Work from Home – How Good is it for the Environment?

Anna Agarwal
Visiting Fellow, Centre for Policy Research

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ABSTRACT

The COVID-19 pandemic led to a large-scale global experiment on work from home (WFH). WFH is expected to continue, albeit at a smaller scale, in the post-pandemic world. WFH is commonly considered to be an energy saving measure that can help reduce office travel related energy demand and energy use in offices. This article presents a framework to analyze the various direct and indirect energy use changes that WFH can potentially induce. We discuss the different long-term structural and behavioral changes from WFH, which will ultimately define energy consumption patterns. We conclude the energy savings and the related environmental impacts are ambiguous. An illustrative analysis has been performed to quantify the direct air quality impacts of work from home adoption in the Delhi region. The results show modest reductions in the levels of PM2.5 emissions, and point to the underlying uncertainties that have the potential to highly amplify or diminish the environmental benefits. The article highlights the need for in-depth multi-sectoral study of the various WFH related energy use changes over both the short- and the long-term. Such an assessment will be key to designing effective policy measures to support work from home as an environmentally beneficial practice.

ABOUT THE AUTHOR

Anna Agarwal is a Visiting Fellow at the Centre for Policy Research. Her research is on understanding India's energy demand transitions, and identifying ways to lock-in low-carbon energy consumption patterns for the long-term. Contact her at annaagarwal@gmail.com.

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1. Introduction

Work from home promises to be one of the most prominent and permanent lifestyle changes brought about by the COVID-19 pandemic. Work from home (WFH) or remote working was gaining worldwide popularity even before the pandemic because of potential business, social and environmental benefits. The pandemic has forced people to practice WFH at an unprecedented scale and pace. Many positives have emerged from this massive global experiment. These include possible work-life-balance benefits while at the same time keeping up the work productivity. Businesses have made enormous investments in digital infrastructure and reformed business processes to enable successful remote working. There seems to be a growing consensus that WFH will be the new normal even in a post-COVID world (Shinde and Alawadhi 2021, Mitchell 2021).

Work from home is commonly considered to be an energy saving and environmentally friendly work practice. The primary energy savings are expected in the transportation sector with the reduced need for work commute. The U.S. Environmental Protection Agency (EPA) has been promoting WFH for decades, and considers it as "one of the most effective transportation demand management (TDM) emissions reductions measures" (US EPA 2001). In India, WFH seems to be a particularly promising intervention as transportation related energy demand is growing very rapidly, with a large part of the increase being driven by private vehicle ownership (S. Sharma and Kumar 2016). The environmental gains can be potentially significant, as transportation makes up 13% of energy related CO_2 emissions (IEA 2020), and in Delhi, vehicles contribute to about 25% of the $PM_{2.5}$ emissions during winters when $PM_{2.5}$ levels are most severe (M. Sharma and Dikshit 2016). Also, since transportation is a major oil consuming sector, a dent in travel energy demand can lower India's reliance on imported oil.

WFH has the potential to alter energy consumption in not just transportation but multiple other energy demand sectors. For example, commercial energy use may come down if more people work from home which in turn may increase residential energy use. WFH can indirectly impact energy use by changing the way people behave. For instance, remote workers may use the time saved from work commute to do more personal travel. Studies conducted in other countries show that when various direct and indirect energy use changes are accounted for, the energy savings from WFH can be ambiguous and in some cases even lead to increased energy consumption (Hook et al. 2020).

The objective of this article is to emphasize the need for a thorough India-centric assessment of the various energy use changes across the different energy demand sectors before drawing conclusive claims on the WFH-related energy and environmental benefits. While the focus of this article is on WFH by the Indian workforce, the broader discussion will be salient to other economic and social activities that are increasingly moving online, for example, online grocery deliveries, remote doctor consultations and online education.

The article outlines the different WFH-related energy changes, and presents a framework to quantify the related environmental benefits with widespread adoption of WFH. Illustrative calculations are done to estimate the direct $PM_{2.5}$ emissions avoided from a fewer number of on-road private vehicles if WFH were to be adopted more widely across the Delhi region. The estimated emission reductions provide an approximation of the direct emissions avoided under a set of simplifying assumptions. The article talks about the underlying uncertainties that make it hard to quantify and ascertain whether and to what extent WFH will lead to reduced energy use and improved environmental quality.

The article aims to stress the need for an informed discussion and assessment of the energy and environmental impacts of WFH. This requires a better understanding of the short-term effects and the long-term structural and behavioral changes that WFH may induce, and availability of empirical data needed to model the multi-sectoral impacts.

The article is organized in the following manner:

Section 2 outlines the different WFH-related energy changes, and discusses the different factors that will influence the magnitude and longevity of the energy consumption trends.

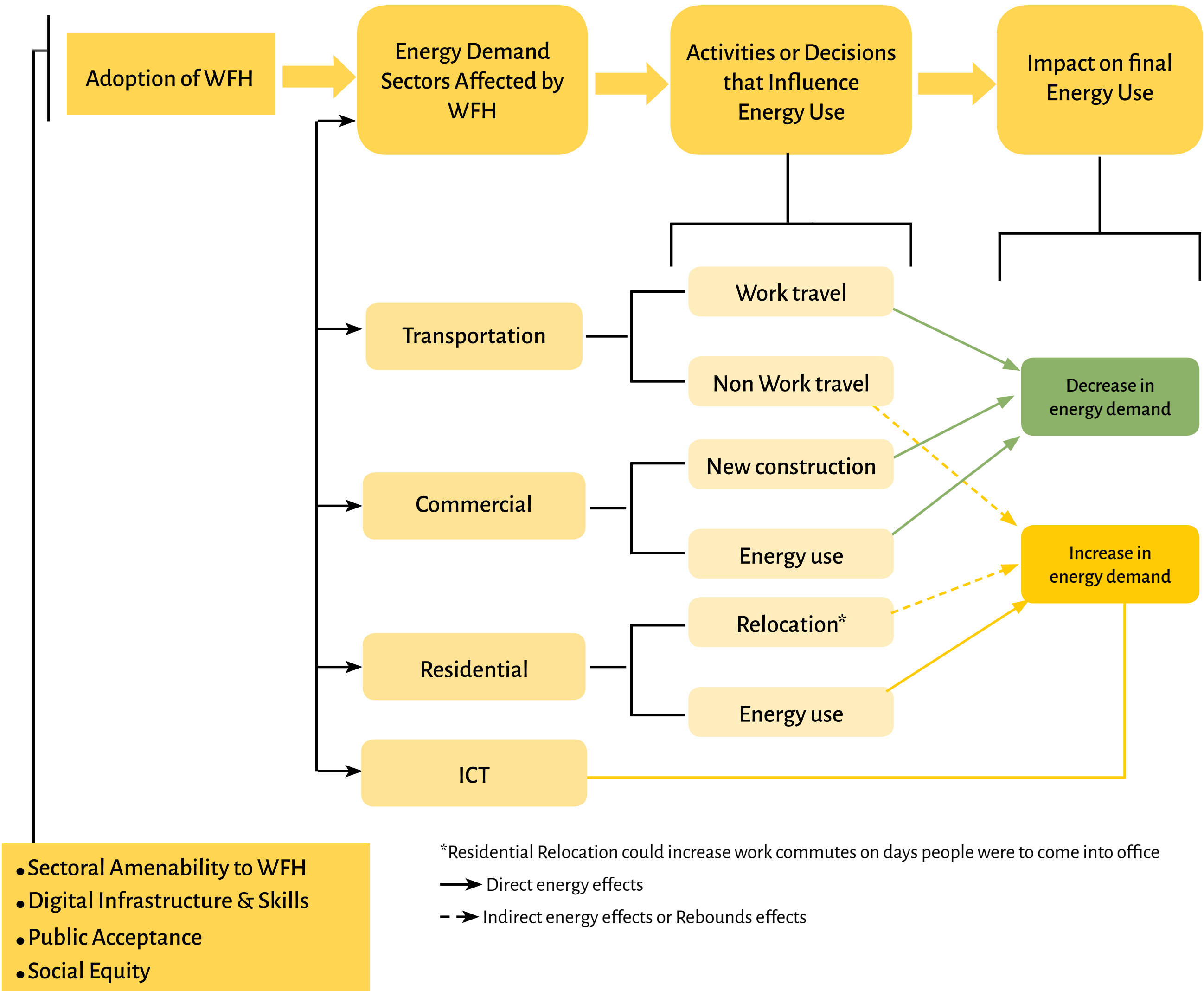
Section 3 presents a framework to quantify the environmental benefits from WFH. The $PM_{2.5}$ emission reductions are calculated with a focus on assessing the impact of reduced office travel via private vehicles on the levels of $PM_{2.5}$ emissions in the Delhi region. A discussion follows on the limitations of the presented analysis, and the key uncertainties which though hard to model dictate the environmental outcomes.

Section 4 concludes with key takeaway messages.

2. Various complex interlinked factors determine the energy changes from WFH

How large (if any) are the energy savings if more Indian businesses and organizations were to permanently move their employees to work from home? The answer to this question is not straightforward. Figure 1 presents the different WFH induced energy demand changes including both the direct and indirect effects. These energy demand changes are discussed later in this section. The magnitude of changes in energy consumption will depend on the scale at which WFH is adopted across the Indian workforce. Factors which will influence WFH adoption are listed in Figure 1 and discussed in subsequent paragraphs.

Figure 1: Changes in Energy Use from Work from Home



2.1 Adoption of WFH

The scale at which WFH is adopted across the country would be a key determinant of the magnitude and trend of energy changes. Amidst COVID-19 related health concerns, for much of 2020 a large part of the Indian workforce, particularly in sectors with heavy digitization, has been working from home. Companies have made massive investments in the past few months to enable their employees to work remotely (Sangani and Chandrashekhar 2020). The industry will want to reap the benefits of these investments in the long-run by moving part of their workforce WFH, particularly in sectors where WFH has resulted in high productivity with lower operational costs.

Three key factors would determine the post-COVID long-run share of remote workers in India:

1. Sectoral Amenability to WFH

Post-COVID, one may see a full range of responses, from sectors switching completely back to regular office working, to those choosing hybrid models, to some shifting to near-complete work-from-home. Core digital sectors such as the IT industry, and fast digitizing sectors such as banking and financial services may continue to see a heavy share of remote workers. IT industry leaders such as TCS have remarked that they will take 75% of their workforce work from home by 2025 (Khetrapal 2020). The current crisis has forced people to rapidly experiment, innovate and adapt to digital applications and technologies, even in sectors where traditionally physical presence was considered essential, such as education, healthcare, and the judiciary. However, sectors such as construction, manufacturing, where physical presence is important, may see near-zero WFH.

The proportion of Indian workforce that may work from home may not be as high as in countries like U.S. because of the heavy share of agriculture-based employment, and low levels of automation and digitization in the Indian economy.

2. Digital Infrastructure and Digital Skills

To enable large-scale WFH requires uninterrupted and equitable access to IT infrastructure and high-speed internet, and at the same time focus on imparting digital skills to our workforce. About 600 million Indians (50% of population) have internet subscriptions, and close to 30% of people have smartphones (MGI 2019). These numbers, though currently modest, are expected to grow substantially in the coming years, and show that this requirement of WFH at scale may well be met.

3. Public Acceptance and Social Equity Issues

Policy makers and organizations would (and should) carefully consider the societal pros and cons of WFH and ensure that its adoption does not further aggravate social evils and increase inequalities. WFH offers the possibility of a better work life balance, and opens up work opportunities for women who otherwise might not take up work for the need to be at home. On the flip side, there have been increased incidences of domestic violence during the lockdown period (Anjali and Ranganathan 2020), and gendered nature of access to phones, computers and internet limits remote working possibilities for women (Barboni et al. 2018).

Remote education and healthcare offer opportunities to expand good quality access to parts of the country that are currently underserved. But, a prerequisite to tap into these opportunities will be access to digital infrastructure and digital skills, both of which are inadequate amongst the urban poor and across rural India, but growing fast. WFH at scale could possibly increase the gaps between the 'haves' and the 'have-nots' if not implemented in a considerate manner.

2.2 Energy Impacts

Work from home has the potential to affect multiple energy demand sectors: transportation, commercial and residential buildings and energy demand for information communication technologies (ICT). As seen from Figure 1, the decisions and actions taken by people and organizations will determine whether WFH will lead to decrease in energy consumption or would the energy consumption go up. Next, the different energy use changes that may be induced by WFH are discussed.

Transportation Demand

The primary energy savings from WFH are expected to be in the transportation sector. This can be particularly significant as India's transportation related energy demand is projected to rise rapidly in the coming decades, with its share in total energy demand to increase to over 30% by 2051 from 17% in 2017 (S. Sharma and Kumar 2016).

- A direct effect of WFH is reduction in work related travel. Fewer daily office commutes, and move to virtual meetings and video conferences will cut down travel demand.

- However, WFH could lead to increased personal travel which can undermine the energy savings (an indirect or rebound effect). People save time from avoiding long office commutes, and could use this time to do more leisure trips. Reduced car use for work purposes may lead to higher car usage for non-work commute by other household members (Kim, Choo, and Mokhtarian 2015).

Commercial Energy Use and Demand for New Buildings

- WFH reduces the need for office spaces and leads to energy savings from reduced need for lighting, heating, cooling and other energy-intensive services.

- The resulting reduced demand for office spaces can alter India's commercial buildings' demand trajectory which is poised to witness a dramatic increase with tripling of the commercial floor area in the next two decades (MoEFCC 2019).

Residential Relocation and Energy Use

- As more people work from home, it is quite likely that residential energy consumption will increase. People will buy more appliances such as coolers and ACs to be comfortable and productive while working from home. Also increased use of work-related equipment such as laptops and printers at home would add to residential energy consumption.

- Higher adoption of WFH might lead people to live further away from the metros and city centers (a rebound effect) (Hook et al. 2020). This decision might further be reinforced by lower property prices and better air quality in smaller towns, and the option of being closer to family. Relocation of homes could mean:

- A longer office commute on days people work from office can potentially undermine the reduced commute on days they don't.

- Such decisions will determine where the new homes get built and how the urban spaces develop in the coming years. Movement into the peripheral areas could decongest the city centers and might improve the air quality, but would this be at the cost of increasing pollution levels in the peripheral areas? The environmental benefits are unclear, and potential changes in urbanization patterns need to be closely watched for.

Energy Demand for Information & Communication Technologies (ICT)

WFH is expected to increase the amount of digital content streaming, and thus will increase the energy demand from ICT services. A survey conducted in India during the COVID-19 lockdown period found 30% increase in internet data consumption, and large part of this was driven by video calls and video streaming by remote workers (Singhal 2020). Globally, energy demand for ICT is poised to dramatically increase in the coming years (Jones 2018), and WFH could accelerate the growth in demand.

The energy consumption patterns that emerge from WFH depend on many complex interlinked factors as discussed above. It is hard to predict how humans, organizations, institutions and the society will respond to the prospect of remote working. The unclear patterns of energy use that will emerge from WFH make it hard to ascertain the environmental impacts.
The next section presents a framework to quantify the environmental impacts of WFH. The focus of the analysis is on assessing the reductions in PM2.5 emissions in the Delhi region from cut down daily work commute by private vehicles.

3. A Framework to Quantify Impact of WFH on Energy Use and Air Quality

This section presents a framework to quantitatively assess the air quality benefits from adoption of WFH. For the purpose of the analysis, the focus is on:

- Reductions in daily **office commute:** as this potentially is the dominant source of direct energy & environmental benefits from WFH.
- Adoption of WFH across the **Delhi region :** Across Indian cities, Delhi has a relatively larger share of technology & knowledge sector jobs, the highest number of registered vehicles, and is one of the most polluted cities in the country. Thus, the environmental benefits from WFH could be substantial in Delhi.
- Reduced trips of **private vehicles** including four-wheelers (4W) and two-wheelers (2W): Reduction in commute by people who carpool or use public transportation is not considered, because of the difficulty in estimating if and by how much would such shared trips come down, and would depend on the scale of WFH.
- Reductions in levels of **PM2.5 emissions:** because of the significant health impacts of PM2.5 emissions

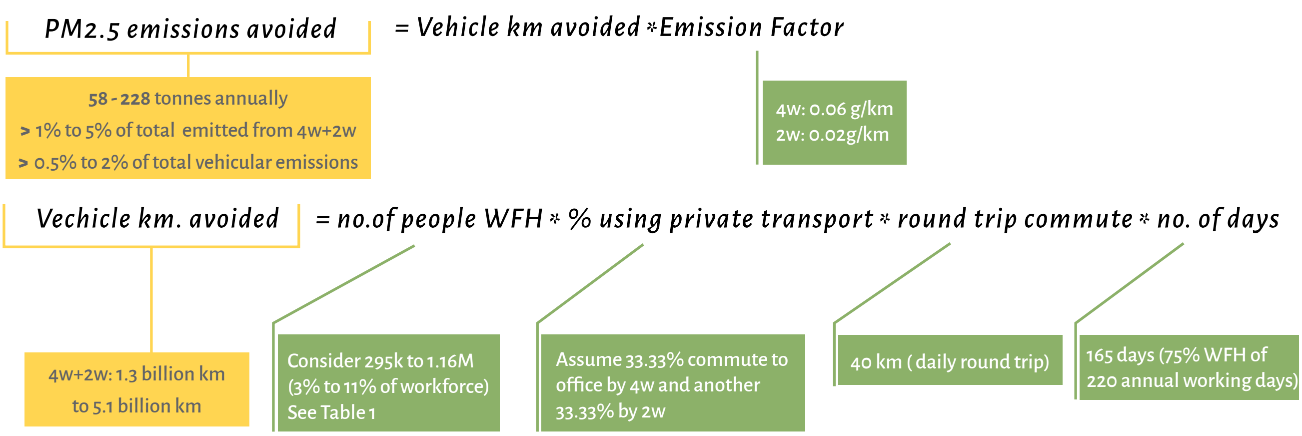
The method and assumptions made to estimate the reductions vehicle kilometers travelled and corresponding PM2.5 emissions avoided are presented in Figure 2.

As seen from Figure 2, **WFH may help avoid** 1.3 billion km to 5.1 billion vehicle km travelled annually in Delhi. The **PM2.5 emissions avoided annually range from 1.3% to 5.1% of the total PM2.5 emitted by 4W (four-wheelers) and 2W (two-wheelers), and 0.5% to 1.9% of total PM2.5 emitted by the entire vehicular fleet in the Delhi region.**

By way of comparison, the Delhi Government's Odd-Even pilot program that was intended to reduce the number of cars on road by about 50% saw modest reductions in PM2.5, with some studies reporting near zero or undetectable reductions to others estimating about 13% reductions (Chowdhury et al. 2017; Greenstone et al. 2017; Mohan et al. 2017). Since, the Delhi/NCR air pollution problem is caused by multiple pollution sources (M. Sharma and Dikshit 2016), any intervention focused on a single source of pollution will tend to have a limited effect on overall pollution levels.

Moreover, before assessing the significance of these estimates, it is important to keep two further factors in mind. First, the estimates of impact of WFH on PM2.5 are sensitive to the choice of input assumptions. And second, there are various indirect effects, including structural and behavioral changes over the long-term that are hard to account for in the simple quantitative assessment carried out here. The next two sections discuss these complex factors and their implications for the estimates provided here.

Figure 2: Illustrative Calculations of PM2.5 Emissions Avoided from Reduced Office Commute



3.1 Inputs and Sensitivity Analysis

As discussed above and summarized in Figure 2, vehicle kilometers avoided and PM2.5 emission reductions depend on various factors including number of people working from home, mode of travel, commuting distance avoided, fuel efficiency, and vehicle emission factors. The key inputs, and sensitivity of the estimated PM2.5 emission reductions to the input values are discussed next.

Workforce WFH: Assumptions on the proportion of workforce that may WFH is one of the key sources of uncertainties around expected PM2.5 emission reductions. Based on the Periodic Labor Force Survey 2017-18 (National Statistical Office 2019), the different sectors are categorized into three tiers depending on presumed amenability to WFH and 3% to 11% of the entire Delhi's workforce is considered to WFH (see Table 1). The tier-wise ranking of different industry sectors and the share of workforce that may WFH in different tiers, closely follows the approach by Dingel and Neiman (2020)[3].

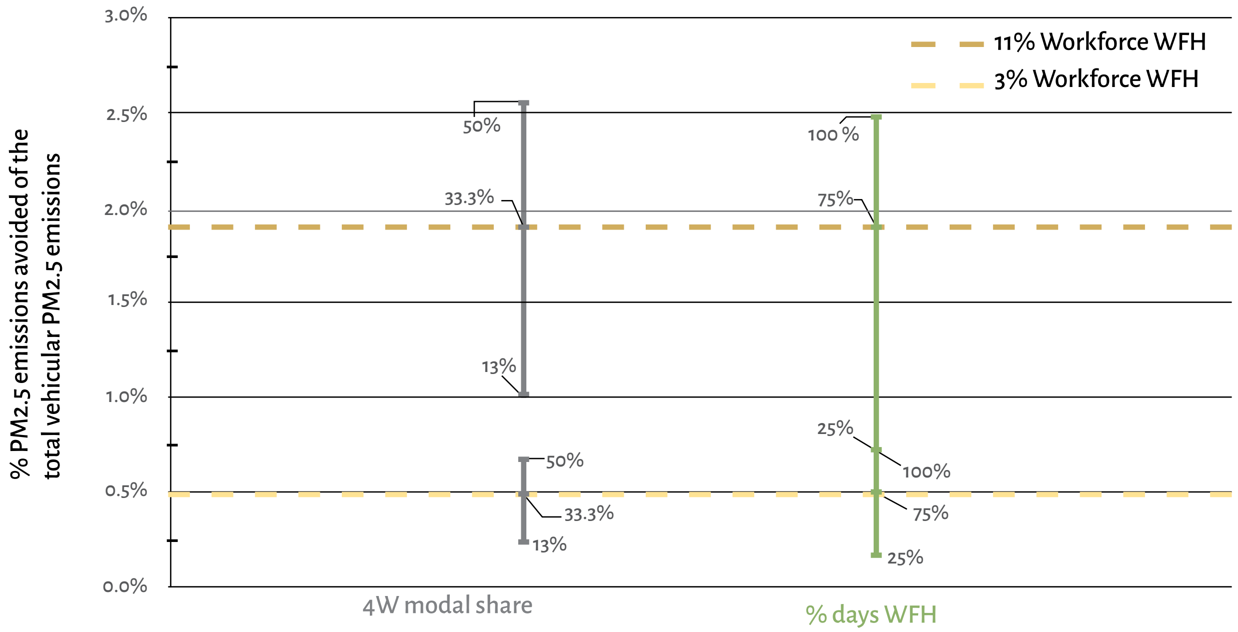
Table 1 : Estimates for Delhi's workforce that may WFH

Tiers (in order of WFH amenability)	Sectors Included	Total Workforce in Delhi Region	% of workforce that can WFH
Tier 1	• Information and communication • Financial and insurance activites • Professional, scientific and technical activities	788,564	Low scenario: 20% High scenario: 60%
Tier 2	• Wholesale and retail trade • Real estate activities • Public administration and defence • Education	2,745,099	Low scenario: 5% High scenario: 25%
Tier 3	Rest of the workforcw including Construction, Manufacturing, Health	6,988,112	nil
Total workforce		10,521,775	High scenario: 11% High (Tier 1)- Low (Tier 2) scenario: 6% Low scenario: 3%

Mode of travel: Only changes in work travel by people who commute by private transportation (4W and 2W) are accounted for. It is assumed that a third of the people (33.33%) who may WFH travel by 4W, a third travel by 2W (33.33%), and the remaining third use other means of transportation like buses, metro (33.33%)[4].

Figure 3 presents sensitivity analysis showing how input assumptions around mode of travel affect the estimated PM2.5 emission reductions. If the modal share of four-wheelers amongst the WFH population was lower (13% - same as Census 2011), or much higher (50%), then the estimated reductions in PM2.5 emissions would range from 0.3%- 2.6% of the total PM2.5 vehicular emissions depending on the number of people working from home. Note, that the sensitivity analysis does not vary the total number of in-use cars in the Delhi region thus keeping fleet level PM2.5 emissions the same.

Figure3: Sensitivity of PM2.5 emission reductions to the proportion of workforce that may WFH, the modal share of 4Ws and % days people may WFH



Commuting distance: An average daily 40km round trip commute is considered (ET Bureau 2019), implying that regular work commute accounts for about 70% of the annual mileage of private vehicles in Delhi (see Table 2 for annual mileage numbers for 4W and 2W). Sensitivity analysis is not done for the commuting distance as a change in work commuting patterns may affect the overall transportation patterns including the fleet level mileage, making it hard to isolate the impact of WFH within our analysis framework.

Number of days WFH: The calculations of emission savings in Figure 2 account for a blended WFH model wherein people work remote for 75% of the time and go into office on 25% of the working days. Figure 3 shows that if assumptions on the blended WFH model were varied, and people were to WFH for only quarter of the time (25% WFH), or on the flip side, permanently shift to WFH (100% WFH), then the PM2.5 emission reductions will range from 0.2% to 2.5% depending on how many people are WFH.

Emission Factors: An average PM2.5 emission factor is calculated for all 4W by dividing the total PM2.5 emissions from 4W in 2020 by the total annual mileage of cars and taxis weighted by their fleet share (Goel and Guttikunda 2015b). The PM2.5 emission factor for 2W is calculated in a similar manner by dividing total emissions from 2Ws by total annual mileage. Emission factors are presented in Table 2. Sensitivity of the PM2.5 emission reductions to emission factors has not been analyzed because a change in emission factors affects the entire fleet level emissions, thus potentially having an insignificant effect on the share of emission reductions from WFH.

Table2 : Key Inputs and Estimated Values of PM2.5 Emission Factors for 4W and 2W (Inputs [1] to [9] are from Goel and Guttikunda (2015b)

Some key Inputs and Values for PM2.5 Emission Factors		
Total PM2.5 from 4W inc. taxi (tons in 2020)	[1]	2,870
Total PM2.5 from 2W (tons in 2020)	[2]	1,590
Total PM2.5 from entire vehicle fleet (tons in 2020)	[3]	12,280
Annual mileage of 4W	[4]	12,483
Annual mileage of taxis	[5]	36,929
Anuual mieage of 2W	[6]	12,377
Total number of in use 4W	[7]	3,245,002
Total number of in use taxi	[8]	63,564
Total number of in use 2W	[9]	5,735,885
1 ton to gram	[10]	907,185
Calculated PM2.5 Emission Factors		
PM2.5 emission factor for 4W inc. taxi (gm/km)	([1]*[10])/([4]*[7]+[5]*[8])	0.06
PM2.5 emission factor for 2W (gm/km)	([2]*[10]/([6]*[9])	0.02

3.2 Uncertainties over Emission Estimates

The estimated PM2.5 emission reductions (Figure 2) and their sensitivity to input assumptions (Figure 3) illustrate only the direct environment impacts of WFH. However, there are various uncertainties (not accounted for in the calculations) that make it very hard to estimate the energy and environmental impacts of WFH, and which if accounted for might lead to significantly higher (or even lower) emissions avoided.

Some key factors that could lead to substantial changes in estimated emission savings include:

Emissions Accounting

- PM2.5 emissions reductions maybe underestimated when just accounting for vehicle exhaust emissions. Fewer on-road vehicles can contribute to lesser PM2.5 emissions from improving the overall levels of congestion, and lowering the resuspension of road dust.

- Lower traffic congestion means less idling and faster travel times for remaining vehicles on the road, resulting in better fuel efficiency and emission factors. Goel and Guttikunda (2015a) estimate that cars in Delhi spend 24% of total travel time idling, and over 250,000 litres of fuel is spent annually by cars just for idling.

- Lower resuspension of dust can be a major contributor to lowering the levels of PM2.5. Chowdhury et al. (2017) point out that if we halve the number of cars on-road in Delhi, PM2.5 emission reductions from road dust resuspension can be 32 times more than PM2.5 reductions from tail pipe.

- Other Air Pollutants & GHG Emissions: PM2.5 emissions are one of the many harmful air pollutants emitted from vehicles, others being NOx, VOCs, and CO emissions. In fact, 4W and 2W together contribute to about 80% of the transport related CO emissions. Further, 4W and 2W make up for 65% of the total CO_2 emissions from all vehicles. Similarly, vehicular exhaust is a major contributor of NOx, and reduced NOx emissions would also lead to reduced formation of secondary PM2.5. Thus, just accounting for PM2.5 reductions would inadequately represent the environmental benefits from WFH.

Future of Transportation

- The private vehicle ownership (includes cars and two-wheelers) in India is expected to rise to 461 per 1,000 people by 2051 (~1 vehicle for every 2 people) from 75 per 1,000 in 2011 (S. Sharma and Kumar 2016). If WFH can reduce the need to own a private vehicle and curtail some of the future growth, then the long-run impacts of WFH on reduced private travel related energy demand can be substantial.

- WFH will lead to higher energy savings in places where more people travel by personal vehicles compared to using public transport. Access to quality public transportation may incentivize people to use public transportation for work commutes, in which case energy savings from WFH will not be very large.

- WFH and general increased demand for online services has the potential to alter multiple sectors of transportation apart from private transport. For example, demand for last mile deliveries of food and non-food related items and services spiked during the pandemic (Deloitte 2020; Thaker and Tripathi 2020), and has the potential to dilute the environmental benefits of reduced work commute (ETAuto 2020)

Future Homes

- Where people choose to live and how far they are from their place of work would determine the distance they commute on days they go to office. As discussed earlier, there is evidence that WFH leads to people moving further away from their place of work, and thus may dilute the energy savings and environmental benefits.

Future of Work

- Future job trends favor larger adoption of WFH amongst the Indian workforce. The rapid pace of digitalization and automation, accompanied by technological innovation and adoption, have the potential to define the future of work and work places in India. In the coming years, the technology and knowledge sectors are expected to be key drivers of new job opportunities particularly in urban India (BCG and CII 2017; NASSCOM, FICCI, and EY 2017). These trends could expand the scope, and impact of WFH.

3. Conclusions

COVID-19 has brought about a large-scale experiment in work from home. WFH is poised to be a more permanent practice, particularly in sectors with strong and growing digital penetration such as information technology and financial services. Other sectors such as healthcare, education, retail have also seen a ramp up of online services, some of which are also expected to continue in a post-COVID world. WFH is commonly considered environmentally beneficial primarily because of the implicit reduction in office commute. The new trend of virtual meetings and conferences can further help cut down work travel. Another area WFH can help reduce energy demand is the commercial sector by limiting the need for new office buildings and at the same time reducing the energy use in existing spaces. However, WFH may induce increase in energy demand by households and drive energy use for ICT services.

Energy consumption patterns that will emerge depend on many complex interlinked factors which are very context dependent. Factors such as industry's willingness and readiness, and levels of digital access and digital literacy will determine the extent to which WFH is adopted and hence the magnitude of energy changes. The trend and longevity of the energy changes will be shaped by the decisions people take in response to WFH. Indirect effects including rebound effects on travel behavior and decisions on residential location could lead to an increase in the overall energy demand.

This article lays out a framework to quantitatively assess the energy and environmental outcomes from WFH. To illustrate, a sensitivity analysis is done to estimate the direct PM2.5 emission reductions for different levels of adoption of WFH in Delhi. It is estimated that 0.5% to 1.9% of total PM2.5 emitted by the entire vehicular fleet in the Delhi region could be avoided if 3% to 11% of the Delhi's workforce were to WFH. Sensitivity analysis on other key inputs: modal share of cars in WFH population and number of days people WFH (part time vs. full time), shows that the range of PM2.5 emission reductions could vary from 0.2% to 2.6% of the total PM2.5 emitted by all vehicles.

These illustrative calculations aim to highlight the difficulties in accurately estimating the emission reductions in both the short- and the long-term. The estimated emission reductions only account for the direct tail-pipe emission reductions. The emission reductions would be much higher if second-order effects like lower levels of road dust resuspension were also accounted for. Long-term structural and behavioral changes, not included in these calculations, would also shape the emission trajectory. For example, WFH has the potential to lower the demand for private vehicles, but on the flip side, it can lead to increase in demand for other modes of transport linked to last mile deliveries. Lack of empirical data on the key uncertainties and drivers makes it hard to accurately assess the emission reductions.

There is an urgent need for India-centric studies that examine the energy and environmental implications of WFH with a multi-sectoral approach. Such studies would account for different direct and indirect energy impacts of remote working and increased use of online services, and how these would change in different socio-economic contexts. A careful assessment of the key uncertainties and the emerging energy patterns can help design effective policy interventions to support WFH as an environmentally beneficial practice.

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End Note

1 Rebound effects refer to the unintended consequences of an energy conservation measure (in this case WFH) that leads to increase in energy use thereby reducing the intended energy savings

2 Delhi region in this article includes the National Capital Territory of Delhi (NCT) and neighboring districts of Gurugram, Faridabad and Gautam Buddh Nagar

3 Dingel and Neiman (2020) rank the different sectors in the US economy by their amenability to WFH and evaluate the upper bound on the fraction of remote workers for each of the sectors. Our tier-wise classification closely resembles the ranking in their paper, with the exception of Education which they rank as the sector with the highest WFH amenability, but considering the low levels of digitalization in India we include Education in Tier 2. The upper bounds on WFH by tier given in Table 1 are close to the minimum of WFH shares (as evaluated by Dingel and Neiman (2020)) across the sectors included in that tier. The lower bounds on WFH in Tier 1 and 2, and zero WFH in Tier 3 are an assumption.

4 As per Census 2011, 13% of work trips in Delhi are by car, 17% by two-wheelers, 26% by bus, 4% by trains, and over 37% of trips are by walking or bicycle (Tiwari and Nishant 2018). For the analysis, higher modal shares of 4W and 2W are considered for the following reason: The people who work in the technology and knowledge sectors (sectors amenable to WFH) tend to have higher incomes, thus more likely to use personal transportation to work and less likely to travel by bus or bicycle.

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