographics constant. The estimated difference between single-occupant males' and females' cooling thermostat settings shrinks to a tightly-estimated zero when controlling for demographics.

Model 3 includes controls for environmental characteristics such as heat fuel, home size, heating and cooling degree days, cooling equipment, and indicator variables for year, census

[8] This assumption is restrictive: it implies that the effects of individual characteristics are the same for males and females—for example, it implies that the effect of age on thermostat setting is the same for males and females. In the next section, this assumption is relaxed.

Y = Heating (° C)	Model 1		Model 2		Model 3	
	Day	Night	Day	Night	Day	Night
Female	0.10	-0.27	-0.09	-0.33	-0.05	-0.37
	(-0.15,0.34)	(-0.59,0.04)	(-0.34,0.16)	(-0.66,-0.01)	(-0.29,0.19)	(-0.68,-0.05)
N	1,280	1,280	1,280	1,280	1,280	1,280
Controls						
Age			Y	Y	Y	Y
Race			Y	Y	Y	Y
Education			Y	Y	Y	Y
Income bins			Y	Y	Y	Y
Heat fuel					Y	Y
Home size					Y	Y
Degree days					Y	Y
Division X Year					Y	Y

Table 3: Results from ordinary-least squares estimation, where the coefficient estimate for Female is interpreted as the winter-heating temperature sex differences. Each specification controls for different sets of explanatory variables. 95% confidence intervals in parentheses constructed using heteroskedasticity-robust standard errors.

Y = Cooling (° C)	Model 1		Model 2		Model 3	
	Day	Night	Day	Night	Day	Night
Female	0.25	0.22	0.04	0.01	0.02	-0.02
	(-0.02,0.53)	(-0.08,0.52)	(-0.25,0.32)	(-0.29,0.32)	(-0.25,0.28)	(-0.31,0.26)
N	1,280	1,280	1,280	1,280	1,280	1,280
Controls						
Age			Y	Y	Y	Y
Race			Y	Y	Y	Y
Education			Y	Y	Y	Y
Income bins			Y	Y	Y	Y
Central air					Y	Y
Home size					Y	Y
Degree days					Y	Y
Division X Year					Y	Y

Table 4: Results from ordinary-least squares estimation, where the coefficient estimate for Female is interpreted as the summer-cooling temperature sex differences. Each specification controls for different sets of explanatory variables. 95% confidence intervals in parentheses constructed using heteroskedasticity-robust standard errors.

division, and interactions between year and census division. When controlling for both demographic and environmental characteristics, all differences between single-occupant males' and females' mean thermostat settings except for nighttime heat are precisely-estimated zeros. The coefficient on the indicator for being female from the nighttime heating regression increases in magnitude to -0.37 and remains statistically different from zero. This coefficient implies a mean nighttime heating thermostat setting of °C [0.66°F] colder for females relative to males when holding demographics and environment constant.

The next section introduces a more general decomposition approach that allows for individual characteristics to affect males' and females' thermostat settings differently.

4 Decomposition approach

This section estimates the difference in mean thermostat settings that can be attributed to physiological and behavioral differences between males and females using an econometric decomposition method commonly referred to as an Oaxaca-Blinder decomposition. The difference in mean temperature preferences between males and females Δ^T can be written

$$\Delta^T = E[T_i | g_i = f] - E[T_i | g_i = m], \tag{3}$$

so that $\Delta^T > 0$ if the mean temperature preference is higher for females than males. The sample analog to equation (3) is the difference in sample means for females and males.

The difference in mean temperature preferences between males and females can be decomposed into the component due to fundamental physiological and behavioral differences between males and females Δ^T_S and the component due to distributional differences in the characteristics Δ^T_X (i.e., the differences between $X_i | g_i = m$ and $X_i | g_i = f$).[9] Using the law of iterated expectations, equation (3) can be written as

$$\Delta^T = E\left[E(T_i | X_i, g = f) | g = f\right] - E\left[E(T_i | X_i, g = m) | g = m\right]. \tag{4}$$

[9]The following derivation closely follows the derivation in Fortin et al. (2011).

Approximate the conditional mean temperature function with a linear-in-parameters function of the individual characteristics and parameters β_g that vary by sex so that

$$E[T_i|X_i, g=\gamma] = X_i'\beta_{g=\gamma} \quad \text{for } \gamma = \{m, f\}, \tag{5}$$

and $T_{i,g=\gamma} = X_i'\beta_{g=\gamma} + \varepsilon_{i,g=\gamma}$ for $\gamma = \{m, f\}$. We can now substitute equation (5) into equation (4) to see that

$$\begin{aligned} \Delta^T &= E[X_i|g=f]'\beta_f + E[\varepsilon_i|g=f] - (E[X_i|g=m]'\beta_m + E[\varepsilon_i|g=m]) && (6) \\ &= E[X_i|g=f]'\beta_f - E[X_i|g=m]'\beta_m, && (7) \end{aligned}$$

because $E[\varepsilon_i|g=\gamma] = 0$ for $\gamma = \{m, f\}$. Finally, add and subtract $E[X_i|g=f]'\beta_m$ and arrange terms to show

$$\begin{aligned} \Delta^T &= E[X_i|g=f]'(\beta_f - \beta_m) + (E[X_i|g=f] - E[X_i|g=m])'\,\beta_m && (8) \\ &= \Delta_S^T + \Delta_X^T. && (9) \end{aligned}$$

The first term in equation (8) is the difference in temperature preferences between males and females that can be attributed to fundamental physiological and behavioral differences between the sexes. The second term is the difference in temperature preferences between males and females that can be attributed to differences in observed demographic and environmental characteristics that systematically differ across sexes. This decomposition can be estimated by replacing the conditional means in equation (8) with conditional sample averages for single-occupant males and females $\bar{X}_g$, $g = \{m, f\}$ and the parameters with ordinary-least-squares estimates from individual thermostat-setting regressions for single-occupant males and females $\hat{\beta}_g$, $g = \{m, f\}$:

$$\begin{aligned} \hat{\Delta}^T &= \bar{X}_f'(\hat{\beta}_f - \hat{\beta}_m) + (\bar{X}_f - \bar{X}_m)'\hat{\beta}_m && (10) \\ &= \hat{\Delta}_S^T + \hat{\Delta}_X^T. && (11) \end{aligned}$$

The decomposition is performed twice, first controlling only for demographic characteristics and second controlling for both demographic and environmental characteristics.

Table (5) displays the decomposition results for heating.[10] When controlling for distributional differences between single-occupant males and females, the adjusted difference in heating thermostat settings that can be attributed to physiology and behavior Δ_S^T is negative or zero. When controlling for demographics, single-occupant females' daytime heating temperatures are 0.06°C [0.11°F] colder than single-occupant males', and single-occupant females' nighttime heating temperatures are 0.30°C [0.53°F] colder than single-occupant males'. When controlling for environmental variables, single-occupant females' daytime heating temperatures are 0.04°C [0.07°F] colder than single-occupant males', and single-occupant females' nighttime heating temperatures are 0.38°C [0.68°F] colder than single-occupant males'. After adjusting for differences between the samples, single-occupant females choose slightly colder heating temperatures than single-occupant males on average, although the gap is small in practice.

The results for cooling are similar. Table (6) displays the decomposition results for cooling. When controlling for distributional differences between single-occupant males and females, the adjusted difference in cooling thermostat settings that can be attributed to physiology and behavior Δ_S^T is essentially zero. When controlling for demographics, single-occupant females' mean daytime cooling temperatures are 0.07°C [0.13°F] warmer than single-occupant males', and single-occupant females' mean nighttime cooling temperatures are 0.01°C [0.02°F] warmer than single-occupant males'. When controlling for environmental variables, single-occupant females' mean daytime cooling temperatures are 0.07°C [0.12°F] warmer than single-occupant males', and single-occupant females' mean nighttime cooling temperatures are 0.04°C [0.07°F] colder than single-occupant males'.

For both heating and cooling, analysis of the detailed components of $\hat{\Delta}_X^T$ indicates that the primary confounding difference between single-occupant males and females is age for cooling temperatures. Other than age, none of the demographic or environmental characteristics is

[10] Appendix tables (8), (9), (10), and (11) display the sample means and parameter estimates used for the decomposition.

Decomposition - Heating

	Model 4		Model 5	
	Day	Night	Day	Night
Decomposition				
$\hat{\Delta}^T$	0.10	-0.27	0.10	-0.27
$\hat{\Delta}^T\_X$	0.16	0.02	0.14	0.11
$\hat{\Delta}^T\_S$	-0.06	-0.30	-0.04	-0.38
Components of $\hat{\Delta}^T\_X$				
Age	0.05	-0.07	0.09	-0.01
Non-white	-0.01	-0.01	-0.01	-0.01
College	-0.01	-0.03	-0.02	-0.03
Graduate degree	0.01	0.02	0.01	0.02
Income 20k-40k	-0.00	-0.03	-0.00	-0.02
Income 40k-60k	0.00	0.01	-0.00	0.01
Income 60k-80k	-0.00	0.02	-0.00	0.02
Income 80k-100k	0.02	0.06	0.01	0.05
Income 100k-120k	0.00	0.00	0.00	0.00
Income > 120k	0.01	0.02	0.01	0.02
Unemployed	0.09	0.03	0.09	0.04
Rents			-0.05	-0.06
Landlord pays heat			-0.00	0.01
Heated square meters			0.01	0.03
Heating degree days (18) ÷ 1000			-0.00	-0.00
Cooling degree days (18) ÷ 1000			0.02	0.02
Electric heat			0.00	0.01
Other heat fuel			-0.01	-0.00
Division X Year			-0.00	0.03
N	1280	1280	1280	1280

Table 5: Results from an Oaxaca-Blinder-style decomposition of the mean differences in heating thermostat settings for single-occupant males and females. $\hat{\Delta}^T$ is the total difference in means, $\hat{\Delta}^T_X$ is the difference that can be attributed to differences in observed demographic and environmental characteristics that systematically differ across sexes, and $\hat{\Delta}^T_S$ is the difference that can be attributed to fundamental physiological and behavioral differences between the sexes. Parameters used to construct these estimates are displayed in appendix tables (8) and (9).

Decomposition - Cooling

	Model 4		Model 5	
	Day	Night	Day	Night
Decomposition				
$\hat{\Delta}^T$	0.25	0.22	0.25	0.22
$\hat{\Delta}^T\_X$	0.18	0.20	0.19	0.26
$\hat{\Delta}^T\_S$	0.07	0.01	0.07	-0.04
Components of $\hat{\Delta}^T\_X$				
Age	0.23	0.28	0.17	0.22
Non-white	0.01	0.01	0.02	0.01
College	0.02	0.03	0.02	0.02
Graduate degree	-0.01	-0.01	-0.01	-0.01
Income 20k-40k	0.02	0.02	0.00	-0.01
Income 40k-60k	-0.01	-0.01	-0.01	-0.01
Income 60k-80k	-0.01	-0.00	-0.01	0.01
Income 80k-100k	-0.03	-0.03	-0.02	-0.01
Income 100k-120k	-0.00	-0.00	-0.00	0.00
Income $>$ 120k	-0.01	-0.01	0.00	0.01
Unemployed	-0.02	-0.07	-0.01	-0.07
Rents			0.05	0.06
Landlord pays ac			-0.00	-0.00
Cooled square meters			-0.02	0.03
Heating degree days (18) $\div$ 1000			0.01	0.00
Cooling degree days (18) $\div$ 1000			0.00	-0.00
Central air			0.02	0.02
Division X Year			-0.00	-0.02
N	1280	1280	1280	1280

Table 6: Results from an Oaxaca-Blinder-style decomposition of the mean differences in cooling thermostat settings for single-occupant males and females. $\hat{\Delta}^T$ is the total difference in means, $\hat{\Delta}^T_X$ is the difference that can be attributed to differences in observed demographic and environmental characteristics that systematically differ across sexes, and $\hat{\Delta}^T_S$ is the difference that can be attributed to fundamental physiological and behavioral differences between the sexes. Parameters used to construct these estimates are displayed in appendix tables (10) and (11).

a large confounder for the sample difference in thermostat settings between the sexes.

5 Interpreting results

Overall, the difference between single-occupant male and female thermostat settings is small on average. Additional controls tend to reduce the gap even further. If individuals set their thermostats to optimize the comfort of their built environments, then their choices of thermostat settings reveal their optimized temperature for thermal comfort. Thus, in practice, thermostat settings in shared spaces designed to satisfy an average female will likely satisfy an average male and vice versa.

The notable exception is in nighttime heating temperature, where single-occupant females choose a colder temperature than single-occupant males do on average—a gap that increases when controlling for demographic and environmental characteristics. Further examination of nighttime heating reveals that this difference is due to a larger proportion of single-occupant females who turn down the thermostat when going to bed relative to single-occupant males. 47.8% of single-occupant females reduce the thermostat from daytime levels when going to bed while only 36.4% of single-occupant males reduce the thermostat from daytime levels when going to bed. Among those who do not reduce the thermostat at night, the average nighttime temperature is 21.46°C [70.62°F] for males and 21.41°C [70.54°F] for females. Among those who do reduce the thermostat at night, the average nighttime temperature is 18.48°C [65.26°F] for males and 18.55°C [65.39°F] for females. Therefore, the differences in mean nighttime heating temperatures occurs because of the differences in the extensive margin of the number of females who turn down the thermostat for sleep rather than the differences in the intensive margin of the level of thermostat setting.

This paper focuses on mean thermostat settings, which may obscure other differences in the distribution of thermostat settings. Figures (1 - 4) plot kernel densities of the full distributions of thermostat settings when at home for both sexes. The distributions of thermostat settings are similar across the entire support. To the eye, the female distributions

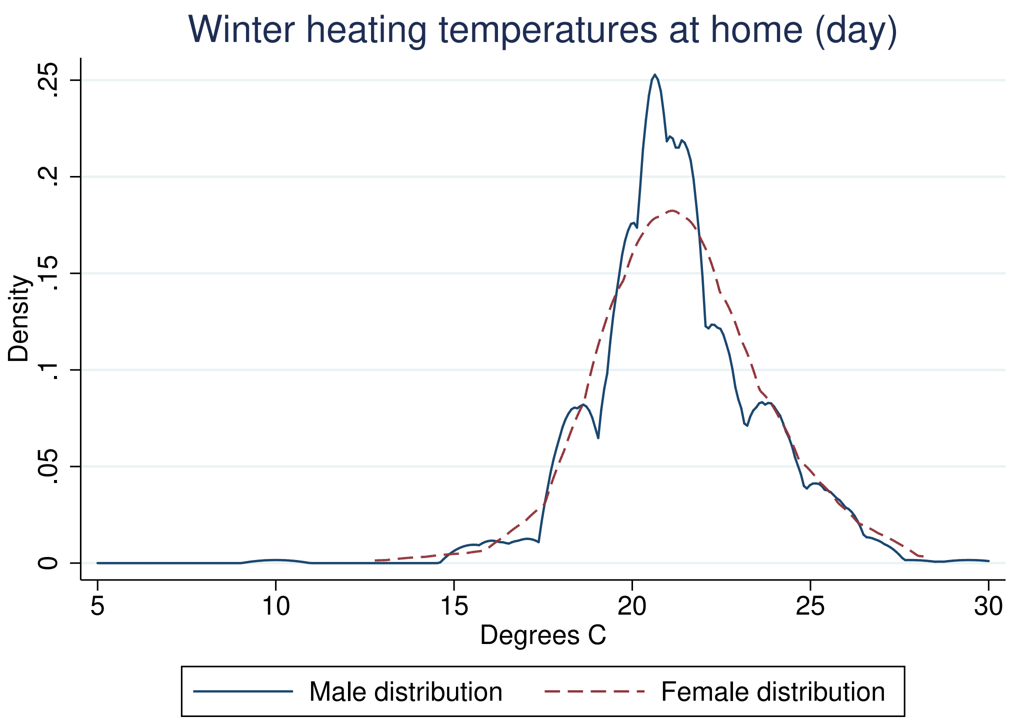

Figure 1: The distribution of winter heating temperatures chosen by males and females when at home during the day using an Epanechnikov kernel with bandwidth of 1.1. The p-value of the combined Kolmogorov-Smirnov test for difference between distributions is 0.754.

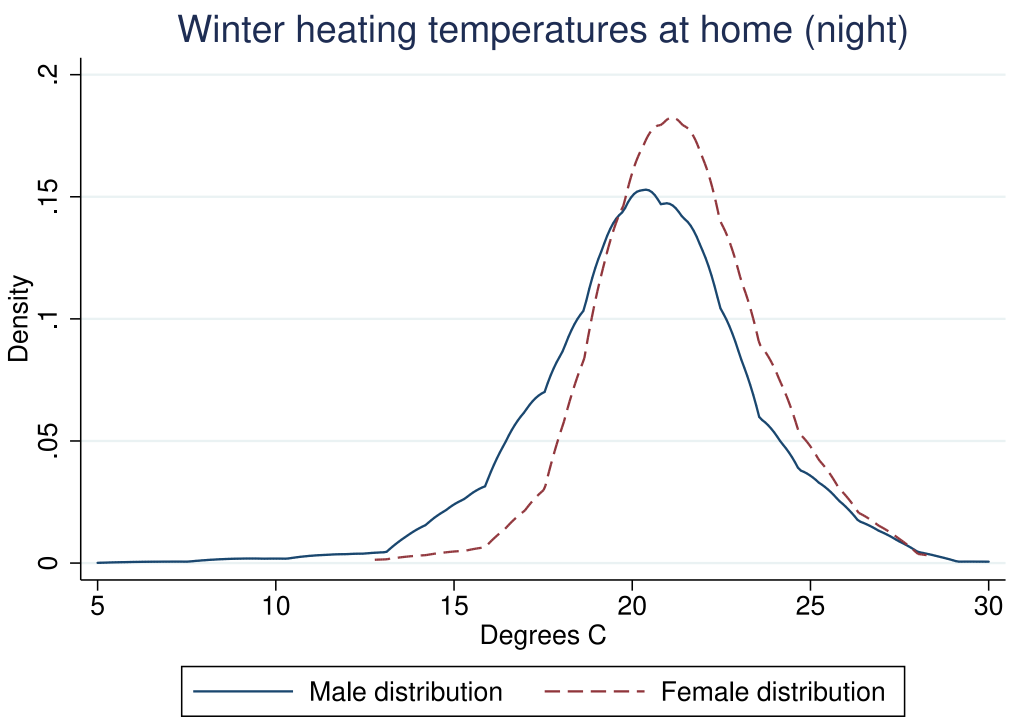

Figure 2: The distribution of winter heating temperatures chosen by males and females when at home during the night using an Epanechnikov kernel with bandwidth of 1.1. The p-value of the combined Kolmogorov-Smirnov test for difference between distributions is 0.054.

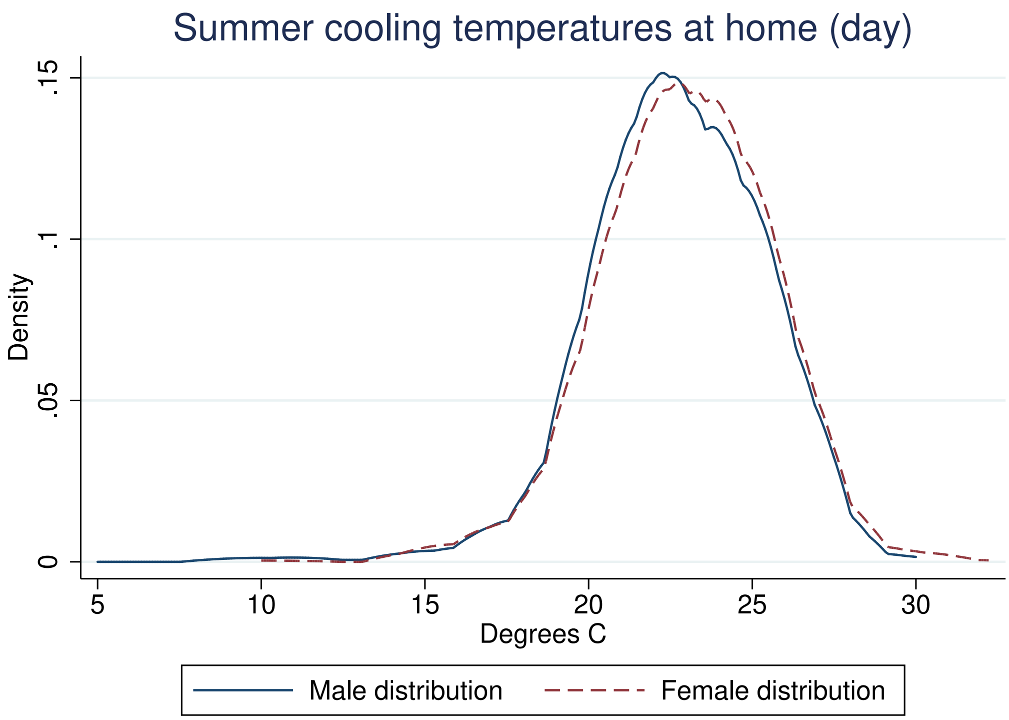

Figure 3: The distribution of summer cooling temperatures chosen by males and females when at home during the day using an Epanechnikov kernel with bandwidth of 1.1. The p-value of the combined Kolmogorov-Smirnov test for difference between distributions is 0.422.

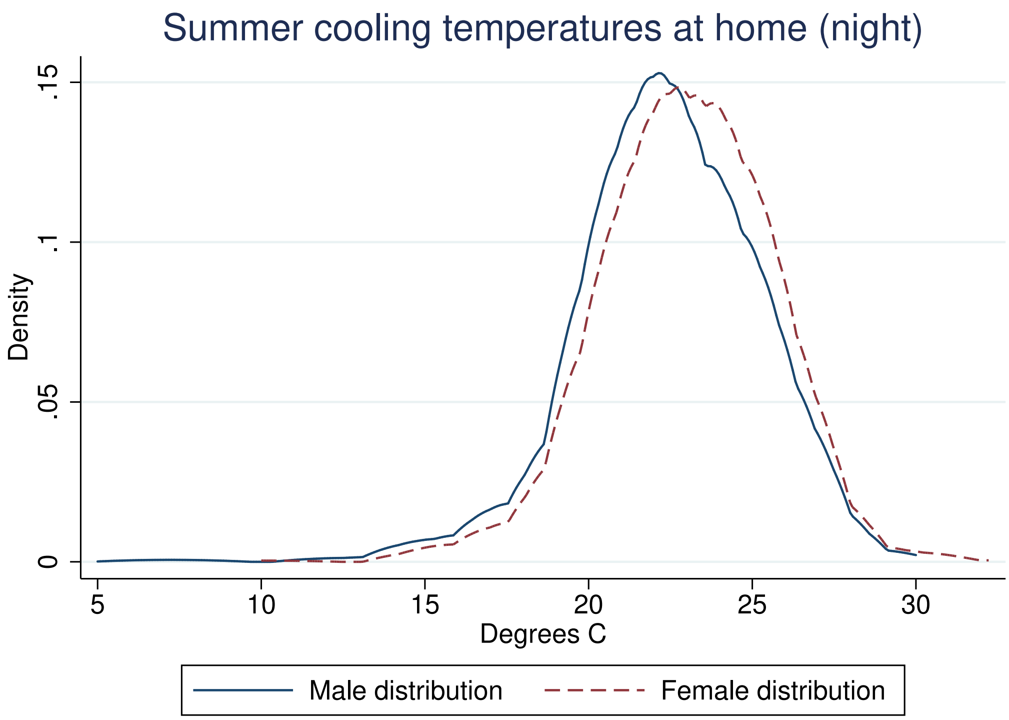

Figure 4: The distribution of summer cooling temperatures chosen by males and females when at home during the day using an Epanechnikov kernel with bandwidth of 1.1. The p-value of the combined Kolmogorov-Smirnov test for difference between distributions is 0.167.

of nighttime thermostat settings appear slightly shifted to the right relative to the male nighttime distributions of thermostat settings; however, Kolmogorov-Smirnov tests for differences between the distributions do not reject a null hypothesis of equality of each pair of distributions.

	(1)	(2)	(3)
Thermostat setting (° C)	Singles (s.d.)	Non-singles (s.d.)	Difference (p val)
Heating temperature at home	21.32	21.33	0.01
	(2.15)	(1.96)	(0.88)
Heating temperature when gone	19.73	19.90	0.17
	(3.12)	(2.75)	(0.06)
Heating temperature at night	20.17	20.44	0.26
	(2.80)	(2.51)	(0.00)
Cooling temperature at home	22.89	22.77	-0.12
	(2.46)	(2.30)	(0.11)
Cooling temperature when gone	23.94	23.81	-0.13
	(2.85)	(2.77)	(0.13)
Cooling temperature at night	22.55	22.54	-0.02
	(2.68)	(2.37)	(0.80)
Observations	1,280	5,530	6,810

Table 7: Differences between thermostat settings by single-occupant households and multiple-occupant households.

Focusing on single-occupant individuals naturally raises questions about sample selection and the external validity of results. Restricting analysis to single-occupant individuals is necessary to attribute each thermostat setting to the sex of one individual. Single-occupant individuals are older, are less educated, have lower income, and live in smaller homes relative to individuals in homes with multiple occupants. By definition, single-household individuals are adults, raising the average age of the sample which reduces the generality of the results despite the steps taken to control for age. Table (7) displays the thermostat settings for single-occupant and non-single-occupant households in the Residential Energy Consumption Survey. The differences are small and statistically insignificant except for in nighttime heating temperature, which is 0.26°C [0.47°F] higher for non-single-occupant individuals.[11]

[11] Interestingly, non-single-occupant individuals' thermostat settings are more "extreme"—warmer in the winter and colder in the summer—during all times of the day relative to single-occupant individuals'. Linear regressions of thermostat settings on the number of household members show that thermostat settings become more extreme with a larger number of household members (other than for daytime heating temperature).

Due to the similarities between single-occupant and non-single-occupant household mean thermostat settings, it is likely that the paper's results generalize to non-single-occupant individuals.

Another potential unobserved difference between males and females may be in the use pattern of heating and cooling equipment. For example, one sex may be inclined to leave the air conditioner running all day, while the other sex may be inclined to cycle the air conditioner on and off. In 2015, the Residential Energy Consumption Survey asked about typical use behaviors for heating and cooling equipment. For single females (males), 41% (46%) set one heating temperature and did not adjust it during the day, 30% (27%) report manually adjusting the heating temperature during the day, 16% (13%) reported using a programmable thermostat to change the heating temperature, and 11% (13%) reported that they turned off the heating equipment to change the heating temperature during the day. None of these differences is practically or statistically significant at the 5% level. For cooling the findings are similar. For single females (males), 41% (50%) set one cooling temperature and did not adjust it during the day, 24% (24%) report manually adjusting the cooling temperature during the day, 16% (13%) reported using a programmable thermostat to change the cooling temperature, and 18% (12%) reported that they turned off the heating equipment to change the cooling temperature during the day. It does appear that a slightly higher fraction of females shut off the air conditioning unit during the day to adjust the temperature, but this difference is small and not statistically different from zero. Table 12 in the appendix reports the differences in means and p-values for the tests for differences.

Finally, these thermostat settings were made at home where clothing and daily activities are different than in shared spaces. Thus, these temperatures may not be optimal outside of the home. Due to the survey design, neither differences in clothing insulation nor in daily activities could be observed. Thus, part of the estimated physiological and behavioral differences should be interpreted as including clothing and activity differences between sexes. It is likely that controlling for these behaviors would reduce the gap even further.

6 Conclusion

Given the popular narrative that thermostats are set too low for females' preferences, the differences in mean thermostat settings between single-occupant males and females are surprisingly small (less than 0.3°C [0.5°F] at most). This finding is robust to controlling for differences in sample characteristics using a regression approach and Oaxaca-Blinder style decomposition. When controlling for demographic and environmental characteristics, the gap shrinks to zero in nearly all cases and is even negative (though small) for nighttime heating temperatures (implying that single-occupant females' nighttime heating temperatures are set colder than single-occupant males' on average). These findings suggest that even if males and females have different temperature preferences as measured in the laboratory, these differences do not lead to meaningfully different choices of thermostat settings when at home.

One natural implication is that thermostat settings in shared spaces that are designed to satisfy an average female will likely satisfy an average male and vice versa. This does not mean that complaints about office temperatures should be ignored. In many contexts, females appear to have stronger thermal preferences than men (Karjalainen, 2012; Wang et al., 2018). If females are uncomfortable with the temperature, it is likely that males are also uncomfortable but to a lesser extent.

In addition, this does not mean that thermostat settings in shared spaces are correctly optimized for thermal comfort. Current practices for choosing thermostat settings in shared spaces rely heavily on methods that estimate comfortable or "neutral" temperatures using a seven-point likert scale. The seven-point thermal comfort scale does not elicit an individual's optimal temperature and it ignores intensity of preferences. It may be that males and females have similar distributions of preferred temperatures, but that one group (or both groups) feels more discomfort from being too cold rather than too warm. An asymmetric aversion to cold would imply that the optimal temperature in a shared space should be warmer. In addition, individuals may have different preferred temperatures in spaces outside of the home due to differences in activities and appropriate clothing. Further research should develop more comprehensive measurements of thermal comfort that emphasizes the role of individual choices, focuses on optimum temperatures, and incorporates intensity of thermal preferences.

References

ASHRAE (2009). *2009 ASHRAE Handbook - Fundamentals (I-P Edition).* American Society for Heating, Refrigerating, and Air-conditioning Engineers.

ASHRAE (2013). Thermal environmental conditions for human occupancy.

Beshir, M. Y. and J. D. Ramsey (1981). Comparison between male and female subjective estimates of thermal effects and sensations. *Applied Ergonomics 12*(1), 29–33.

Blinder, A. S. (1973). Wage discrimination: Reduced form and structural estimates. *The Journal of Human Resources 8*(4), 436–455.

Cena, K. and R. de Dear (2001). Thermal comfort and behavioural strategies in office buildings located in a hot-arid climate. *Journal of Thermal Biology 26*(4), 409–414.

Chang, T. Y. and A. Kajackaite (2019, May). Battle for the thermostat: Gender and the effect of temperature on cognitive performance. *PLOS ONE 14*(5), e0216362.

Fanger, P. O. (1970). *Thermal Comfort.* Danish Technical Press.

Fortin, N., T. Lemieux, and S. Firpo (2011, Jan). Decomposition methods in economics. In O. Ashenfelter and D. Card (Eds.), *Handbook of Labor Economics*, Volume 4, Chapter 1, pp. 1–102. Elsevier.

Griefahn, B. and C. Knemund (2001). The effects of gender, age, and fatigue on susceptibility to draft discomfort. *Journal of Thermal Biology 26*(4), 395–400.

Indraganti, M., R. Ooka, and H. B. Rijal (2015, Sep). Thermal comfort in offices in india: Behavioral adaptation and the effect of age and gender. *Energy and Buildings 103*, 284–295.

ISO (2004, October). Iso 8996: Ergonomics of the thermal environment - determination of metabolic rate.

ISO (2005, November). Iso 7730: Ergonomics of the thermal environment - analytical determination and interpretation of thermal comfort using calculation of the pmv and ppd indices and local thermal comfort criteria.

Karjalainen, S. (2007). Gender differences in thermal comfort and use of thermostats in everyday thermal environments. *Building and Environment 42*(4), 1594–1603.

Karjalainen, S. (2012). Thermal comfort and gender: a literature review. *Indoor Air 22*(2), 96–109.

Kingma, B. and W. van Marken Lichtenbelt (2015, Aug). Energy consumption in buildings and female thermal demand. *Nature Climate Change 5*, 1054–1056.

Maykot, J. K., R. F. Rupp, and E. Ghisi (2018, Nov). A field study about gender and thermal comfort temperatures in office buildings. *Energy and Buildings 178*, 254–264.

Muzi, G., G. Abbritti, M. P. Accattoli, and M. dellOmo (1998, Aug). Prevalence of irritative symptoms in a nonproblem air-conditioned office building. *International Archives of Occupational and Environmental Health 71*(6), 372–378.

Oaxaca, R. (1973). Male-female wage differentials in urban labor markets. *International Economic Review 14*(3), 693–709.

Parsons, K. C. (2002). The effects of gender, acclimation state, the opportunity to adjust clothing and physical disability on requirements for thermal comfort. *Energy and Buildings 34*(6), 593–599.

Pellerin, N. and V. Candas (2003). Combined effects of temperature and noise on human discomfort. *Physiology and Behavior 78*(1), 99–106.

Reynolds, S. J., D. W. Black, S. S. Borin, G. Breuer, L. F. Burmeister, L. J. Fuortes, T. F. Smith, M. A. Stein, P. Subramanian, P. S. Thorne, and et al. (2001). Indoor environmental quality in six commercial office buildings in the midwest united states. *Applied Occupational and Environmental Hygiene 16*(11), 1065–1077.

Wang, Z., R. de Dear, M. Luo, B. Lin, Y. He, A. Ghahramani, and Y. Zhu (2018, Jun). Individual difference in thermal comfort: A literature review. *Building and Environment 138*, 181–193.

A Appendix

Males - Heating	Model 4		Model 5		Mean
	Day	Night	Day	Night	
Age	0.01	-0.01	0.01	-0.00	54.02
	(-0.01,0.02)	(-0.03,0.01)	(-0.00,0.03)	(-0.02,0.02)	
Non-white	1.01	1.28	0.85	1.23	0.16
	(0.40,1.61)	(0.55,2.02)	(0.24,1.46)	(0.48,1.98)	
College	-0.23	-0.74	-0.57	-0.81	0.69
	(-0.80,0.33)	(-1.40,-0.09)	(-1.18,0.03)	(-1.55,-0.06)	
Graduate degree	-0.51	-1.07	-0.83	-1.23	0.16
	(-1.21,0.20)	(-1.90,-0.24)	(-1.56,-0.10)	(-2.12,-0.33)	
Income 20k-40k	-0.04	-0.43	-0.02	-0.33	0.27
	(-0.65,0.58)	(-1.25,0.39)	(-0.65,0.61)	(-1.14,0.48)	
Income 40k-60k	-0.02	-0.59	0.18	-0.44	0.22
	(-0.65,0.62)	(-1.35,0.16)	(-0.45,0.81)	(-1.22,0.35)	
Income 60k-80k	0.02	-1.03	0.09	-0.84	0.12
	(-0.68,0.72)	(-1.90,-0.16)	(-0.63,0.82)	(-1.77,0.09)	
Income 80k-100k	-0.45	-1.16	-0.20	-0.98	0.09
	(-1.29,0.39)	(-2.15,-0.17)	(-1.17,0.77)	(-2.12,0.16)	
Income 100k-120k	-0.57	-1.00	-0.33	-0.70	0.03
	(-1.32,0.19)	(-2.19,0.19)	(-1.24,0.59)	(-2.00,0.61)	
Income $>$ 120k	-0.34	-0.76	-0.33	-0.75	0.05
	(-1.19,0.51)	(-1.88,0.36)	(-1.21,0.56)	(-1.90,0.40)	
Unemployed	0.72	0.25	0.71	0.31	0.42
	(0.21,1.24)	(-0.42,0.93)	(0.18,1.24)	(-0.35,0.97)	
Rents			0.62	0.79	0.35
			(0.09,1.15)	(0.16,1.42)	
Landlord pays heat			-0.29	0.66	0.06
			(-1.16,0.59)	(-0.36,1.67)	
Heated square meters			0.00	0.00	137.35
			(-0.00,0.00)	(0.00,0.01)	
Heating degree days (18) $\div$ 1000			0.14	0.28	2.02
			(-0.34,0.62)	(-0.41,0.97)	
Cooling degree days (18) $\div$ 1000			1.01	1.09	1.03
			(0.22,1.80)	(0.03,2.16)	
Electric heat			0.18	0.50	0.45
			(-0.31,0.68)	(-0.08,1.07)	
Other heat fuel			0.38	0.02	0.08
			(-0.49,1.26)	(-1.41,1.44)	
Constant	20.79	21.71	17.50	17.95	
	(19.88,21.71)	(20.65,22.77)	(15.21,19.79)	(14.87,21.03)	
Division X Year			Y	Y	
N	494	494	494	494	

Table 8: Regression parameters and sample means for male heating temperatures used to construct the decomposition results in table (5). 95% confidence intervals in parentheses constructed using heteroskedasticity-robust standard errors.

Females - Heating	Model 4		Model 5		Mean
	Day	Night	Day	Night	
Age	0.02	0.00	0.03	0.01	62.11
	(0.01,0.03)	(-0.01,0.02)	(0.01,0.04)	(-0.00,0.03)	
Non-white	1.33	1.34	1.08	0.99	0.15
	(0.81,1.84)	(0.75,1.94)	(0.57,1.59)	(0.39,1.59)	
College	-0.11	-0.26	-0.18	-0.51	0.73
	(-0.53,0.30)	(-0.85,0.33)	(-0.65,0.30)	(-1.17,0.16)	
Graduate degree	-0.00	-0.40	-0.26	-0.79	0.14
	(-0.56,0.55)	(-1.20,0.41)	(-0.83,0.30)	(-1.64,0.06)	
Income 20k-40k	-0.02	-0.14	0.18	0.05	0.34
	(-0.41,0.37)	(-0.67,0.38)	(-0.23,0.60)	(-0.48,0.59)	
Income 40k-60k	-0.26	-0.30	0.11	0.07	0.20
	(-0.72,0.20)	(-0.92,0.31)	(-0.38,0.60)	(-0.56,0.70)	
Income 60k-80k	-0.61	-0.87	-0.17	-0.33	0.10
	(-1.20,-0.01)	(-1.62,-0.13)	(-0.76,0.42)	(-1.09,0.43)	
Income 80k-100k	-0.60	-0.83	-0.12	-0.20	0.04
	(-1.21,0.01)	(-1.83,0.16)	(-0.76,0.52)	(-1.24,0.85)	
Income 100k-120k	-0.70	-0.88	-0.27	-0.32	0.03
	(-1.40,0.01)	(-1.91,0.16)	(-1.05,0.51)	(-1.36,0.72)	
Income > 120k	-0.26	-1.31	0.07	-0.78	0.03
	(-0.82,0.31)	(-2.13,-0.49)	(-0.60,0.73)	(-1.81,0.26)	
Unemployed	0.12	-0.15	0.03	-0.22	0.55
	(-0.23,0.47)	(-0.63,0.32)	(-0.33,0.38)	(-0.70,0.25)	
Rents			0.66	0.67	0.27
			(0.23,1.08)	(0.13,1.21)	
Landlord pays heat			0.25	0.70	0.07
			(-0.29,0.80)	(-0.04,1.45)	
Heated square meters			-0.00	0.00	144.68
			(-0.00,0.00)	(-0.00,0.00)	
Heating degree days (18) ÷ 1000			-0.31	-0.01	2.01
			(-0.76,0.13)	(-0.59,0.57)	
Cooling degree days (18) ÷ 1000			0.13	0.74	1.05
			(-0.59,0.85)	(-0.20,1.67)	
Electric heat			0.24	0.39	0.48
			(-0.09,0.58)	(-0.07,0.86)	
Other heat fuel			-0.11	-0.25	0.06
			(-0.66,0.45)	(-1.01,0.50)	
Constant	20.20	20.22	19.60	17.70	
	(19.36,21.05)	(19.10,21.33)	(17.25,21.94)	(14.83,20.58)	
Division X Year			Y	Y	
N	786	786	786	786	

Table 9: Regression parameters and sample means for female heating temperatures used to construct the decomposition results in table (5). 95% confidence intervals in parentheses constructed using heteroskedasticity-robust standard errors.

Males - Cooling	Model 4		Model 5		Mean
	Day	Night	Day	Night	
Age	0.03	0.03	0.02	0.03	54.02
	(0.01,0.04)	(0.02,0.05)	(0.01,0.04)	(0.01,0.04)	
Non-white	-1.14	-1.18	-1.38	-1.25	0.16
	(-1.83,-0.45)	(-1.91,-0.45)	(-2.06,-0.71)	(-1.96,-0.55)	
College	0.62	0.77	0.51	0.44	0.69
	(-0.07,1.31)	(0.09,1.44)	(-0.25,1.26)	(-0.26,1.13)	
Graduate degree	0.75	0.76	0.72	0.56	0.16
	(-0.12,1.61)	(-0.08,1.61)	(-0.15,1.58)	(-0.26,1.39)	
Income 20k-40k	0.22	0.21	0.02	-0.09	0.27
	(-0.50,0.93)	(-0.51,0.93)	(-0.65,0.69)	(-0.77,0.59)	
Income 40k-60k	0.65	0.53	0.60	0.26	0.22
	(-0.07,1.38)	(-0.20,1.27)	(-0.10,1.31)	(-0.46,0.99)	
Income 60k-80k	0.33	0.10	0.31	-0.23	0.12
	(-0.45,1.11)	(-0.74,0.93)	(-0.45,1.06)	(-1.08,0.62)	
Income 80k-100k	0.66	0.70	0.48	0.28	0.09
	(-0.17,1.49)	(-0.14,1.54)	(-0.40,1.36)	(-0.62,1.17)	
Income 100k-120k	0.86	0.49	0.11	-0.54	0.03
	(-0.42,2.15)	(-0.89,1.86)	(-1.07,1.29)	(-1.72,0.65)	
Income > 120k	0.42	0.24	-0.02	-0.30	0.05
	(-0.59,1.43)	(-0.86,1.35)	(-0.97,0.93)	(-1.37,0.76)	
Unemployed	-0.15	-0.52	-0.11	-0.51	0.42
	(-0.77,0.48)	(-1.18,0.14)	(-0.67,0.44)	(-1.15,0.12)	
Rents			-0.57	-0.80	0.35
			(-1.11,-0.03)	(-1.38,-0.22)	
Landlord pays ac			-0.36	-0.39	0.05
			(-1.27,0.54)	(-1.22,0.45)	
Cooled square meters			0.00	0.00	125.44
			(-0.00,0.00)	(-0.00,0.00)	
Heating degree days (18) ÷ 1000			-0.08	0.09	2.02
			(-0.62,0.47)	(-0.51,0.69)	
Cooling degree days (18) ÷ 1000			0.89	1.13	1.03
			(0.05,1.73)	(0.10,2.15)	
Central air			-0.33	0.65	0.86
			(-1.10,0.44)	(-0.21,1.50)	
Constant	20.57	20.02	18.80	17.22	
	(19.61,21.53)	(18.86,21.18)	(16.01,21.58)	(13.81,20.64)	
Division X Year			Y	Y	
N	494	494	494	494	

Table 10: Regression parameters and sample means for male cooling temperatures used to construct the decomposition results in table (6). 95% confidence intervals in parentheses constructed using heteroskedasticity-robust standard errors.

Females - Cooling	Model 4		Model 5		Mean
	Day	Night	Day	Night	
Age	0.03	0.03	0.02	0.02	62.11
	(0.02,0.05)	(0.01,0.04)	(0.01,0.04)	(0.01,0.04)	
Non-white	-0.54	-0.40	-0.60	-0.49	0.15
	(-1.10,0.01)	(-0.97,0.18)	(-1.15,-0.04)	(-1.03,0.06)	
College	0.51	0.92	0.16	0.16	0.73
	(-0.06,1.08)	(0.26,1.58)	(-0.43,0.75)	(-0.49,0.81)	
Graduate degree	0.73	1.16	0.28	0.37	0.14
	(0.06,1.40)	(0.36,1.97)	(-0.41,0.97)	(-0.45,1.19)	
Income 20k-40k	0.51	0.40	0.19	-0.03	0.34
	(0.04,0.98)	(-0.13,0.93)	(-0.30,0.67)	(-0.55,0.49)	
Income 40k-60k	0.30	0.16	-0.06	-0.32	0.20
	(-0.21,0.81)	(-0.40,0.73)	(-0.61,0.48)	(-0.91,0.27)	
Income 60k-80k	0.28	0.11	-0.11	-0.30	0.10
	(-0.38,0.94)	(-0.60,0.81)	(-0.80,0.57)	(-1.02,0.42)	
Income 80k-100k	0.63	0.61	0.11	0.06	0.04
	(-0.23,1.50)	(-0.35,1.57)	(-0.77,1.00)	(-0.89,1.02)	
Income 100k-120k	0.87	0.67	0.11	-0.18	0.03
	(-0.15,1.89)	(-0.39,1.74)	(-0.93,1.14)	(-1.26,0.91)	
Income > 120k	0.73	0.53	0.11	-0.25	0.03
	(-0.41,1.88)	(-0.82,1.88)	(-0.99,1.22)	(-1.57,1.07)	
Unemployed	-0.03	-0.22	-0.06	-0.35	0.55
	(-0.45,0.39)	(-0.70,0.27)	(-0.46,0.34)	(-0.81,0.12)	
Rents			-0.44	-0.38	0.27
			(-0.92,0.04)	(-0.90,0.13)	
Landlord pays ac			-0.56	-0.39	0.06
			(-1.39,0.28)	(-1.27,0.49)	
Cooled square meters			0.00	0.00	136.15
			(-0.00,0.00)	(-0.00,0.00)	
Heating degree days (18) ÷ 1000			0.36	0.30	2.01
			(-0.16,0.89)	(-0.27,0.87)	
Cooling degree days (18) ÷ 1000			1.45	1.28	1.05
			(0.67,2.22)	(0.44,2.13)	
Central air			0.95	1.48	0.91
			(0.21,1.69)	(0.64,2.32)	
Constant	20.25	19.89	17.18	16.74	
	(19.22,21.29)	(18.76,21.01)	(14.52,19.84)	(13.85,19.64)	
Division X Year			Y	Y	
N	786	786	786	786	

Table 11: Regression parameters and sample means for female cooling temperatures used to construct the decomposition results in table (6). 95% confidence intervals in parentheses constructed using heteroskedasticity-robust standard errors.

Behavior	(1) Males (s.d.)	(2) Females (s.d.)	(3) Difference (p val)
Set one heat temp	0.46	0.41	-0.05
	(0.50)	(0.49)	(0.23)
Manually adjust heat temp	0.27	0.30	0.04
	(0.44)	(0.46)	(0.35)
Program thermostat to adjust heat temp	0.13	0.16	0.03
	(0.34)	(0.37)	(0.33)
Shut off heater to adjust heat temp	0.13	0.11	-0.02
	(0.34)	(0.31)	(0.39)
Other/not reported heating behavior	0.01	0.02	0.01
	(0.09)	(0.13)	(0.39)
Set one cooling temp	0.50	0.41	-0.09
	(0.50)	(0.49)	(0.03)
Manually adjust cooling temp	0.24	0.24	0.00
	(0.43)	(0.43)	(0.96)
Program thermostat to adjust cooling temp	0.13	0.16	0.03
	(0.34)	(0.37)	(0.33)
Shut off ac to adjust cooling temp	0.12	0.18	0.06
	(0.32)	(0.38)	(0.04)
Other/not reported cooling behavior	0.01	0.01	-0.00
	(0.11)	(0.09)	(0.61)
Observations	233	351	584

Table 12: Differences in behavior for how single males and females change the indoor temperature from the 2015 iteration of the Residential Energy Consumption Survey (not asked in 2009).