

Energy Consumption Behaviour and Work from Home (WFH): A Survey from India

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May 20, 2022

Abstract

We study energy consumption behaviour and transportation behaviour of individuals during the peak of restrictions and lockdowns in India and attempt to find possible relations with them working from home in that period. With the initial phase of lockdowns imposed by the government in March 2020, there were other spells of severe lockdowns in India especially after the second wave of the pandemic in March-April 2021. We conduct a primary survey in the city of Ahmedabad, Gujarat, India and ask respondents about their energy consumption behaviour and transportation during the period of March 2020 – May 2021 when a significant number of jobs moved to Working from Home (WFH). Results show education to be strongly associated with energy consciousness and enjoying WFH. Dividing job profiles across sectors, we find certain sectors to be more conducive to WFH. Individuals prefer to drive personal vehicles and not use car pooling, walking/cycling or public transport for relatively short distances to work.

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1 Introduction

According to Cambridge University Press (2022), Working from Home is "used to refer to a person doing their job in their home rather than travelling to an office, etc. in order to do it". Given the issues of zoom fatigue and extended Work from Home (WFH) hours because of managing household as well as office, productivity in most cases got affected. The question of the factors behind a more or less productive WFH and other behaviours of people while WFH is our focus in this paper. We are particularly interested in behaviours related to household energy consumption and transportation while people were mostly doing WFH.

Reports by Accenture Research (2021) and JLL Research (2020) describe the COVID-19 pandemic as the most important driver for a change in how people work and think about the workplace. Their surveys describe access to technology, autonomy in job, a supportive and agile leadership and quality of the home environment as the most important factors in increasing productivity and enjoying a better work-life balance for workers during WFH. As employees' also miss socializing with colleagues and collaborating in face-to-face settings, the reports conclude working hybrid is the way forward ¹ which is preferred by employees to working strictly offline or online. But International Labour Organization (2020) points out that in the context of India, the lack of a proper work environment at home such as a separate office space and ergonomic furniture, especially for women, makes WFH more stressful and demanding. There are no productivity gains as the workdays tend to be longer during WFH. For India, surveys show the adverse effect of WFH on women compared to men during the pandemic and some employees wanting to return to office post pandemic (Business Standard (2021), The News Minute (2021), Deccan Chronicle (2021)).

2 Literature Review

We study the effects on energy consumption and transportation behaviour by individuals and households during WFH. We consider the period of March 2020 - May 2021 when government announced restrictions and lockdowns were the most common in India.² Works in this area relating WFH to household energy and transportation needs have been limited. Works by Jiang, Fan, and Klemeš (2021) and Chitnis and Hunt (2012) do calculate energy demand at a country level, but the former is written in context of the COVID-19 pandemic and WFH. Jiang, Fan, and Klemeš (2021) further discuss stabilizing energy demand with more energy efficiency, energy saving such that some of the energy saved can be used to fight the pandemic, increased energy usage in materials and research and development. They also propose solutions for building smarter cities with digitalization and Internet of Things (IOT) and cleaner cities which reduce total energy demand while recovering basic energy demand at a country level as in pre-COVID-19 times. While the paper lends us ideas for future research, we believe our work to be the first to connect household energy consumption and transportation during WFH in a developing country such as India. Pathak et al. (2020) analyzed electricity consumption in two Indian cities during the peak of the lockdowns and showed reduced consumption of large electrical appliances in certain cases due to uncertainty in getting the appliance fixed in case of damage or overuse. From the supply side, electricity generation from the five regional grids and peak demand before and after the initial lockdown period in March 2020 is shown in Pandey et al. (2020). We suppose that as WFH and flexible work hours made people spend more time at home, this may have influenced energy consumption and transportation behaviour in a direct and indirect way. While staying at home and commuting less to work changes the energy consumption and transportation in a direct way, individuals' and households' may also be primed to be more energy conscious in terms of the choices they make. This would be the indirect influence on energy consumption and transportation behaviour. Reduced usage of electrical appliances, choosing greener modes of transportation during the occasional workday at office and attending conferences and seminars online would be some of the examples. At a household level, these

¹Accenture Research (2021) defines hybrid as the ability to work remotely between 25% and 75% of the time

²With the initial phase of lockdowns introduced in March 2020, there were other spells of severe lockdowns in India especially after the second wave of the pandemic in March-April 2021.

choices would be determined by factors such as number of household family members and the presence of children or elderly in the family, and other factors. Another question of interest would be if some of these changes in behaviour would persist in the future when things are back to normal in a post COVID world. As is mentioned in the previous section, the response may be very different for women vs. men due to longer work hours and the pressure of handling work and household responsibilities (International Labour Organization (2020), The News Minute (2021), Deccan Chronicle (2021)). On the other hand, quality work environments at home may also see some continue spending more hours at home (Accenture Research (2021), JLL Research (2020), The Economic Times (2021)).

Papers by Gottlieb et al. (2021) and Alipour, Falck, and Schüller (2020) measure the task content of jobs to arrive at an index for WFH ability for occupations and sectors. While the former work is carried out for Germany, the latter is for the developing countries of Brazil, Costa Rica and Peru. While there haven't been any such study for India, it can be expected that the ability (or not) to WFH would similarly depend on academic qualifications, gender, the presence of young children and years of experience in the current job as is shown in Alipour, Falck, and Schüller (ibid.). Gottlieb et al. (2021) interestingly finds the ability to WFH to be correlated to the income per capita in developing countries. Using data from the US, a similar result is found in Mongey, Pilossoph, and Weinberg (2021) who also find jobs more likely to be exposed to pandemic and resultant job losses would be those requiring a high degree of physical proximity to others and a low possibility to WFH. Decomposing the results into worker characteristics, the paper finds that people born outside the US, without a college degree and employed part-time are more likely to face the brunt of the employment shock due to the pandemic. Paper by Balbontin et al. (2021) study WFH attitudes and commuting modes of transportation across Australia, South Africa and a sample of South American countries. It finds about employers' flexibility to allow WFH for some days of the week, individual preferences for WFH now and after COVID restrictions have been eased and choice of private/public modes of transportation as determinants for working from home. Australia and South Africa seem to be more flexible in terms of attitudes towards WFH now as well as after restrictions are eased while use of public transport is more common for countries in South America. As is expected, the employers' attitude of mandatory WFH or allowing employees' to choose where to work from is one of the most important determinant of WFH now and in the future. Other results indicate that older people and females are more likely to take the WFH option in South America, whereas for Australia and South Africa, access to private transport and less travel time to office respectively would make individuals less likely to WFH.

3 Data and Summary Statistics

3.1 Data

The data used in this study has been collected from 400 households in the city of Ahmedabad in the state of Gujarat, India. The city was chosen because of job profiles of the study's authors and surveyors had collected data from the field. A method of stratified random sampling was used when the city was divided into various areas and households were selected randomly from each area. There were approximately 500 households chosen based on random sampling out of which around 100 were not available or declined to participate in the survey.³ The survey started with participants' being debriefed about the aims and objectives of the study. Informed consent was obtained from the participants of the survey by showing them a letter consisting the purpose of the study, the anonymity of responses and contact details of the investigators. The questions asked were on household energy consumption behaviour and transportation demand during the period of March 2020 to May 2021 when jobs shifted

³Ahmedabad was considered equally likely to be affected by the national level lockdowns imposed during the period of March 2020 - May 2021 containing the first and second wave of the pandemic in India (in addition to national lockdowns, there were minor additional measures imposed by each state within the country). As in cities throughout India, there were areas with high incidence of COVID-19 cases within the city resulting in the area being declared a containment zone etc. and there were also households selected from those areas for the study. As we are interested in finding about households' energy use and transportation behaviour during the pandemic, we expect the choice of areas not to particularly affect the results.

to WFH. There were some questions on future travel plans (if respondents would prefer attending meetings and seminars online rather than travel) and future shopping plans (if respondents would prefer buying groceries and other essentials online) expecting things to get back as they were in pre-pandemic times. Participants were given the option to say "Do not know", "Prefer not to say" or "Do not want to answer" to questions.

The study was approved by the Ethics Committee of Ahmedabad University in Ahmedabad, Gujarat, India.

3.2 Summary Statistics

Details on various demographics such as household size, household income, age distribution of family members, number of working adults etc. were obtained. Summary statistics of data on key demographics are presented in table 1.

The first couple of rows shows the gender and average age of the respondent. The respondent had to be an adult to participate in the survey. There were instructions given to surveyors to collect responses from the head of the household if possible for accurate information regarding household energy consumption and transportation behaviour during March 2020 - May 2021. We find that 224 out of 400 households only consisted of individuals aged between 10 to 60 years and there were 4 households consisting only of retirees or who had not answered the question. There were 65 households with at least one child aged between 0-9 years. The following two rows showing the number of working adults in the household and net family income are self explanatory. There were however 66 households who chose not to respond to the question on family income. The next rows show the highest educational qualification, employment status, the sector of employment and whether WFH was allowed by the employer. We would assume these responses with regards to the head of the household for further analysis. There were 18 and 9 cases respectively of no response pertaining to the question on highest educational qualification and whether WFH was permitted.

Tables 2 and 3 group the various variables of interest based on distance to work and sector of employment in the private sector. Given the number employed in the private sector to be the largest share (see table 1), we focus on this sector. In table 2, we find that use of private vehicles of 4-wheelers and 2-wheelers to be the largest when distance to work is within 10 km. The use of 4-wheelers jumps up significantly when distance to work increases beyond 3 km and use of public transport is almost none for the first two categories. Although we find some use of public transport for the last two categories, a question of interest is the over dependence on private modes of transportation for the largest share of the data, i.e. distance to work between 4 to 10 km. Our categorization of the type of private sector uses the fact that while IT and related jobs, work in the financial and services sector and education and research may be largely sedentary, the sector "Other" may not be so. The question on WFH satisfaction which is a binary (yes/no) variable shows some cases when WFH is not enjoyed combined with a significant number of respondents employed in the Other sector. We conclude from the "WFH cont" column that a significant number do not want to continue WFH or are flexible between working from office or WFH and that this fact holds for all categories of distance to work. It must be noted that the numbers for "WFH permitted" depict the flexibility of the employer to allow employees' WFH (papers by Gottlieb et al. (2021) and Alipour, Falck, and Schüller (2020) measure the ability of various jobs to do WFH and is beyond the scope of this work). The final column of table 2 shows the number of households having children up to 9 years and older adults aged 61 years and above and we see the greatest concentration in the 4 km to 10 km category having the largest share of the data. The presence of young or older family members would be especially important for variables such as WFH satisfaction and WFH cont which would be shown in the figures that follow. We find from table 3 that while the distribution of number of employees is similar across the sectors except education and research, the variables for whether WFH is permitted and WFH satisfaction reveal a different story for the Other category as expected. A limitation however of the paper is that we only have information about the total number of employees working at office and not the position/profile of the head of the household. A parameter of interest for our research question of whether people derive satisfaction from WFH or not is related to the job profile and the number of people one socializes with in an office environment: Mint (2021) and Statista (2021) show that younger and single individuals may not enjoy WFH as the office space is also used for socializing. The results for the column of WFH cont again reemphasize the difference between the sectors.

Table 1: Demographic variables summary statistics

Variable	Count
Gender	
-male	294
-female	106
Age	Mean = 41.86
Household Age Distribution (young/old)	
- hh without children or older members	224
- hh with children or older members (0-9 years and/or 61 years and above)	172
Household Age Distribution (children)	
- hh without children (0-9 years)	335
- hh with at least 1 child (0-9 years)	65
No. of Working Adults in Household	
- 1	179
- 2 or higher	221
Net Family Income of Household (INR)	
-(> 70k per month)	244
- (≤ 70k per month)	90
- NA	66
Highest Educational Qualification	
- high school	26
- bachelor's degree	203
- master's degree or higher	153
Employment Status	
- full time	317
- self -employed	56
- part-time	8
- others (retired, student, not working)	19
Sector	
- government	32
- private	275
- other†	75
WFH Permitted by Employer	
-yes	275
- no	116

† Respondents were given the options to choose among government, private and other, in addition to no response or not applicable. Given the number choosing "other", this may be considered a limitation of the paper in terms of lack of understanding/clarity for the respondents.

Table 2: Distance, transportation and WFH

distance to work	transport*	sector private†	WFH permitted	WFH satisfaction	WFH cont**	hh with young and/or old
less than 3 km	4W n= 17	ITCom n= 3	yes n= 24	yes n= 18	yes n = 4	yes n= 16
	2W n= 17	BankFinSer n= 3	no n= 12	no n= 16	no n=16	no n= 19
	pub trans n= 2	EducR n= 7			flexible n= 10	
4 to 10 km	4W n= 181	ITCom n= 40	yes n= 168	yes n= 125	yes n= 23	yes n= 98
	2W n= 53	BankFinSer n= 59	no n= 65	no n= 96	no n= 102	no n= 136
	pub trans n= 1	EducR n= 19			flexible n= 90	
11 to 20 km	4W n= 57	ITCom n= 16	yes n= 53	yes n= 41	yes n= 6	yes n = 39
	2W n= 16	BankFinSer n= 7	no n= 24	no n= 37	no n= 39	no n= 42
	pub trans n= 8	EducR n= 4			flexible n= 26	
more than 20+km	4W n= 21	ITCom n= 5	yes n= 22	yes n= 20	yes n= 2	yes n= 11
	2W n= 2	BankFinSer n= 5	no n= 9	no n= 10	no n= 15	no n= 20
	pub trans n= 8	EducR n= 2			flexible n= 12	
		Other n= 10			not sure n= 1	

* 4W = private vehicle 4-Wheeler (petrol/diesel), 2W = private vehicle 2-wheeler, pub trans = public transport/walking-cycling/car pooling

† ITCom = Information Technology, Communications, Software and Advertising companies, BankFinSer = Banking, Finance, Insurance companies/firms and Medical Doctors and HR, Marketing, Consulting, Legal Service companies/firms and Computer Hardware firms, EducR= Education and Research sector, Other = companies ranging from Manufacturing and Construction, Textiles, Automobile, Real Estate, Oil & Gas and Energy, Pharma, Chemical, Logistics and Transportation, Retail and Sales and Food Processing

** asks the question whether WFH would be preferred in future even after offices reopen and things are back to normal

We first show our basic results in terms of the following graphs. Figure 1 shows the obvious fact that heads of households who do not enjoy WFH do not want to continue WFH across all housing typologies (see the first paragraph in section 5.1 which discusses the relation between housing typology and energy consumption). But among those who enjoy WFH, a significant number are flexible doing work either at home or office. The numbers are highest for low rise and mid rise apartments due to distribution of the respondents in these categories. We think this result to be highly associated with presence of household conditions conducive to work and lack of interference or distraction (deWind et al. (2021)). On the other hand, there were very few households buying home appliances during the year 2020 - 2021

Table 3: WFH by private sector

sector private*	number of employees	WFH permitted	WFH satisfaction	WFH cont [†]	hh with young and/or old
ITCom	≤ 50 n= 21	yes n= 56	yes n= 47	yes n = 10	yes n= 19
	51-200 n = 22	no n= 8	no = 17	no n= 17	no n= 45
	> 200 n= 21			flexible n = 35 not sure n = 2	
BankFinSer	≤ 50 n= 32	yes n=60	yes n= 48	yes n= 10	yes n= 29
	51-200 n= 30	no n= 13	no n= 20	no n= 24	no n= 44
	> 200 n= 11			flexible n = 35 not sure n = 1	
EducR	≤ 50 n= 17	yes n=27	yes n= 25	yes n= 5	yes n= 14
	51-200 n= 10	no n= 6	no n= 8	no n= 14	no n= 18
	> 200 n= 6			flexible n = 13 not sure n = 1	
Other	≤ 50 n= 57	yes n=66	yes n= 44	yes n= 7	yes n= 44
	51-200 n= 28	no n= 35	no n= 55	no n= 59	no n= 59
	> 200 n= 16			flexible n = 28 not sure n = 6	

* ITCom = Information Technology, Communications, Software and Advertising companies, BankFinSer = Banking, Finance, Insurance companies/firms and Medical Doctors and HR, Marketing, Consulting, Legal Service companies/firms and Computer Hardware firms, EducR= Education and Research sector, Other = companies ranging from Manufacturing and Construction, Textiles, Automobile, Real Estate, Oil & Gas and Energy, Pharma, Chemical, Logistics and Transportation, Retail and Sales and Food Processing

[†] asks the question whether WFH would be preferred in future even after offices reopen and things are back to normal

and we cannot make much of an association with continuing WFH. Concentrating on buying groceries online and reducing home appliance usage during 2020 -2021, we see that whether WFH is enjoyed or not, the thought of continuing WFH or being flexible does have an impact on reducing home appliance use.⁴ This is also evident from the figure that those who have bought groceries online in 2020 - 2021 want to continue buying so and many of these households enjoy WFH. We can thus conclude that while living in a certain kind of house may not influence the satisfaction derived from WFH or the likelihood to continue WFH, being satisfied with WFH certainly has a positive impact on continuing WFH or being flexible to work from home or the office. As outlined in the first paragraph of section 4.1, we notably find that **enjoying WFH or being likely to continue WFH, makes reducing home appliance use or continuing online grocery purchases more likely**. These results are in line with (Pathak et al. (2020)) and is confirmed by figure 2. The width of the boxes indicate the number of observations in each category and while the distribution is even across all housing typologies, there is some effect on energy consciousness of the presence of younger and/or older members of the family ($hh_{agedist}$). The even stronger association of energy consciousness with mode of transport and WFH satisfaction is shown in the regression outputs of tables 4, 5 and 6.

4 Model

4.1 Overview

We specifically analyze three broad questions: i) the factors associated with being more energy conscious, ii) the factors associated with WFH satisfaction and, most importantly, iii) the association, if any, between enjoying WFH and being more energy conscious. While table 4 deals with the first question, the other two are addressed through tables 5 and 6 respectively. Our focus in this paper is to understand the relation between households' in general spending more time at home and whether this is associated with being more energy conscious in terms of energy and transportation choices. In our opinion, this is the first study that relates WFH and energy saving behaviour in the Indian context. It must be noted that methods we employ do not prove any causation but correlations. We plan to investigate causations in future research when working with a richer dataset.

⁴The question on buying home appliances ranged from appliances such as AC, Microwave, Refrigerator, Air Cooler and Other and the question asked whether 1, 2 or more than 3 were bought during the period under study of March 2020 to May 2021. Similarly, for the question on reducing home appliance use it provided the options of reducing less than 2 hours to more than 15 hours per week for the same appliances.

Figure 1: House type, appliances, WFH and online groceries

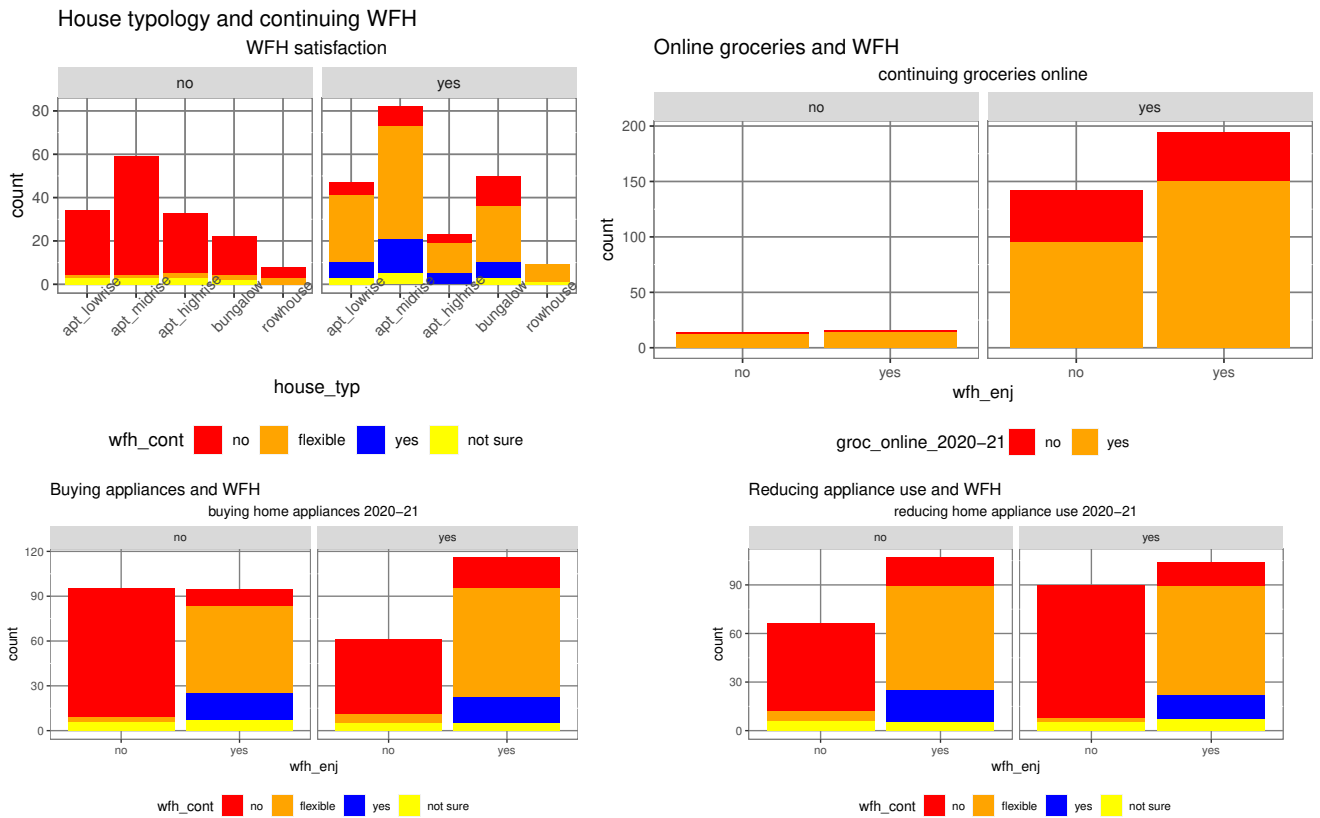
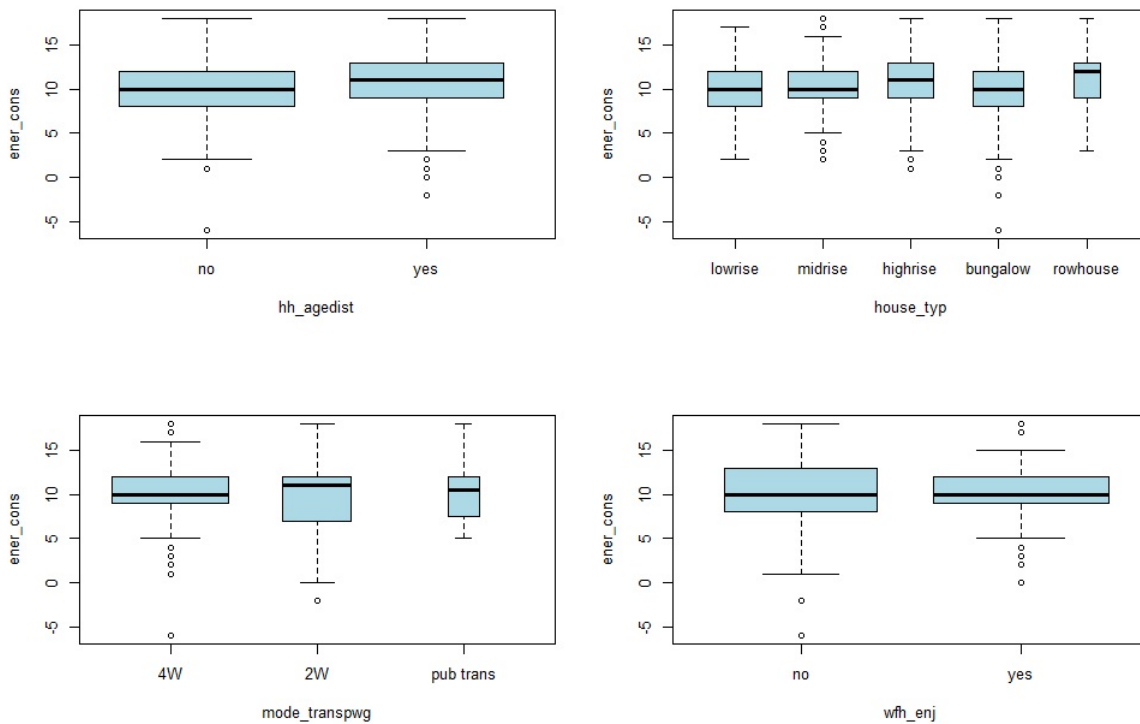


Figure 2: Energy consciousness



4.2 Framework

We first estimate a linear model of the form

$$enercons_i = x_i\beta + u_i \quad (1)$$

where ‘enercons’ is an index of energy consciousness, x ’s are the vector of explanatory variables with β ’s being the regression coefficients, and u_i represents the error term.

Energy consciousness is an index measured across six different categories of unplugging chargers/turning off chargers when not in use, turning off lights and fans when not in use, closing doors and windows when the AC is on, loading the washing machine until full, loading dishwasher until full and buying electrical products that are 4/5 star energy efficient. Assigning a score from ‘Never’ to ‘Always’ of -1 to 3 (with Not Applicable being 0), we arrive at a final score for energy consciousness. Our explanatory variables include demographic controls such as gender, education, family income and others such as the presence of young and/or older family members, whether WFH is enjoyed or not, the building typology and the mode of transport used to go to work.⁵ Results are presented in table 4.

We then assume a linear probability model of the form (Wooldridge (2002))

$$P(y = j|x) = \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_Kx_K \quad (2)$$

where j denotes the outcome for the dependent variable and usual explanations follow for the y , the x ’s and the β ’s.

We first carry out logistic regression to see the change in the probability of WFH enjoyment as a function of distance to work, sector of private sector employment, number of employees in office, household age distribution consisting of young/older family members and demographic controls of gender, education and family income. WFH satisfaction or enjoyment is a binary response dependent variable assuming the values 0 for “No” and 1 for “Yes”. As explained earlier, the number of employees in office may have an association with enjoying WFH or not as younger employees also use the office space for socializing. Results are presented in table 5. We proceed to multinomial logistic regression where the dependent variable is choosing greener modes of transportation to go to work: although we concentrate on WFH, this deals with going to office during the occasional workday not spent at home. The dependent variable is ordered with 3 possible responses. The reference category is the most polluting means of transport of 4W-petrol or diesel vehicles (coded as 0) and then we move to 2W and public transport (coded as 1 and 2 respectively). Results are presented in table 6.

5 Results

5.1 Main Results

Table 4 shows that education is positively associated with being more energy conscious and the results are significant at the 1% level across all models. Interestingly, a percentage point increase in family income reduces energy consciousness on average for both models 2 and 3 where the latter model includes the presence of young and/or older family members and housing typology. We include housing typology as living in midrise or highrise vs. lowrise apartments (the reference category) is usually associated with higher energy consumption (Finch et al. (2010), Jang and Kang (2018)). We believe the negative association between energy consciousness and family income is due to the greater likelihood of larger families living in larger accommodations, i.e. a bungalow or rowhouse. This is especially the case of Ahmedabad, where higher income groups with large families tend to live in these kinds of accommodation and for the head of the household, this may influence him/her being energy saving with many people around. We see a positive association between WFH satisfaction and energy consciousness

⁵The age of the head of the household is omitted from regressions as in cases of somebody in the age group of 62 years and above, there would be high correlation with the household age distribution consisting of young and/or older family members. We also believe that in general, the presence of young or old family members requires attention from the head of the household which in turn influences the dependent variables or their probabilities considered in this paper.

showing that holding other variables constant, enjoying WFH increases the energy consciousness score by 1.18 points on average. But neither the effect of gender nor choosing greener modes of transportation to go to work has any effect on energy consciousness. However, the decrease in the number of observations across the models is because of missing values and the F-tests show that the explanatory variables are all jointly significant.

Table 5 shows the logistic regression for WFH satisfaction as a function of demographic variables such as gender, education and family income and variables on presence of young and/or old family members, the sector of private sector employment, number of employees at work and distance to work. The reference categories for the explanatory variables can be clearly understood from tables 2 and 3. In interest of brevity, models 2 and 3 show the general fit of the models with respect to the previous model (Likelihood Ratio test) and we do not show whether addition of one more variable adds more explanatory power to the model. The fewer number of observations for successive models in table 5 shows the number of non-responses collected for a number of variables as is evident from tables 1, 2 and 3. The results confirm that controlling for other variables, a one percentage point increase in the level of education increases the probability of enjoying WFH over not enjoying WFH by about 80% in model 2. This result is significant at the 1% level. A similar result also holds for model 3 and it is significant. This fact is possibly related to higher levels of education usually being associated with jobs that are more sedentary in nature and thus allows WFH. This is again evident for jobs in the “Other” sector which are less sedentary in nature (see tables 2 and 3 for reference) relative to jobs in “ITCom” which decreases the probability of enjoying WFH by about 70% in models 3 and 4. Model 4 shows that addition of the distance to work variable to model 3 is necessary and the beta’s show expected results of a longer distance increasing the probability of enjoying WFH. However, we only see a significant result for a distance of greater than 20 km such that the probability increases by more than 3 times relative to a distance of less than 3 km holding other variables constant. Interestingly, the presence of young and/or older family members does not play any role in the probability of WFH satisfaction as would not be expected: young or older people may require more attention and thus may not be conducive for WFH. We also see that the effect of gender is insignificant. We can conclude that neither being Male nor having young or older family members has any statistically significant effect on the probability of enjoying WFH vs. not enjoying WFH. Looking at predicted probabilities, the probability for a male without young and/or old family members, working in the banking and financial services sector, with number of employees between 51-200, and a distance to work between 4 to 10 km to enjoy WFH is 63.3%. Likewise, the probability of enjoying WFH for a female without young and/or older family members and with the exact same profile in terms of work, the number of employees and distance to work is 68.9%. This shows that controlling for other factors, females might be happier working from home as compared to males.

Results in table 6 shows that age and family income are highly significant in terms of the association with choosing greener modes of transportation to go to work. While we see the odds-ratio for the intercept to be significant across all models for switching from 4W to 2W, it is not the case for switching from 2W to public transport. This is due to public transport being rarely used in Ahmedabad as in table 2. Interestingly, the effect of education is insignificant here as were the case earlier. While most other variables are significant, we see that the probability of choosing greener modes of transportation decreases. While being male decreases the probability by about 50% for all models, being in the age group 44-61 involves a smaller decline as compared to the age group 26-43 (over the reference group of 18-25). An increase in family income has an effect similar to education as seen in the table. We can however see that the head of the household working in larger size companies is between 3 to 4 times more likely to choose greener modes of transportation while a distance of 4 to 10 km makes him/her about 52% less likely to choose greener ways to go to work. This can again be verified from our results in table 2. In Ahmedabad as well as in other parts of India, companies with large number of employees are more likely to provide for office bus/staff bus or employees’ may also go for car pooling and this probably explains our result. Lastly, WFH satisfaction decreases the probability of choosing a greener mode of transport by 60% which may be due to the fact that people who enjoy WFH may not necessarily care much about their carbon emissions during the occasional workday at the office. Models 2, 3 and 4 show the general fit of the models with respect to the previous model and results show the explanatory power of the variables included in the model. The fewer number of observations for successive models in table 6 are due to the lack of observations evident from tables 1, 2 and 3.

Table 4: Energy consciousness

Dependent variable: <i>enercons</i>	Model1	Model2	Model3	Model4
<i>Intercept</i>	10.132 (59.39)***	8.957 (13.245)***	9.04 (12.44)***	8.606 (10.498)***
<i>male</i>		0.1337 (0.342)	0.245 (0.63)	0.351 (0.887)
<i>educ</i>		1.283 (4.094)***	1.328 (4.151)***	0.983 (2.956)***
<i>family income</i>		-0.513 (-1.66)*	-0.634 (-1.972)**	-0.51 (-1.542)
<i>hh with young and/or old</i>			-0.326 (-0.889)	-0.393 (-1.058)
<i>apt_{midrise}</i>			-0.093 (-0.201)	-0.144 (-0.305)
<i>apt_{highrise}</i>			0.403 (0.68)	0.529 (0.875)
<i>bungalow</i>			0.017 (0.033)	-0.271 (-0.515)
<i>rowhouse</i>			1.111 (1.378)	1.126 (1.359)
<i>WFH satisfaction</i>				1.178 (3.169)***
<i>transport_{2W}</i>				0.261 (0.595)
<i>transport_{pubtrans}</i>				-0.108 (-0.142)
	N= 400	N=329	N= 325	N= 304
		Adjusted R ² =0.043	Adjusted R ² =0.037	Adjusted R ² = 0.042
		F _{3,325} = 5.883 (p-val = 0.000)	F _{8,316} = 2.542 (p-val = 0.011)	F _{11,292} = 2.217 (p-val = 0.014)

*, **, *** significance levels at 10%, 5% and 1% respectively. t-stat in parentheses. Reference categories are being *female*, *households not having any young or older family members*, *apt_{lowrise}*, *not enjoying WFH*, and *transport_{4W}*. Check earlier tables 2 and 3.

5.2 Extensions

Results in the above tables 4, 5 and 6 makes us propose a model where energy consciousness and mode of transportation to go to work are jointly determined by the demographic factors of education, family income and age and other factors such as WFH satisfaction, the sector of employment, number of employees and distance to work. To tackle the problem of multivariate data analysis with one dependent variable being continuous while the other being categorical (Hair et al. (2006)), we first make energy consciousness a categorical variable (“least conscious”, “more or less conscious” and “most conscious”) and interact the two dependent variables. We then assign scores to the various categories of “least conscious” and “4W”, “more or less conscious” and “2W”, “most conscious” and “4W” etc., order the scores and perform an ordinal logistic regression. We arrive at 3 levels such that $score_0$ is least conscious and chooses 4W to go to work whereas the highest $score_3$ is most conscious and chooses public transport to go to work when necessary. A snapshot of the results are presented in table 7. The previous graphs show housing typology does not play a role in energy saving behaviour and that presence of children or older members in the family is also insignificant: we decide to include this latter variable in the combined model. Elangovan et al. (2021) mention the disruption faced by various employees in terms of managing work and household responsibilities and untimely eating habits and deWind et al. (2021) analyze the unequal access to WFH in terms of lack of workplace environment and call it Work-Home Interference (WHI) which may lead to fatigue and burnout. In our opinion, difficulties in managing household responsibilities and WHI are even greater with presence of children and older adults and thus the variable is included in the regressions. For the same reasons of some head of household being 62 years or older having a high correlation with the factor of presence of young and/or older members present in the family, we omit this age category (see footnote 5) from the regression considered for table 7.

Results in table 7 show that when energy consciousness and mode of transportation to work are determined jointly, the effect of a 1 percentage point increase in education is to increase the likelihood of making greener choices by about 50% in Model2, this effect goes away in Model3. While the effect

Table 5: WFH satisfaction

Dependent variable: wfh_{enj} odds-ratios	Model1	Model2	Model3	Model4
<i>Intercept</i>	1.321 (2.67)***	0.836 (-0.389)	1.455 (0.548)	1.221 (0.246)
<i>male</i>		0.843 (-0.636)	0.832 (-0.518)	0.778 (-0.685)
<i>educ</i>		1.802 (2.673)***	1.727 (1.849)*	1.61 (1.585)
<i>family income</i>		1.011 (0.054)	0.968 (-0.119)	0.959 (-0.153)
<i>hh with young and/or old</i>			1.572 (1.397)	1.589 (1.410)
<i>BankFinSer</i>			0.852 (-0.359)	0.83 (-0.413)
<i>EducR</i>			0.795 (-0.415)	0.773 (-0.458)
<i>Other</i>			0.295 (-3.033)***	0.282 (-3.069)***
<i>employees 51-200</i>			1.551 (1.215)	1.523 (1.158)
<i>employees > 200</i>			0.997 (-0.008)	0.808 (-0.472)
<i>4 to 10 km</i>				1.436 (0.658)
<i>11 to 20 km</i>				1.452 (0.620)
<i>more than 20+ km</i>				3.621 (1.615)**
	N= 376 McFadden R ² = 0.000	N=307 McFadden R ² =0.021 LR test statistic (χ_3) = 116.621 (p-val = 0.000)	N= 227 McFadden R ² = 0.084 LR test statistic (χ_3) = 132.4 (p-val = 0.000)	N= 226 McFadden R ² = 0.093 LR test statistic (χ_1) = 3.321 (p-val = 0.068)

***, ***, ** significance levels at 10%, 5% and 1% respectively. t-stat in parentheses. Reference categories are being *female*, *households not having any young or older family members*, private sector of *ITCom*, number of employees of ≤ 50 , and distance of less than 3 km. Check earlier tables 2 and 3.

of an increase in age and family income is similar to those found in table 6, the effect of the presence of young and/or older family members is likely to decrease the probability of making greener choices by around 30% in both models 2 and 3 and the results are significant at 10% level. Firms with a larger number of employees shows a significant increase in the probability of making greener choices and a distance of 4 to 10 km to work actually makes individuals choose less greener options. This is probably due to the effect of Ahmedabad having very few options of public transport and the overdependence on 4W as has been mentioned earlier. The t-statistics for EducR and Other show significance at close to 11% and the odds-ratios can be interpreted in the following way: heads of households employed at EducR with higher education may choose greener alternatives and be more energy conscious, people employed in sectors where WFH is not as desirable (see table 5) may not choose green options. This latter fact may be due to relatively less educated people being employed in such sectors and places to work being far away with no availability of public transport (see tables 2 and 3). Interestingly, the effect of WFH satisfaction has no effect on the probability of being more energy conscious or choosing greener modes of transport and the odds-ratio is also close to unity.

6 Discussion and Conclusions

This work investigates the association between Work from Home (WFH) and choices related to energy savings and modes of transportation in the city of Ahmedabad, Gujarat, India. We undertake a primary survey and ask respondents about choices made during the period of March 2020 to May 2021. Data is collected at a household level for our analysis and demographic information such as age, gender and education are collected to what pertains to the head of the household. The period under consideration was that of severe lockdowns and other government imposed restrictions in India on movements of people forcing many to WFH. Our survey does not cover individuals engaged in critical services for whom WFH was not possible. Going with the method of stratified random sampling, households were chosen randomly after non-consideration of households for whom the head of the household was employed in a critical sector.

Our analysis is carried out at a household level as some critical energy decisions such as household appliance usage, buying new appliances, purchasing groceries online are a collective decision. On the other hand, individual behaviours in a household such as turning off lights and fans when not in use,

Table 6: Modes of transportation

Dependent variable: <i>mode_{transpwg}</i> odds-ratios	Model1	Model2	Model3	Model4
<i>Intercept- 4W to 2W</i>	2.474 (8.161)***	0.064 (-4.994)***	0.0499 (-4.008)***	0.027 (-4.536)***
<i>Intercept- 2W to pubtrans</i>	18.8 (12.785)***	0.746 (-0.567)	0.697 (-0.501)	0.396 (-1.226)
<i>age26-43</i>		0.139 (-4.527)***	0.168 (-3.486)***	0.141 (-3.753)***
<i>age44-61</i>		0.086 (-6.015)***	0.104 (-4.596)***	0.082 (-4.943)***
<i>male</i>		0.506 (-2.432)***	0.564 (-1.91)**	0.556 (-1.921)**
<i>educ</i>		0.967 (-0.136)	0.986 (-0.053)	1.189 (0.631)
<i>family income</i>		0.507 (-3.143)***	0.509 (-2.751)***	0.474 (-2.911)***
<i>working adults ≥ 2</i>			0.781 (-0.857)	0.816 (-0.692)
<i>employees 51-200</i>			1.117 (0.319)	1.278 (0.683)
<i>employees > 200</i>			3.003 (2.759)***	3.387 (2.966)***
<i>4 to 10 km</i>			0.476 (-1.646)*	0.477 (-1.63)*
<i>11 to 20 km</i>			0.5797 (-1.095)	0.651 (-0.853)
<i>more than 20+ km</i>			0.58 (-0.855)	0.575 (-0.866)
<i>WFH satisfaction</i>				0.394 (-2.813)***
	N= 396 McFadden R ² = 0.000	N=321 McFadden R ² =0.146 LR test statistic (χ ₅) = 169.401 (p-val = 0.000)	N= 310 McFadden R ² = 0.174 LR test statistic (χ ₆) = 35.415 (p-val = 0.000)	N= 304 McFadden R ² = 0.191 LR test statistic (χ ₁) = 13.079 (p-val = 0.0003)

*** ** * significance levels at 10%, 5% and 1% respectively. t-stat in parentheses.
Reference categories are *age18-25*, being *female*, *working adults in family = 1*, number of employees of ≤ 50 , distance of *less than 3 km* and *not enjoying WFH*. Check earlier tables 2 and 3.

loading the washing machine until full etc. would typically be overseen by the head of the household. Marrying this with WFH satisfaction and the likelihood of continuing WFH, we disaggregate our broader research question into smaller questions. We find that continuing with WFH in future (or at least being flexible with working at home or at office) is mostly associated with enjoying WFH. But WFH satisfaction or the preference for continuing WFH is equally distributed across people living in low-rise to high-rise apartments and bungalows and rowhouses. Continuing with buying online groceries in future is highly associated with having bought groceries online during the period of March 2020 to May 2021. However, while modelling energy consciousness, WFH satisfaction and making greener choices in terms of transportation to go to work, we find in general:

- Education being positively associated with being more energy conscious
- Rise in education increasing the likelihood of WFH satisfaction
- Family income being negatively associated with energy consciousness
- Rise in family income decreasing the likelihood of being energy conscious and choosing greener modes of transportation to work
- Males less likely to choose greener modes of transportation compared to females
- Individuals in the age groups of 26 - 43 and 44- 61 are less likely to choose greener modes of transportation
- WFH satisfaction positively associated with energy consciousness
- WFH satisfaction decreasing the likelihood of choosing greener modes of transportation to go to work
- Working at firms with employees greater than 200 in number significantly increases the likelihood of choosing greener modes of transportation to work

Table 7: Combined energy consciousness and modes of transportation scores

Dependent variable: combined score of <i>enercons</i> and <i>modetranspwg</i>			
odds-ratios	Model1	Model2	Model3
<i>Intercept- score₀ to score₁</i>	0.042 (-12.412)***	0.004 (-10.181)***	0.001 (-7.404)***
<i>Intercept- score₁ to score₂</i>	1.276 (2.406)**	0.147 (-4.105)***	0.059 (-3.468)***
<i>Intercept- score₂ to score₃</i>	8.9 (13.109)***	1.213 (0.435)	0.678 (-0.495)***
<i>age26-43</i>		0.175 (-4.165)***	0.256 (-2.531)***
<i>age44-61</i>		0.137 (-5.113)***	0.1997 (-3.051)***
<i>hh with young and/or old</i>		0.691 (-1.59)*	0.664 (-1.374)*
<i>educ</i>		1.497 (1.95)*	0.943 (-0.214)
<i>family income</i>		0.546 (-3.073)***	0.509 (-2.556)***
<i>BankFinSer</i>			0.704 (-0.883)
<i>EducR</i>			2.134 (1.566)
<i>Other</i>			0.627 (-1.185)
<i>employees 51-200</i>			2.348 (2.54)**
<i>employees > 200</i>			6.923 (4.329)***
<i>4 to 10 km</i>			0.377 (-1.878)**
<i>11 to 20 km</i>			0.584 (-0.974)
<i>more than 20+ km</i>			0.336 (-1.542)*
<i>WFH satisfaction</i>			0.935 (-0.215)
	N= 396 McFadden R ² = 0.000	N=322 McFadden R ² =0.075 LR test statistic (χ_6) = 215.502 (p-val = 0.000)	N= 225 McFadden R ² = 0.163 LR test statistic (χ_9) = 227.095 (p-val = 0.000)

*** ** * significance levels at 10%, 5% and 1% respectively. t-stat in parentheses. Reference categories are *age18-25*, *households not having any young or older family members*, *private sector of ITCom*, *number of employees of ≤ 50* , *distance of less than 3 km* and *not enjoying WFH*. Check earlier tables 2 and 3.

- Distance of 4 to 10 km to office significantly decreases the likelihood of choosing greener modes of transportation to work
- Jobs that are less sedentary in nature such as those in Manufacturing and Construction, Textiles, Automobile, Real Estate, Oil & Gas and Energy, Pharma, Chemical, Logistics and Transportation, Retail and Sales and Food Processing are significantly less likely to enjoy WFH as compared to more sedentary jobs in IT, Communications, Banking and Financial Services and the Education sector
- Presence of young and/or older family members (0-9 years and/or 61 years and above) somewhat reduces the likelihood of being energy conscious and choosing greener modes of transportation

We can conclude that while education is definitely a factor positively influencing energy consciousness and the probability to enjoy WFH, the points about rise in family income negatively associated with energy consciousness and choosing relatively more polluting modes of transportation to work are puzzling. Based on the last point about the presence of young and/or older household members, there are distractions in the house and turning off lights and fans when not in use, turning off AC when not in use and practising other energy conscious behaviours may not always be feasible. We also hypothesize that rise in family income may be associated with larger houses such as bungalows and rowhouses, and alongwith a larger family consisting of young and/or older people, this may again be associated with being less energy conscious. The fact that males and older adults are less likely to choose greener modes of transportation to work can be considered a limitation of the paper. About 75% of the sample consist of males and about 90% of the sample consist of individuals above 25 years of age. In addition, about 60% of the respondents are going to office within a distance of 4 to 10 km. The limitation of the work is in the fact that while individuals in the age group of 18 - 25 years of age may be students, they are less likely to own a private transport and individuals in the age groups of 26 - 43 and 44 - 61 who are predominantly male in the sample are choosing their own 4W vehicles (petrol/diesel) to go to

work which is at a distance of less than 10 km. Our results for the paper hinge on the fact that WFH satisfaction is positively associated with being energy conscious and our reason for being less likely to choose greener modes of transportation would just be not caring as enough on the occasional one-day at work. The result for less sedentary jobs not liking WFH as much is self explanatory. However, an interesting result is that larger size firms has employees being more likely to choose greener modes of transportation to go to work: from our sample we see that some of these companies provide for office buses and staff buses which would again significantly reduce the carbon footprint from driving a personal vehicle. Heads of households working at larger sized firms and also located at a distance of more than 20 km may also engage in car pooling.

Some suggested policy recommendations would be to introduce city buses serving populations commuting within 10 km of distance to work. Secondly, some of the jobs in IT, Communications, Banking and Financial Services sector and Education and Research sectors can be permanently moved online or be made completely flexible for practicing WFH when needed. Finally, education and spreading awareness about choosing greener options to go to work such as biking, car pooling and public transport needs to continued in future. Ahmedabad, Gujarat is a city with a not so well connected and efficient public transport system. In addition, moving jobs online may have unintended consequences on the engagement of the employee and his/her long term productivity thereby increasing a firm's cost. These are broad questions to answer and we need further research to come up with a desirable solution.

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