The effect of working from home on commuting time: Evidence for Portugal using worker microdata

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Abstract

This paper intends to estimate the impact of working from home on commuting time in Portugal. Given the recent increase in the number of individuals working from home (i.e. about 17.5% of the total workforce, according to the latest information for the third quarter of 2023), this analysis holds significant value from transportation and regional policymaking perspectives. The impact is estimated using worker microdata from the *Inquérito ao Emprego* (i.e. Employment Survey) for the period between the second quarter of 2022 and the third quarter of 2023, while controlling for both individuals' socio-demographic and job characteristics.

The preliminary results suggest a non-linear relationship between commuting time and the number of days working from home. Commuting time progressively increases with the number of days working from home until reaching four days, where the maximum difference in commuting time is observed compared to individuals not working from home. Subsequently, for individuals working from home five days a week, the difference in commuting time continues to be positive but considerably lower, while the difference is not statistically significant for individuals working from home six or seven days a week.

These results bear important and potentially negative consequences for the sustainability of the urban mobility system, particularly in urban regions where house prices in urban centres have risen sharply, further encouraging people to relocate to areas further away from their workplaces. In future iterations of this work, different estimators

will be employed, including estimators such as propensity score matching, to address potential endogeneity between commuting time and working from home.

Extended Abstract

The surge in remote work experienced accelerated growth during the COVID-19 pandemic (Dalton et al., 2023). While some companies initially adopted it as a temporary measure to prevent business closure, others embraced it as a long-term strategy. This transition was influenced by the increased importance employees placed on flexibility and the realisation by firms that productivity remained unaffected, leading to cost-saving opportunities (Barrero et al., 2023).

However, while some studies in the past have analysed the impact of this practice on commuting duration (Melo & de Abreu e Silva, 2017; de Abreu e Silva, 2022), they were not conducted in a world where remote work was so prevalent. Therefore, the goal of this paper is to contribute to the discussion about the influence of working from home on commuting duration. Estimating such a relationship requires controlling for sociodemographic characteristics of the individuals, such as age and gender, as well as characteristics linked to their jobs, such as the sector of activity. Such analysis holds value from transportation and regional policymaking perspectives.

The data utilised in this paper are derived from the *Inquérito ao Emprego*, i.e. Employment Survey, conducted by Statistics Portugal. Initiated in the 1970s, this survey aimed to estimate both the active and inactive population. Over the years, it has evolved to adapt to changing social realities in the labour market, ensuring the production of comparable results across various European countries. Presently, the main data collected in the survey pertain to labour status, sector of economic activity, job and professional situation, education and vocational training, job search, and career trajectory. Moreover, since the second quarter of 2020 (2Q20), it includes a new module specifically focused on working from home.

The survey is conducted quarterly, with the sample uniformly distributed across each quarter. However, not all questions are asked quarterly; some are posed annually or biennially. The sampling frame comprises family households used as primary residences. The sample is a panel type with a rotation scheme, where households remain in the sample for six consecutive quarters. The total sample is divided into six subsamples (rotations), with each subsample replaced by another after being observed six times.

Although the survey's module about work from home started in 2Q20, the question measuring commuting time only became part of the survey in 2Q22. Therefore, the period of analysis in this paper spans the six quarters between 2Q22 and 3Q22. Furthermore, the preliminary estimations only consider one observation per individual (the most recent), resulting in a total of 105548.

In the sample analysed, 89.5% of the individuals do not work from home. However, it is of interest to estimate the impact of this growing trend, as Statistics Portugal highlights that 17.5% of the working force worked from home to some extent during 3Q23 (INE, 2023). In particular, we aim to consider the influence of the number of days working from home (Table 1 displays the distribution).

Table 1 – Number of days working from home

Number of days working from home	Percentage of individuals
0	89.5%
1	1.5%
2	2.4%
3	2.1%
4	1.0%
5	2.5%
6 or 7	1.0%

Our dependent variable is the stated average commuting time in minutes during the month prior to the survey for each individual i ($CommutingTime_i$). Technically, in the Employment Survey, respondents were asked the following question: "In the last month, how many minutes on average did you spend travelling from home to work?".[1] The explanatory variables were all collected from the Employment Survey as well. These variables encompass sociodemographic and job characteristics. The model can be presented as follows:

$$CommutingTime_i = dayswfh_i + male_i + ISCED_i + residence_i + portugues_i + age_i + age_i^2 + tenure_i + tenure_i^2 + fulltime_i + selfemployed_i + cae_i + quarter_i + u_i$$

[1] The respondents were instructed not to consider exceptional situations (e.g. adverse weather conditions or unusual traffic jams) or time spent for other purposes (e.g. taking children to school).

The variable $dayswfh_i$ represents the average number of days per week an individual i worked from home in the month prior to the survey.[2] The dummy variable $male_i$ equals 1 if the individual is male and 0 otherwise. $ISCED_i$ corresponds to the International Standard Classification of Education, where the lowest education level (less than primary education) is the base category, coded as 0, and the highest level (doctoral level) is 8. The region of residence for i is controlled using the categorical variable $residence_i$, indicating Portuguese regions Norte, Algarve, Centro, Metropolitan Area of Lisbon (AML), Alentejo, Açores, and Madeira. $portugues_i$ is a dummy variable equal to 1 if i has Portuguese nationality and 0 otherwise. Age is controlled for individuals by including both their age and the square of their age to account for potential non-linear effects. The same logic is applied to the impact of the number of months in the current job for i ($tenure_i$). $fulltime_i$ is a dummy variable equal to 1 if the respondent has a full-time job and 0 otherwise. Similarly, $selfemployed_i$ is a dummy variable equal to 1 if the respondent is self-employed and 0 otherwise. cae_i is a categorical variable representing the sector of activity for i based on the Portuguese Economic Activities Classification Code (CAE). $quarter_i$ is just used to control for potential differences explained by the quarter in which the survey was responded. Finally, u_i is the error term. Descriptive statistics are presented in Table 2.

Table 2 – Descriptive statistics

VARIABLES	(1) N	(2) mean	(3) p50	(4) sd	(5) min	(6) max
residence	105548	3.4	3.0	2.0	1.0	7.0
male	105548	0.5	0.0		0.0	1.0
age	105548	46.5	48.0	12.5	16.0	89.0
cae	105548	58.5	56.0	26.7	1.0	99.0
tenure	105548	170.5	127.0	148.7	0.0	871.0
fulltime	105548	0.9	1.0		0.0	1.0
ISCED_2011	105548	4.4	4.0	2.2	1.0	9.0
TC9	105548	19.3	15.0	17.9	0.0	240.0
portugues	105548	1.0	1.0		0.0	1.0
selfemployed	105548	0.1	0.0		0.0	1.0
days_wfh	105548	0.4	0.0	1.2	0.0	6.0

[2] The base category corresponds to zero days of working from home, while six and seven days were combined into a single category due to fewer observations.

The previously presented equation was estimated using the Tobit model with robust standard errors. The choice of the Tobit model over OLS is motivated by the nature of the outcome variable (commuting time), which cannot be lower than zero. OLS may yield inconsistent estimates with such censored variable (Tobin, 1958). The preliminary results are presented in Table 3.

Table 3 – Preliminary results

VARIABLES		VARIABLES	
1 day WFH	4.546***	37.cae	3.533*
	(0.567)		(2.000)
2 days WFH	6.307***	38.cae	0.287
	(0.460)		(0.751)
3 days WFH	6.801***	39.cae	-3.295***
	(0.501)		(1.095)
4 days WFH	7.685***	41.cae	6.076***
	(0.796)		(0.415)
5 days WFH	1.902***	42.cae	9.052***
	(0.397)		(1.067)
6 or 7 days WFH	0.563	43.cae	3.846***
	(0.582)		(0.502)
Male	0.883***	45.cae	-2.379***
	(0.120)		(0.382)
Level 1 ISCED	-2.269***	46.cae	-0.574
	(0.695)		(0.413)
Level 2 ISCED	-3.801***	47.cae	-1.527***
	(0.701)		(0.301)
Level 3 ISCED	-3.624***	49.cae	2.516***
	(0.703)		(0.522)
Level 4 ISCED	-2.412***	50.cae	-2.306*
	(0.901)		(1.368)
Level 5 ISCED	-3.365***	51.cae	4.560***
	(1.071)		(1.260)
Level 6 ISCED	-1.995***	52.cae	1.991***
	(0.730)		(0.559)
Level 7 ISCED	-2.269***	53.cae	-0.558
	(0.715)		(0.798)
Level 8 ISCED	0.866	55.cae	2.859***
	(1.126)		(0.415)
Algarve	-2.726***	56.cae	-2.738***
	(0.179)		(0.319)
Centro	-1.327***	58.cae	-1.610
	(0.172)		(1.176)
AML	7.823***	59.cae	1.039
	(0.201)		(2.116)
Alentejo	-1.563***	60.cae	0.272
	(0.196)		(1.219)
Açores	-4.905***	61.cae	4.257***

	(0.164)		(0.925)
Madeira	-0.673***	62.cae	4.100***
	(0.179)		(0.784)
Portuguese	-3.044***	63.cae	-1.842
	(0.381)		(3.183)
Age	-0.0502	64.cae	6.267***
	(0.0308)		(0.691)
Age squared	9.30e-05	65.cae	3.941***
	(0.000339)		(1.020)
Tenure	-0.00922***	66.cae	-2.560***
	(0.00125)		(0.895)
Tenure squared	1.06e-05***	68.cae	-2.652***
	(2.52e-06)		(0.548)
Full-time	1.473***	69.cae	-0.690
	(0.232)		(0.437)
Self-employed	-5.829***	70.cae	5.649***
	(0.166)		(1.511)
2.cae	7.917***	71.cae	-0.00699
	(1.428)		(0.679)
3.cae	-0.701	72.cae	5.144***
	(0.865)		(1.938)
6.cae	-18.18***	73.cae	1.761*
	(4.599)		(1.010)
7.cae	5.761***	74.cae	1.586
	(1.553)		(1.275)
8.cae	-1.678*	75.cae	0.848
	(1.000)		(1.274)
9.cae	-2.419	77.cae	1.062
	(5.262)		(0.964)
10.cae	-3.077***	78.cae	6.045***
	(0.379)		(2.074)
11.cae	-0.394	79.cae	2.444***
	(0.925)		(0.795)
12.cae	0.521	80.cae	4.225***
	(3.123)		(0.668)
13.cae	-3.404***	81.cae	3.837***
	(0.516)		(0.586)
14.cae	-4.307***	82.cae	3.037***
	(0.435)		(1.011)
15.cae	-5.398***	84.cae	1.387***
	(0.461)		(0.335)
16.cae	-2.421***	85.cae	-0.608*
	(0.645)		(0.342)
17.cae	0.412	86.cae	1.284***
	(1.064)		(0.344)
18.cae	-2.495***	87.cae	-2.782***
	(0.953)		(0.355)
19.cae	-0.807	88.cae	-1.819***
	(1.525)		(0.463)
20.cae	2.347*	90.cae	7.572***

	(1.284)			(2.046)
21.cae	-0.580		91.cae	1.835*
	(1.386)			(1.055)
22.cae	-0.383		92.cae	5.436*
	(0.709)			(3.092)
23.cae	-2.819***		93.cae	-0.990*
	(0.510)			(0.561)
24.cae	1.307		94.cae	-0.213
	(1.577)			(0.748)
25.cae	-2.648***		95.cae	-1.832*
	(0.417)			(1.079)
26.cae	-1.071		96.cae	-1.235***
	(1.005)			(0.451)
27.cae	-0.903		97.cae	5.094***
	(0.842)			(0.517)
28.cae	-1.363*		99.cae	3.515*
	(0.750)			(1.990)
29.cae	1.496***		3Q2022	-0.0880
	(0.544)			(0.196)
30.cae	5.229***		4Q2022	0.287
	(1.405)			(0.192)
31.cae	-5.013***		1Q2023	0.229
	(0.468)			(0.191)
32.cae	-1.194		2Q2023	0.203
	(0.870)			(0.191)
33.cae	1.823**		3Q2023	-0.00674
	(0.804)			(0.188)
35.cae	3.480***		Constant	26.06***
	(0.942)			(1.056)
36.cae	-0.543			
	(0.831)			
Observations	105548			

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; WFH = working from home

Focusing first on the relationship between commuting time and the number of days working from home, individuals working from home one to five days a week experience a higher one-way commuting duration, ceteris paribus, compared to those not working from home. Commuting duration appears to increase with the number of days working from home and then abruptly falls when an individual works from home five days a week. For an individual working from home once a week, the average extra commuting time, compared to someone not working from home, is about 4.5 minutes. This average extra commuting time progressively increases with the number of days working from home, reaching a value of 7.7 minutes for individuals working from home four times a week. However, the difference considerably decreases to 1.9 minutes when

an individual works from home five days a week and then disappears for individuals working from home six or seven days a week. These results have important and potentially negative consequences for the sustainability of the urban mobility system, particularly in urban regions where house prices in city centres have risen sharply, further encouraging people to move to areas further away from their place of work. In this sense, Miles and Sefton (2023) suggest that increasing opportunities for working from home may lead to a decline in land and house prices.

In terms of the impact of sociodemographic characteristics on commuting time, we have found that, on average, males are associated to almost one additional minute in commuting time, while age has no significant impact. The level of education is an important explanatory variable with a non-linear effect. Individuals with some completed level of education tend to have lower commuting time, except those with doctoral level, for whom commuting time is not statistically different.

Commuting time is relatively higher for individuals living in the AML, by about 7.8 minutes more than in the Norte region. This latter region (which includes the Metropolitan Area of Porto) is the second region where commuting time tends to be higher. It is observed that commuting time is lower in all other regions than in the Norte region, with a maximum average difference of 4.9 minutes observed in the Açores region.

Now, we will focus on the impact of job characteristics. Firstly, the relationship between commuting time and the number of months in the current job is statistically significant, indicating a U-shaped relationship. Additionally, it was estimated that commuting time tends to be 1.5 minutes higher for individuals working full-time and 5.8 minutes lower for those who are self-employed.

The sector of activity of individuals also seems to be a significant determinant, with several estimated coefficients being statistically significant. In this preliminary analysis, we primarily use the sector of activity as a control variable, but our intention is to extend the analysis by paying attention to the specificities of the sectors. For example, some jobs are more feasible from home than others (Dingel & Neiman, 2020), which might also introduce endogeneity with the number of days working from home. As highlighted by Miles and Sefton (2023), potential welfares gains favour more individuals with more work-from-home opportunities.

Another step in the development of this paper is to explore various estimators to address the potential issue of endogeneity arising from reverse causality between commuting time and working from home. For example, in addition to the estimator we

have already employed (which appears to reveal a non-linear effect of working from home on commuting time), we intend to test propensity score matching. This method initially estimates the probability of being a teleworker and/or working from home a certain number of days a week.

Furthermore, another avenue of development for this paper is related to the overall balance of mobility. By simulating the weekly duration of commuting mobility, we may gain insights into the potential benefits or costs.

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