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Do Investments in Digital Infrastructure Improve Employment Outcomes?

Evidence from Türkiye

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Abstract

This paper examines the impact of improvements in digital infrastructure on labor market performance, focusing on employment and productivity, measured by average wages. The empirical setting exploits the staggered expansion of high-speed fiber broadband across provinces in Türkiye, using linked employer-employee administrative data and complementary Labor Force Surveys. Across specifications, better digital connectivity raises formal employment and wages, with effects concentrated in occupations amenable to remote work. Most of these gains arise from workers—disproportionately women—entering teleworkable occupations enabled by high-quality internet access. Detailed occupational data reveal that these effects are driven by within-province switches from non-teleworkable to teleworkable jobs, consistent with the relaxation of mobility constraints and the expansion of work-from-home opportunities as a key channel. Wage gains are concentrated among high-skilled workers, although employment effects also extend to lower-skilled women in teleworkable roles. In contrast to the effects of digital connectivity, comparable investments in road infrastructure that enhance physical connectivity produce more mixed results: reduced travel times can improve access to jobs, but competition from nearby regions may offset these benefits.

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Do Investments in Digital Infrastructure Improve Employment Outcomes? Evidence from Türkiye *

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1 Introduction

Digital infrastructure plays a pivotal role in driving economic growth, creating jobs, and lifting populations out of poverty. It serves as a catalyst for economic development. For households and individuals, digital technology improves access to timely information and reduces transaction costs, increases educational outcomes, participation in the labor force, income, consumption, and welfare (Jensen, 2007; Aker and Mbiti, 2010; Hjort and Poulsen, 2019a; Bahia et al., 2023a; Viollaz and Winkler, 2022; Derksen et al., 2022). In principle, digital infrastructure should boost participation in economic activity (Grover, 2025) and especially for women through, for example, expansion in flexible and remote job opportunities. Few studies have systematically examined how investments in electronic infrastructure expand economic opportunities, particularly for certain occupation groups or gender, and the specific channels through which such investments influence labor market outcomes. Furthermore, the relative importance of digital connectivity compared to other forms of infrastructure—such as roads, highways, or ports—remains largely unexplored.

To bridge this gap, our paper investigates how investments in digital infrastructure shape labor market outcomes, with particular attention to employment opportunities and productivity, as measured by average wages. Using spatial and temporal variation in fiber optic roll-out in Türkiye during the 2010s and combining this information with rich administrative linked employer-employee data, we show three main results. *First*, improved digital connectivity significantly increases formal employment and wages, with effects concentrated in teleworkable occupations where remote work is technologically feasible. *Second*, using administrative data on firms and workers with detailed occupation information we find that improvements in labor market outcomes are driven by teleworkable occupations, suggesting the rise in work-from-home opportunities with high-speed Internet as an important channel. *Third*, much of the aggregate gain is driven by women entering teleworkable jobs, consistent with supply-side responses to reduced commuting and increased job flexibility, alongside demand-side productivity gains. Thus, we show that the high-speed Internet increases relative female employment and wages, thus narrowing the gender gap in labor markets.

We conduct several robustness checks to test the sensitivity of our results on improved labor market outcomes for women. First, we include an interaction term between the fiber network and the intensity of female employment to address the potential selection of more women into teleworkable occupations. The estimated coefficient on the interaction with teleworkability remains unchanged, suggesting that the relative increase in female employment or wages is driven by their participation in teleworkable occupations. Second, we replace region-occupation fixed effects with region-industry-occupation fixed effects to exploit variation within our cross-section unit over time. The estimated effects of improvements in digital connectivity on relative female employment and earnings in teleworkable occupations remain robust to the addition of more disaggregated fixed effects. Third, we examine the role of skill intensity by including an interaction term between the fiber network and an indicator of skill intensity. The results confirm that the employment effects of high-speed Internet on female participation in teleworkable occupations are robust to the selection of women by skills.

Considering the transmission mechanisms underlying the impact of digital connectivity we find that high-speed Internet availability, encourages women to switch occupations within a province, particularly from non-teleworkable to teleworkable jobs. The effects on labor market outcomes for females are more pronounced when the move is between two teleworkable occupations compared to a move from a non-teleworkable occupation, suggesting a common set of skills required for teleworkable jobs. Additionally, the impact of Internet connectivity on women's job mobility differs based on the skill intensity of the initial occupation. Women in low-skill occupations are more likely to transition to teleworkable jobs with improved Internet connectivity, while women in high-skill occupations benefit from Internet connectivity only when the move is between two teleworkable occupations. Thus, women in high-skill occupations also experience relative wage gains due to enhanced digital connectivity.

Lastly, we compare the effects of digital infrastructure investments with investments in road infrastructure in reducing gender disparities. We exploit the large-scale public investment in roads in Türkiye during the 2000s, which aimed to improve safety and travel times across the country (Cosar et al., 2021). Our findings suggest that unlike the effect of digital infrastructure, the impact of road infrastructure investments on female labor market outcomes is not unambiguous. While improvements in *market access* are associated with an increase in female employment share, *competition effects* arising from shorter commute times to the most populated district, especially from proximate districts reduce female employment share.

We contribute to the vast and growing literature investigating the effects of Internet access on various economic outcomes Hjort and Tian (2021). These include employment creation Hjort and Poulsen (2019a), skill composition of employment Akerman et al. (2015), and household earnings Zuo (2021). For businesses, digital technology can improve decision making, increase efficiency, facilitate innovation, and expand markets (Bloom et al., 2012; Barrero et al., 2023; Demir et al., 2024). Firms connected to the Internet are also more likely to provide on-the-job training, contributing to the upskilling of workers. Investment in digital infrastructure can also foster a country's integration into regional and global value chains (Freund and Weinhold, 2004) and facilitate export diversification as well as access to foreign inputs (Fernandes et al., 2019; Malgouyres et al., 2021; Hjort and Poulsen, 2019b).

From a broader perspective, investments in digital infrastructure can support policymakers' overarching objectives of job creation and economic development, with potential implications for reducing gender disparities where connectivity enables occupational shifts. In the context of our findings, interventions that complement infrastructure—such as skills upgrading and regulations that strengthen digital data protection and cyber security—may enhance these benefits (Grover, 2025). In addition, our research suggests that to harness the full potential of digital connectivity for *inclusive* economic growth, policy-makers could prioritize facilitating flexible work-from-home arrangements through, for instance, transforming social norms and updating legal regulations. Finally, implementing policies, reforms, and interventions would be critical to enable women to switch to teleworkable occupations by reducing barriers, addressing occupational segregation, and enhancing access to information and resources.

The remainder of the paper proceeds as follows. Section 2 describes the data sources and the background of fiber cable roll-out in Türkiye. Section 3 sets up the empirical strategy, and Section 4 presents the results for the effects of fiber cable roll-out on relative female employment outcomes. Section 5 concludes.

2 Data

Our analysis combines spatially disaggregated data on investment in fiber cable with two micro-level datasets from Türkiye.

2.1 Micro-level Data on Employment and Wages

For most of our analysis, we use linked employer-employee data, an administrative dataset collected by the Social Security Institution. It covers the universe of formal workers and allows tracking workers over time and across establishments (plants) over the 2012-2019 period. It reports (monthly) wage, age, gender, and occupation of every worker employed by any establishment in Türkiye.[1] Establishments can further be linked to firms using unique social security identifiers. This dataset is merged, using unique identifiers, with the administrative establishment registry, which reports their location (province and district) and the main industry of operation (4-digit NACE ("Nomenclature statistique des

[1]Occupation information at the 4-digit International Standard Classification of Occupations (ISCO) level is available from 2014 onwards.

Activites economiques dans la Communaute Europeenne") code).

We also deploy the Labor Force Survey, which is a micro-level datasets comprising repeated cross-sections of households. It reports information on the structure of the labor force, including employment status, as well as hours worked, salary, and broadly-defined occupation and industry for employed individuals.[2] Importantly, for our purposes, it also reports the intensity of work-from-home (WFH).

Using these multiple micro-level datasets, we explore gendered differences in labor market participation, wages, and transitions from regular to remote jobs by exploiting the spatial variation in fiber cable Internet infrastructure across Turkish regions. This brings us to the complementary database used in our paper.

2.2 Regional Data on Internet Infrastructure Investment

Prior to 2010, Türkiye's Internet infrastructure was extensive but had limited speed. In October 2011, the government made a significant decision regarding Fiber Access Services, stipulating their exemption from regulations for a span of five years or until the proportion of fiber Internet subscribers reached 25% of the fixed broadband subscriber base. Over the subsequent eight years, from 2011 to 2019, the fiber network expanded extensively, covering a remarkable distance of 390,800 thousand kilometers, equivalent to an impressive 0.48 kilometers per square kilometer of land area.

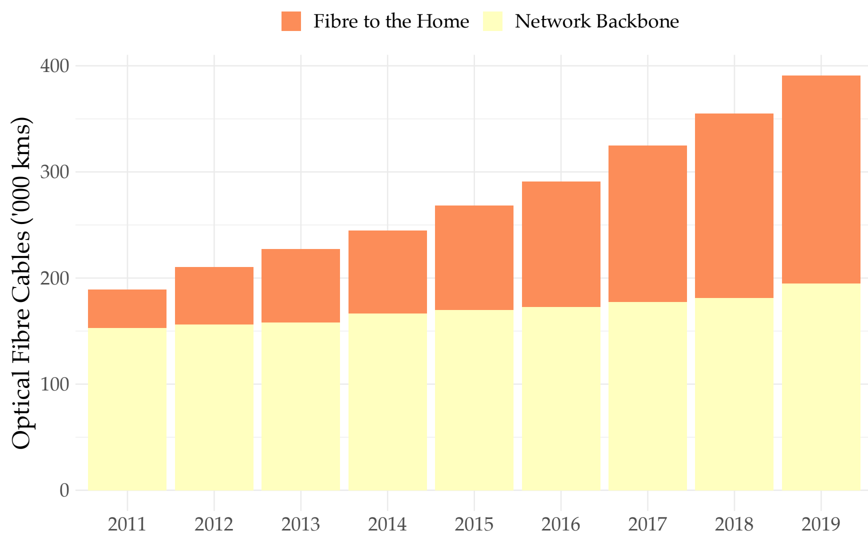
In addition, private Internet providers were granted the authority to utilize Botas, the local natural gas and oil distributor's fiber cables, which played a pivotal role in accelerating the roll-out of fiber connectivity across the country. Figure 1 shows that the length of optical fiber cables rolled out in Türkiye almost doubled from 2012 to 2019. It also shows that investment in fiber optic infrastructure was primarily directed toward rolling out "fiber to the home" for farther locations and less toward the "network backbone".[3]

[2] More details about the survey can be found here: https://data.tuik.gov.tr/Kategori/GetKategori?p=Employment,-Unemployment-and-Wages-108.

[3] Backbone infrastructure refers to the primary network connections forming the foundation of the net-

We exploit the distance from urban centers to Botas pipeline network as a source of exogenous variation to construct our instrument in the empirical analysis. Between 2012 and 2019, not only did the number of subscribers (both households and firms) to fiber Internet lines increased five-fold, but their share in all fixed broadband connections also steadily increased. As of 2020, the fiber Internet lines accounted for 23.9% of all fixed broadband connections in Türkiye, converging to the OECD average of 30.6%.

Figure 1: **Fiber Internet roll-out**



Note: The top panel depicts the evolution of the number of fiber Internet subscribers in Türkiye during the period 2012-2019. The bottom panel shows the breakdown of fixed broadband connections into fiber, xDSL, Cable TV and others. Over 2012-2019, not only did the number of subscribers increase five-fold, but the share of broadband subscriptions due to fiber Internet also increased.

We obtained data on the roll-out of fiber Internet from the Information and Communication Technologies Authority (ICTA) in Türkiye. This provides the length of fiber optic cables laid out in each province across 2012-2019. Fiber optic cable intensity across regions indeed translates to better Internet connectivity in Turkish provinces, as measured by upload and download speeds reported across provinces for 2016-2019 as illustrated in Appendix Figure A1.

work while FTTH refers to the installation of fiber-optic cables directly to individual buildings.

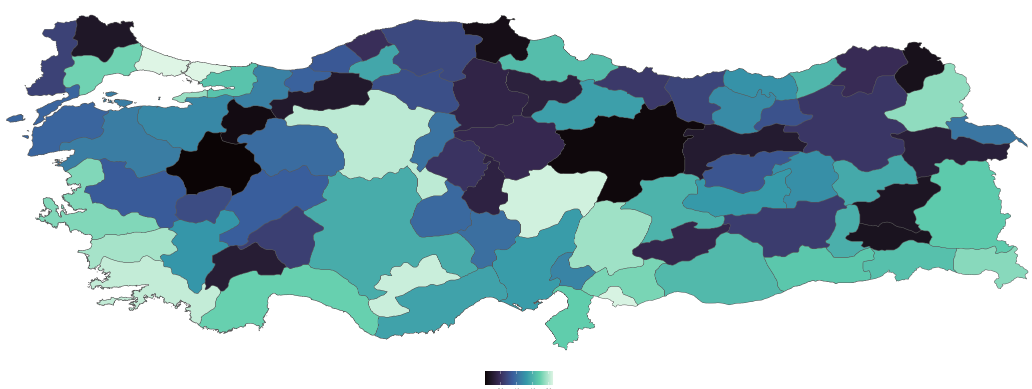
3 Empirical Strategy

We estimate the impact of digital connectivity on outcomes for women by exploiting the spatial and time variation in the roll-out of fiber optic infrastructure across Turkish provinces and years. To this end, we construct a measure of fiber intensity for each province and year. In particular, following Demir et al. (2024), we measure fiber intensity as the length of fiber optic cables rolled out in a province normalized by its land area. Formally, for a province r in year t, fiber intensity Fiber_{rt} is calculated as:

$$\text{Fiber}_{rt} = \ln\left(1 + \frac{L_{rt}}{A_r}\right), \tag{1}$$

where L_{rt} denotes the length of optical fiber cables (in kms) rolled out in province r in year t and A_r is the surface area of the province (in km^2). Figure 2 depicts the change in fiber intensity across Turkish provinces between 2012 and 2019.

Figure 2: **Change in Optical fiber Length**



Note: This figure depicts the spatial variation in optical fiber cable roll-out across Turkish provinces during the period 2012-2019. The median Turkish province saw a 68% increase in optical fiber roll-out, with a maximum of 177% for Istanbul and a minimum of 31% for Kutahya.

To investigate the effect of improved Internet connectivity on labor market outcomes, particularly for women, we use the administrative linked employer-employee dataset which covers the universe of private sector formal workers. This data provides the location of workplaces, allowing us to exploit the differential change in fiber cable availability across Turkish provinces. Moreover, the detailed occupation information reported in the data allows us to study the possibility of heterogeneous effects across occupations, particularly between teleworkable and non-teleworkable occupations, and thus explore WFH as a channel through which high-speed Internet affects female labor market outcomes.

We aggregate employment (or earnings) annually at the level of provinces (i.e. NUTS3 regions), 4-digit NACE industries, and occupations (4-digit ISCO codes). For specifications that examine gender differentials, outcomes are further disaggregated by gender. As a first step we estimate the effect of fiber expansion on overall labor market outcomes (total employment and average earnings) regardless of gender. This establishes whether fiber roll-out has an aggregate effect on labor markets before examining gender differentials. Specifically, we estimate:

$$\text{Outcome}_{rost} = \delta \text{Fiber}_{rt} + \alpha_{sot} + \alpha_{rs} + v_{rost}, \tag{2}$$

where Outcome_{rost} denotes either total employment (log) or average earnings in province r, industry s, occupation o, and year t. The specification includes a rich set of fixed effects. With industry–occupation–time fixed effects (α_{sot}), we account for potential labor supply changes at the level of industries and occupations. Region–industry fixed effects (α_{rs}) control for the industry composition in provinces. Standard errors are clustered at the province level.

After establishing aggregate effects using equation (2), we turn to gender-specific and heterogeneity specifications. We estimate two specifications. The first one uses gender-specific outcome variables and ignores heterogenous effects across occupations:

$$\text{Outcome}_{rosgt} = \beta \text{Female}_g * \text{Fiber}_{rt} + \alpha_{sot} + \alpha^{g}_{ot} + \alpha_{rs} + \alpha_{rt} + \epsilon_{rosgt}, \tag{3}$$

As before, the specification is saturated with a rich set of fixed effects. In addition to equation (2), we add time-varying provincial fixed effects (α_{rt}) to control for any demand and supply related shocks affecting the local labor market. In addition, α^{g}_{ot} further account for gender-related compositional changes at the level of occupations. Our second specification aims to study the potentially heterogenous effects of improvements in Internet connectivity across occupations. To do so, we use as dependent variable, relative female outcomes, e.g. share of female employment or relative female earnings:

$$\text{Relative female outcome}_{rost} = \gamma \text{Teleworkability}_o * \text{Fiber}_{rt} + \alpha_{sot} + \alpha_{rs} + \alpha_{rt} + \varepsilon_{rost} \tag{4}$$

We measure teleworkability of occupations based on the classification proposed by Dingel and Neiman (2020a). The coefficient of interest is γ which captures the differential effect for teleworkable occupations, which would be informative about the importance of WFH as a plausible channel.

In general, estimating the effects of improvements in infrastructure, such as roads or communication network, on key economic outcomes is challenging since allocation of investment may not be random and might be correlated with other observed or unobserved location-specific factors. The initial phase of Türkiye's fiber Internet roll-out was concentrated in "urban and economically attractive" areas but then expanded to universal coverage. Thus, in our setting, one potential concern is that expansion of the fiber optic network is endogenous, which may create spurious correlation between increases in fiber intensity and regional outcomes. To address this concern, following the approach in Demir et al. (2024), we construct an instrument for fiber intensity for each province by exploiting the fact that the roll-out of fiber cable Internet in Türkiye kicked off after private Internet providers were granted access to use fiber cables fed through the existing gas pipes. The BOTAS optical fiber network was built decades before the start of the optical fiber network expansion. Since the BOTAS network was not designed to facilitate Internet connectivity across provinces, we can exploit plausibly exogenous variation in the distance of individual districts in Türkiye to the BOTAS network to construct our instrument for Internet connectivity.

Figure 3 shows the BOTAS pipeline network. We calculate the minimum distance from each district center to the network and then aggregate distances to the province level by weighting districts with their respective population in 2011. This measure is an informative instrument for the amount of investment a region received during this period as it is negatively correlated with the cost of investing in FTTH (Fiber to the Home) network.[4] In Figure A2, we show that these distance measures across provinces are not correlated with a series of initial province characteristics, such as GDP, area, population, manufacturing share of GDP, urbanization rate, and employment rate, pertaining to the year 2011.

The informativeness of the instrument can be confirmed by running the following first stage regression equation:

$$Fiber_{r,t} = \sum_{l=2013}^{2019} \beta^{l} \mathbb{1}_{t=l} \times IV_r + \alpha_r + \alpha_{NUTS2,t} + e_{rt} \quad (5)$$

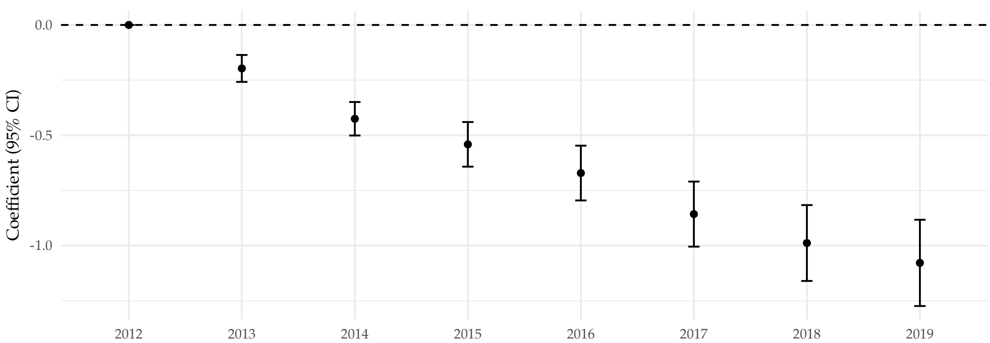
Figure 4 presents the estimates of β^l with their 95% confidence interval. In line with our expectations, the estimated coefficients are negative and their magnitudes increase toward the end of the investment period.

[4]As presented in Figure 1, investment in fiber network was geared toward FTTH rather than backbone investment during this period.

Figure 3: BOTAS Oil and Gas Pipeline Network

Note: This map shows the gas pipeline network of BOTAS as of the year 2011.

Figure 4: First-stage estimates



Note: The distance of a province to BOTAS pipelines is constructed as the weighted average of the distances of districts within the province where the district population are used as weights. This figure plots the coefficient estimates and the corresponding 95% confidence intervals obtained from regressing this distance on initial provincial characteristics (pertaining to 2011), controlling for NUTS2 level fixed effects.

4 Results

This section sets out the empirical findings in three steps. We begin by examining the aggregate impacts of fiber-optic broadband expansion on formal employment and wages, using both OLS and 2SLS estimates. To understand the overall results, we first investigate whether these gains are concentrated in particular occupational groups, focusing on the role of teleworkability. Finally, we assess whether the observed occupational effects are disproportionately driven by changes in female employment and earnings and relate these patterns to the descriptive evidence on gender gaps in labor market participation. Throughout this paper, our main analysis focuses on formal employment using administrative linked employer–employee data, which do not cover informal jobs.[5]

4.1 Aggregate Labor Market Impacts

To investigate the effect of improved Internet connectivity on labor market outcomes, particularly for women, we use the administrative linked employer-employee dataset which covers the universe of private sector formal workers. This data provides the location of workplaces, allowing us to exploit the differential change in fiber cable availability across Turkish provinces. Moreover, the detailed occupation information reported in the data allows us to study the possibility of heterogeneous effects across occupations, particularly between teleworkable and non-teleworkable occupations, and thus explore WFH as a channel through which high-speed Internet affects female labor market outcomes. These results are confirmed using the Household Labor Force survey data which reports directly the frequency with which individuals work-from-home.

Table 1 reports the baseline estimates of the impact of high-speed Internet availability on overall labor market outcomes, measured by total employment and average earnings. Columns (1) and (2) present OLS estimates, while Columns (3) and (4) report 2SLS estimates that instrument fiber intensity using distance to the BOTAS pipeline network. Across specifications, improved digital connectivity is associated with economi-

[5] Informal employment in Türkiye is concentrated in occupations and sectors with limited scope for remote work and low teleworkability. As a result, improved digital connectivity is unlikely to generate large work-from-home gains within informal jobs themselves. Instead, access to high-speed Internet may facilitate transitions from informal or marginal employment into formal teleworkable occupations, or induce exit from informal employment when remote work opportunities become available. To the extent that such transitions are not fully captured in the administrative data, our estimates should be interpreted as reflecting changes within the formal sector and may therefore represent a lower bound on the overall impact of digital connectivity on women's labor market opportunities.

cally meaningful increases in employment and earnings. In the OLS results, a one-unit increase in fiber intensity is associated with a statistically significant increase in total employment, while the corresponding effect on average earnings is positive but imprecisely estimated. By contrast, the IV estimates indicate substantially larger effects on both employment and wages. In particular, the 2SLS coefficient implies that fiber expansion leads to a sizeable increase in total employment and a statistically significant rise in average earnings, suggesting that OLS estimates may understate the true effect of digital connectivity due to measurement error or endogenous roll-out patterns. Together, these results establish that investments in high-speed Internet generate positive aggregate labor market effects, providing a natural benchmark for investigating heterogeneity across occupations and, subsequently, by gender.

Table 1: Labor Market Outcomes and High-Speed Internet

Dependent Variable:	Total employment OLS (1)	Average earnings OLS (2)	Total employment 2SLS (3)	Average earnings 2SLS (4)
Fiber	0.510***	0.0781	1.109***	0.497**
	(0.0939)	(0.0493)	(0.347)	(0.204)
Fixed Effects:				
Industry×Occupation×Time	✓	✓	✓	✓
Region×Industry	✓	✓	✓	✓
Observations	3,490,367	3,490,367	3,490,367	3,490,367

Note: * 10%, ** 5%, *** 1% significance levels. Standard errors, clustered at the province level, are reported in parentheses.

4.2 Heterogeneity by Occupation

High-speed Internet availability affects labor market outcomes through both the demand and the supply channels. On the demand side, digital connectivity increases firm productivity and employment opportunities particularly in occupations with greater amenability for remote work, that is, more teleworkable occupations. On the supply side, workers with a preference for flexibility may be more likely to take up such jobs. We examine here whether these aggregate employment and earnings effects are concentrated in occupations that are more suitable to remote work. To do so, we augment the baseline specification by interacting fiber intensity with occupation-level teleworkability, as defined by Dingel and Neiman (2020a). This allows us to assess whether the labor market gains from improved digital connectivity operate primarily through occupations for which high-speed Internet is a more direct input. The results presented in Table A1 indicate that the positive effects of fiber expansion on both total employment and average earnings are strongly concentrated in teleworkable occupations. While fiber intensity is associated with higher aggregate employment and wages, the interaction terms reveal that these gains are significantly larger in occupations with greater scope for remote work. This pattern suggests that the expansion of teleworkable jobs is an important channel through which digital infrastructure affects labor market outcomes at the aggregate level.

4.3 Heterogeneity by Gender

Having established that improvements in digital connectivity generate positive aggregate effects on formal employment and earnings, we next examine whether these effects differ systematically by gender. After all, supply side factors, such as childcare responsibilities, can increase the likelihood for women to take remote jobs, especially if increased flexibility in working arrangements comes at the cost of lower wages (Barrero et al., 2023). Women may be more likely to trade off the former against the latter. The results obtained from estimating equation (3) for employment are presented in Appendix Table A2. While the estimated coefficient on the interaction between the female dummy and province-level fiber intensity is positive, it is imprecisely estimated for the full sample which pools all occupations. The last two columns further split the sample by teleworkability of occupations. Column 5 shows that female employment increased disproportionately in teleworkable occupations with the availability of high-speed Internet. This motivates us to move directly to our second empirical specification (4) which investigates occupation heterogeneity.

Results are presented in Table 2. The first two columns estimate the effect of improvements in Internet connectivity on the fraction of female employment in a given province-industry-occupation cell at time t, and the last two columns the effect on relative female monthly wages within the same cell. The results obtained for relative female employment confirm that the availability of high-speed Internet increases the share of female employment in teleworkable occupations. This is consistent with the hypothesis that high-speed Internet makes it more feasible and efficient to WFH, thus boosting relative female employment in WFH compatible occupations. The availability of high-speed Internet also led to an increase in relative female earnings as presented in the last two columns of Table 2. While the estimated coefficient for fiber is small, and statistically insignificant (column 3), the coefficient on its interaction with occupation-level teleworkability is positive, sizeable, and statistically significant in both specifications.

Table 2: Female labor Market Outcomes and High-Speed Internet

Dependent Variable:	Share of female employment		Relative female earnings	
	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
Fiber	-0.114		0.0133	
	(0.0768)		(0.0524)	
Teleworkability×Fiber	0.0152***	0.0153***	0.0500***	0.0501***
	(0.00198)	(0.00198)	(0.00673)	(0.00673)
Fixed Effects:				
Industry×Occupation×Time	✓	✓	✓	✓
Region×Industry	✓	✓	✓	✓
Region×Time		✓		✓
Observations	3,490,367	3,490,367	3,490,367	3,490,367

Note: * 10%, ** 5%, *** 1% significance levels. Standard errors, clustered at the province level, are reported in parentheses.

These gender-specific results are important in light of the descriptive patterns documented in Table 3 using the Household Labor Force Survey data for Türkiye. The first column of Table 3 shows that women are less likely to be employed for a given region (NUTS2 level) and year, and conditional on various individual characteristics such as age, experience, education level, and marital status. The gap is also visible in wages earned per hour of work for employed women.

Table 3: Gender Differences in Employment, Wages, and WFH Intensity

Dependent Variable:	Employed (1)	(Log) Wage per hour (2)	WFH (3)
Female	-0.296*** (0.00743)	-0.0869*** (0.00648)	0.0339** (0.0135)
Age	0.0302*** (0.000668)	0.0429*** (0.00171)	0.000612*** (0.000131)
Age squared	-0.000368*** (0.00000895)	-0.000479*** (0.0000216)	-0.00000525*** (0.00000145)
High school diploma	0.102*** (0.00766)	0.136*** (0.00578)	-0.00127 (0.00141)
Married	0.0441*** (0.0114)	0.0559*** (0.00329)	0.00532*** (0.00164)
Large employer		0.102*** (0.00421)	-0.0120*** (0.00152)
Employed in public sector		0.427*** (0.0292)	0.00420 (0.00263)
Has managerial responsibilities		0.165*** (0.00721)	0.00309* (0.00154)
Fixed Effects:			
Region×Time	✓	✓	✓
Industry×Occupation×Time		✓	✓
Region×Industry		✓	✓
Observations	3,813,289	839,758	839,758

The Household Labor Force Survey comprises information on individuals' ability to WFH and their intensity or frequency.[6] Figures A3 and A4 show the fraction of survey

[6]The Household Labor Force Survey covers both formal and informal employment. In Türkiye, informal work is concentrated in sectors and occupations with limited scope for remote work, and thus improve-

respondents who work-from-home at least part of the time. Both figures show significant variation in WFH intensity across industries or occupations. Also, women are more likely to WFH than men. This final observation is also confirmed by descriptive regression analysis (Table 3, column 3) that controls for unobserved time-varying regional, industry, and occupation level factors.

Since much of the aggregate employment and wage growth from fiber expansion is driven by women, particularly those entering teleworkable occupations, the remainder of the paper focuses on further understanding these gender-specific findings.

4.3.1 Robustness Checks

We test the robustness of the results on improved labor market outcomes for women to several alternative specifications.

First, it is possible that the increased employment in teleworkable occupation is driven by the selection of more women in those occupations. To address this, we add to our base specification an interaction of fiber network with the intensity of female employment (Table A3, column 1).[7] Adding an interaction between Fiber_{rt} and female intensity of occupations does not change the estimated coefficient on the interaction with teleworkability, thereby suggesting that the relative increase in female employment or wages is indeed driven by their participation in teleworkable occupations.

Second, to test the robustness of our results to an alternative source of variation, we replace region-occupation fixed effects in the baseline specification with region-industry-occupation fixed effects, allowing us to exploit variation within our cross-section unit over time. The estimated effects of improvements in digital connectivity on relative female employment and earnings in teleworkable occupations are robust to the addition of

ments in digital connectivity are unlikely to generate large work-from-home gains within informal jobs. Where survey estimates include informal workers, results should be interpreted accordingly, and as potentially reflecting transitions from informal to formal employment not directly observed in administrative data.

[7] Female intensity is measured by the share of female employment in each occupation in EU 15 countries using EUROSTAT data.

more disaggregated fixed effects (Table A3, column 2).

Third, we suspect that the increased employment in teleworkable occupations may be attributed to the self-selection of individuals with specific skill sets for those occupations. To this end, we additionally include an interaction of fiber network with an indicator of skill intensity (Table A3, column 3).[8] The results presented in the last column of Table A3 suggest that while the employment effects of the availability of high-speed Internet on women in teleworkable occupations are robust to the selection of women by skills, the wage response disappears (panel B). This suggests that the increase in relative wages for women attributed to digital connectivity observed in the base specification is indeed explained by those in high-skilled occupations, rather than their teleworkability per se.

Fourth, we turn to the data from the Household Labor Force Survey which reports the frequency with which individuals work-from-home. While it provides a direct measure of WFH intensity, this dataset has a couple of shortcomings. It reports spatial units at a more aggregated level, i.e. NUTS2 regions, than the administrative linked employer-employee data, which weakens the identification assumption we employ in the empirical analysis. In addition, it reports occupations at a very aggregate level, making it infeasible to rely on an external measure of teleworkability. Therefore, we use the survey data to check the robustness of our main result, suggesting WFH as a relevant channel through which Internet connectivity improves relative female labor market outcomes. Our estimating equation is:

$$WFH_{it} = \gamma \text{Female}_i \times \text{Fiber}_{rt} + \Gamma X_i + \alpha_{sot} + \alpha^g_{ot} + \alpha_{rs} + \alpha_{rt} + \epsilon_i, \quad (6)$$

where i indexes individuals; r, o, and s denote the NUTS2 region, 2-digit ISCO occupa-

[8]Skill intensity is measured using the classification developed by Caunedo et al. (2023) who classify the O-NET occupational categories according to the usage of routine/non-routine, analytical/interpersonal skills. In particular, for each occupation, we calculate the simple average of its non-routine analytical (NRA) and non-routine interpersonal (NRI) skill measures. The ranking of this skill measure is intuitive: The occupation with the highest skill is Information Technology Trainers (2356) and the one with the lowest skill is Vehicle Cleaners (9122). Using this data we construct a dummy variable for high-skill occupations which have the average skill intensity above the mean across all occupations

tion, and 2-digit NACE industry of the individual i, respectively. In the equation, α_{ot}^{g} denote gender specific occupation-time fixed effects which, among other factors, control for selection of men or women into certain occupations over time. We further include industry-occupation-time interacted fixed effects as well as region-industry fixed effects which control for the industry composition of regions. This specification is quite demanding as it also includes time-varying regional fixed effects which control for any time-varying demand- and supply-related factors at the regional level. The parameter of interest is γ.

Appendix Table A4 reports results based on the Household Labor Force Survey, which provides a direct measure of work-from-home (WFH) intensity. The interaction between Fiber and the female indicator is positive and statistically significant in the WFH regression, indicating that improved digital connectivity increases the likelihood that women work remotely. At the same time, the corresponding interaction in the employment regression is negative and statistically significant, suggesting that high-speed Internet does not lead to a uniform expansion of female employment in the aggregate. Rather than reflecting a deterioration in women's labor market opportunities, this negative coefficient is consistent with a reallocation effect. As digital connectivity improves, women increasingly sort into teleworkable jobs, while employment in non-teleworkable occupations declines. This interpretation aligns closely with our administrative data results, which show that female employment gains are concentrated in teleworkable occupations and that these gains differ by skill level. In the aggregate, such occupational reallocation can manifest as a decline in overall female employment in the LFS, even as employment opportunities improve for women in specific teleworkable occupations. In this sense, the LFS evidence reinforces our main conclusion that digital infrastructure reshapes the composition of female employment rather than expanding it uniformly across the labor market.

Appendix Table A4 presents the results from estimating equation (6). Our results on the direct measure of WFH available in the Labor Force Surveys show that the interaction of Fiber with the female dummy is positive and statistically significant (column 1), thereby implying increased probability of women working remotely post access to digital connectivity. This corroborates our result in Table 2 based on the interaction of fiber with the teleworkability of occupations (columns 1 and 2). The interaction coefficient in Table A4 for the employment regression is negative and statistically significant (column 2), implying that the high-speed Internet in aggregate does not improve the labor market opportunities for women, a result broadly in line with the finding in Table 2 (column 1) where the coefficient for Fiber was found to be negative albeit statistically insignificant. Opportunities for females are heightened only in teleworkable occupations, a finding that we confirm using both the administrative data in Table 2 and here with the Labor Force Survey data. Results obtained from the household level data also suggest that the estimated coefficient on the interaction of Fiber with the female dummy for wages is positive (column 3), although not statistically different from zero. This is also consistent with the positive (and not significant) coefficient on Fiber in Table 2 (column 3).

A related concern is whether our main results are driven by a small number of large metropolitan areas, in particular Istanbul, which experienced significant expansion in fiber coverage during the study period. The fact that our identification strategy exploits within-province changes over time and relies on plausibly exogenous variation in fiber roll-out generated by distance to the BOTAS pipeline network alleviated this concern. Importantly, this instrumental variable varies substantially across provinces and is not mechanically correlated with initial levels of urbanization, population size, or economic activity. As a result, the estimated effects reflect average responses across a broad set of regions rather than being driven by a single metropolitan area. Moreover, the inclusion of province-year fixed effects in some of our main specifications absorbs time-varying regional shocks, further limiting the scope for large metropolitan areas to disproportionately influence the estimated coefficients.

4.3.2 Role of Skills

To motivate our analysis of heterogeneous effects by skill intensity, Table 4 provides descriptive evidence on the occupational composition of teleworkable jobs in our sample.[9] The table reports female employment shares in selected teleworkable occupations in 2014 and 2019, along with their skill classification. Female employment shares increased markedly between 2014 and 2019 in high-skill teleworkable occupations such as Teaching Professionals, Science and Engineering Professionals, and Legal, Social and Cultural Professionals. By contrast, low-skill teleworkable occupations such as General and Keyboard Clerks exhibit a decline in female employment share over the same period.

Table 4: Female employment shares in selected teleworkable occupations

Occupation	Skill index	Female share (2014)	Female share (2019)	Change
General and Keyboard Clerks	-0.566	0.480	0.456	-0.023
Teaching Professionals	1.167	0.542	0.591	0.049
Business and Administration Professionals	0.957	0.199	0.219	0.020
Administrative and Commercial Managers	1.239	0.251	0.255	0.005
Chief Executives, Senior Officials and Legislators	1.434	0.095	0.130	0.036
Information and Communications Technicians	0.405	0.140	0.132	-0.008
Business and Administration Associate Professionals	0.241	0.310	0.311	0.002
Legal, Social and Cultural Professionals	0.679	0.289	0.363	0.075
Science and Engineering Professionals	0.975	0.255	0.312	0.057
Mean	0.725	0.284	0.308	0.024

Note: The table reports female employment shares in selected teleworkable occupations in 2014 and 2019. The skill index is based on the non-routine analytical and interpersonal task intensity following Caunedo et al. (2023); higher values indicate higher skill intensity. Changes are defined as the difference between 2019 and 2014 female employment shares.

The table clarifies what is covered by teleworkable occupations in the Turkish context. Teleworkable jobs in our data span both low- and high-skill categories. Low-skill teleworkable occupations are primarily clerical and administrative support roles (e.g.,

[9]While age and education are closely related to skill intensity, we focus on an occupation-based measure of skills to capture task content and teleworkability more directly. In complementary work using Turkish administrative and survey data, we show that the gendered labor market responses to technological change and remote work opportunities are strongest for women in prime working ages and for those with medium and high levels of education. These patterns are consistent with the mechanisms emphasized in this paper, whereby digital connectivity relaxes constraints related to work flexibility, job search, and occupational mobility. Data limitations prevent us from further disaggregating the analysis by age and education groups within the current empirical setting.

General and Keyboard Clerks), while high-skill teleworkable occupations include teaching professionals, legal and cultural professionals, science and engineering professionals, and managerial positions. Importantly, female employment shares decline or stagnate in low-skill teleworkable occupations over time, while they increase substantially in high-skill teleworkable occupations. This descriptive pattern provides a natural motivation for the regression analysis below, which examines how the labor market effects of improved digital connectivity differ across skill groups.

As reported in the previous subsection, the results of wage effects are driven primarily by women in high-skilled occupations. To investigate the role of skill for women's labor market gains from access to high-speed Internet, we re-run the most stringent specification for the two skill groups separately. For relative female employment, both skill groups in teleworkable occupations respond to the availability of the high-speed Internet, with a stronger response from women in the low-skill group (Table 5, columns 1 and 2). By comparison, only high-skilled women working in tele-workable occupations appear to obtain wage gains (Table 5, columns 3 and 4).

Table 5: Female labor Market Outcomes and High-Speed Internet: Results by skill groups

Dependent Variable:	Share of female employment		Relative female earnings	
	2SLS	2SLS	2SLS	2SLS
	Low-skill	High-skill	Low-skill	High-skill
	(1)	(2)	(3)	(4)
Teleworkability×Fiber	0.0450***	0.0134*	-0.0119	0.0309**
	(0.00807)	(0.00759)	(0.0116)	(0.0142)
Fixed Effects:				
Industry×Occupation×Time	✓	✓	✓	✓
Region×Industry	✓	✓	✓	✓
Region×Time	✓	✓	✓	✓
Observations	1,221,796	858,169	1,221,796	858,169

Note: * 10%, ** 5%, *** 1% significance levels. Standard errors, clustered at the province level, are reported in parentheses.

4.3.3 Transmission Mechanism

A natural question raised by our findings is why improvements in digital connectivity lead to stronger occupational reallocation responses for women than for men. Several complementary mechanisms are consistent with the observed patterns. First, women face more binding constraints on physical mobility and work schedules due to unequal responsibilities for childcare and household production. As a result, reductions in the need for on-site presence disproportionately relax women's labor supply constraints, making teleworkable occupations relatively more attractive. Second, women are more concentrated in occupations with lower initial teleworkability and lower flexibility, so improvements in digital infrastructure generate larger marginal gains for women by expanding the feasible set of jobs they can access. Third, enhanced digital connectivity reduces job search and matching frictions, which may matter more for women given higher penalties associated with job switching and career interruptions. These mechanisms together imply that women are more likely than men to respond to improved Internet access by reallocating toward teleworkable occupations, even when such moves involve limited or delayed wage gains, a pattern that aligns closely with our empirical evidence.

We now explore the underlying transmission mechanisms that can explain our main results on gender. One potential channel could be that better digital connectivity motivates women to switch occupations - from non-teleworkable to teleworkable - within a province. The linked employer-employee dataset allows us to track the movement of workers across jobs over time. The outcome of interest is the share of female workers in total employees that switch occupations in a given province between two consecutive years. We estimate the following equation:

$$\begin{aligned} \text{Share of female switchers}_{odpt} \;&=\; \theta_1 \text{Non-Teleworkable}_o \times \text{Teleworkable}_d \times \text{Fiber}_{rt} \\ &+\; \theta_2 \text{Teleworkable}_o \times \text{Teleworkable}_d \times \text{Fiber}_{rt} \\ &+\; \theta_3 \text{Teleworkable}_o \times \text{Non-Teleworkable}_d \times \text{Fiber}_{rt} \end{aligned}$$

$$+ \quad \alpha_{odt} + \alpha_{odr} + \alpha_{rt} + e_{odpt}, \tag{7}$$

where the dependent variable is the share of female workers in total number of switchers between an origin occupation o and destination occupation d in region r in year t. As we include the region-time fixed effects, the base category is share of female workers in origin-destination occupation pairs that are both non-teleworkable.

Table 6: Worker Movements within Provinces

Dependent Variable: Share of female movers	2SLS All (1)	2SLS Low-skill (2)	2SLS High-skill (3)
Non-Teleworkable$_o$ × Teleworkable$_d$ × Fiber	0.101**	0.110***	0.0357
	(0.0316)	(0.0375)	(0.0493)
Teleworkable$_o$ × Teleworkable$_d$ × Fiber	0.162***	0.335***	0.117***
	(0.0270)	(0.0647)	(0.0265)
Teleworkable$_o$ × Non-Teleworkable$_d$ × Fiber	0.0311	0.028	-0.0322
	(0.0325)	(0.0484)	(0.0268)
Fixed Effects:			
Source Industry × Destination Industry × Time	✓	✓	✓
Region × Source Industry × Destination Industry	✓	✓	✓
Region × Time	✓	✓	✓
Observations	633,614	351,299	261,421

Note: * 10%, ** 5%, *** 1% significance levels. Standard errors, clustered at the province level, are reported in parentheses.

Results obtained from estimating equation (7) are presented in Table 6. The results presented in column 1 suggest that women were more likely to change jobs to teleworkable occupations in provinces with high-speed Internet. The estimated effect of high-speed Internet availability on the relative job mobility of female workers appears to vary with respect to the similarity in teleworkability between former and new jobs. In particular, the estimated effect is almost twice as large when the move is between two teleworkable occupations than when it is from a non-teleworkable occupation. This could be driven by the possibility that there are common sets of skills required for teleworkable occupations.

Columns 2-3 of Table 6 split the sample based on the skill-intensity of the source occupations. The results are in line with those presented in the first two columns of Table 5. The share of women in low-skill occupations, who move to teleworkable occupations, increases with the improvement in Internet connectivity in a region. For women in high-skill occupations, their share in total number of movers increases with Internet connectivity only in cases where the move is between two teleworkable occupations. Combining this with our earlier results, these women also benefited from relative wage gains.

4.4 Is Investment in Digital Infrastructure Different? Comparisons with Physical Infrastructure Investments

In this section, we investigate whether other types of infrastructure investments generate similar effects for women in the labor market. To do so, we exploit the large-scale public investment in roads in Türkiye during the 2000s. The aim of the investment project was to expand the lane capacity of existing roads to improve safety and the reliability of travel times on the national transportation network through investments across the country. Specifically, a substantial share of existing two-lane single-carriageways with two-way traffic were upgraded to dual carriageways separated by a small earthen medium, with two-lane one-way traffic on each carriageway.[10]

Our aim is to study whether the large-scale public investment in roads generated similar gains for female workers to the one we have exploited so far, which led to improvements in internet connectivity. To compare the effects generated by the two investment episodes, we need to introduce some changes in our empirical setting. For the road investment program, due to data availability, we can only estimate long-term effects, i.e. between 2005-2015. Our variable of interest is the population-weighted average of bilat-

[10]See Cosar et al. (2021) for details of the investment program.

eral travel time reductions between 2005 and 2015 for each district in Turkiye:[11]

$$\Delta \ln \text{Travel Time}_d^{Wgt} = \sum_{d'} \ln \left(\frac{\text{Travel Time}_{dd',2015}}{\text{Travel Time}_{dd',2005}} \right) \text{Population share}_{d',2005} \tag{8}$$

This measure is inversely related to changes in market access for districts.

Another important difference in data availability for the road infrastructure period is that the administrative linked employer-employee data does not report the occupation codes for workers. Therefore, to investigate the role of WFH, we will exploit industry heterogeneity.

Our estimating equation is as follows:

$$\begin{aligned} \Delta(\text{Share of female employment})_{ds} &= \eta_1 \Delta \ln (\text{Travel time})_d^{Wgt} + \eta_2 \ln \text{Distance}_d^{Wgt} \\ &+ \eta_3 \text{Teleworkability}_s * \Delta \ln (\text{Travel time})_d^{Wgt} \\ &+ \eta_4 \text{Teleworkability}_s * \ln \text{Distance}_d^{Wgt} \\ &+ \eta_5 \text{Female intensity}_s * \Delta \ln (\text{Travel time})_d^{Wgt} \\ &+ \eta_6 \text{Female intensity}_s * \ln \text{Distance}_d^{Wgt} \\ &+ \alpha_s + \alpha_p + \epsilon_{ds}, \end{aligned} \tag{9}$$

where the dependent variable is the period change (i.e. 2006-2016) in the ratio of female employment to total employment in industry s and district d. Aggregate province- and industry-level changes are controlled by including α_p and α_s. $\ln \text{Distance}_d^{Wgt}$ and $\ln (\text{Travel time})_d^{Wgt}$ denote the population-weighted average of bilateral distance and period-change in bilateral travel times at the district level.[12] The former controls for the initial connectivity of districts. Since our specification controls for provincial fixed effects and initial remoteness of the district, we exploit “unexpected" or “random" variation in im-

[11] Türkiye is administratively divided into 81 provinces, which are further divided into districts.

[12] The empirical specification as well as the construction of variables of interest follow the approach in Cosar et al. (2021).

provements in remoteness of the district due to the road infrastructure investments. We also include interactions with female employment intensity at the industry level to run a horse race with our teleworability measure which is constructed by Dingel and Neiman (2020b).

Table 7: Female Labor Market Effects of Internet and Road Infrastructure Investments

Dependent Variable: Change in female	employment share (1)	relative earnings (2)	employment share (3)	relative earnings (4)
Teleworkability × Fiber	0.00843* (0.00480)	0.0233*** (0.00686)		
Female intensity × Fiber	-0.00332 (0.0128)	0.0666*** (0.0144)		
$\Delta \ln (\text{Travel time})^{Wgt}$			0.298** (0.117)	0.195 (0.219)
$\ln \text{Distance}^{Wgt}$			0.0108*** (0.00372)	0.00212 (0.00514)
Teleworkability$\Delta \ln (\text{Travel time})^{Wgt}$			0.0948 (0.133)	0.227 (0.149)
Teleworkabilityln Distance^{Wgt}			-0.00511* (0.00274)	0.00190 (0.00326)
Female intensity$\Delta \ln (\text{Travel time})^{Wgt}$			-0.190 (0.393)	-0.138 (0.480)
Female intensityln Distance^{Wgt}			-0.00350 (0.00764)	-0.00552 (0.00910)
Fixed Effects:				
Industry × Occupation × Time	✓	✓		
Region × Time	✓	✓		
Region × Industry × Occupation	✓	✓		
Province			✓	✓
Industry			✓	✓
Observations	2,165,388	2,165,388	54,288	54,288

Note: * 10%, ** 5%, *** 1% significance levels. Standard errors, clustered at the province level, are reported in parentheses.

Table 7 presents the results comparing the labor market effects of digital infrastructure investments with those of large-scale road infrastructure investments. Consistent with our main findings, improvements in digital connectivity are associated with an increase in relative female employment and earnings in teleworkable occupations, as captured by the positive and statistically significant coefficients on the interaction between teleworkability and fiber intensity. By contrast, the effects of road infrastructure investments on female labor market outcomes are more nuanced. While reductions in travel times—reflecting improved market access – are associated with an increase in the female employment share, the interaction terms indicate that these gains are offset by competition effects arising from improved connectivity to nearby districts. In particular, shorter commute times to larger population centers reduce the share of female employment in the home district, suggesting that women disproportionately reallocate across space when transportation costs fall.

Overall, the comparison highlights an important distinction between digital and transport infrastructure. Digital connectivity expands employment opportunities for women primarily by enabling remote work and reducing the need for physical mobility, whereas road infrastructure affects female employment through spatial reallocation and competitive pressures that can generate both positive and negative effects. These findings underscore that, unlike digital infrastructure, traditional transport investments do not unambiguously reduce gender disparities in local labor markets.

5 Conclusion

Our study highlights the potential role of the availability of high-quality digital infrastructure in delivering measurable gains in formal employment and productivity, reflected in higher average wages, especially for women. Exploiting the staggered roll-out of fiber cable Internet in Türkiye during the 2010s and using rich administrative worker-level data, we find that high-speed Internet significantly increases employment in occupations amenable to remote work. These aggregate gains are driven predominantly by women, thereby contributing to the narrowing of the gender gap in labor market outcomes. In particular, the availability of high-speed Internet has facilitated an increase in female employment in teleworkable occupations, pointing to work-from-home opportunities as a potential channel. These patterns are consistent with the view that improved digital connectivity disproportionately relaxes constraints faced by women in balancing paid work with household responsibilities and job search frictions, thereby amplifying gender-differentiated responses in occupational mobility.

Our results also suggest that the employment gains for women from the availability of high-quality Internet originated from switches toward teleworkable occupations, rather than from an increase in female labor force participation. While both low- and high-skilled women increased their employment shares, the wage gains were accrued only by high-skilled women. Low-skilled women have transitioned from non-teleworkable to teleworkable jobs, which has increased their employment opportunities but has also led to a decrease in their wages. Conversely, high-skilled women have moved within teleworkable occupations to higher-paying positions, reflecting a positive wage effect for this group.

Overall, our findings highlight how investments in digital infrastructure can be associated with the creation of more and better jobs—those with higher average wages—and with reductions in gender disparities, particularly through the expansion of teleworkable occupations. In contexts where remote work is technologically feasible, broader social acceptance of flexible arrangements, supported by public awareness and dissemination through role models, may help realize these gains. Safeguards for data protection and cybersecurity are likewise important for sustaining trust in digital work environments. Complementary investments in human capital, including targeted training and mentoring, can address digital skill gaps that may otherwise limit access to teleworkable roles. Finally, because much of the observed impact of connectivity operates through occupational mobility, initiatives that improve job matching efficiency and adapt labor market institutions to accommodate flexible work could enhance the inclusivity of employment growth driven by infrastructure roll-out.

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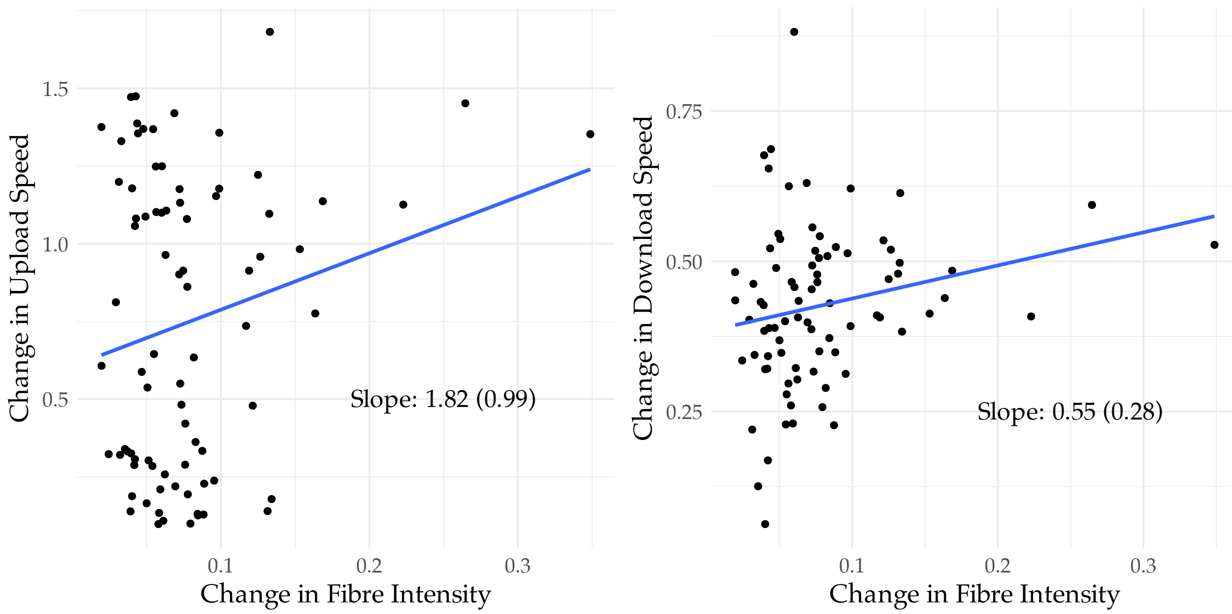
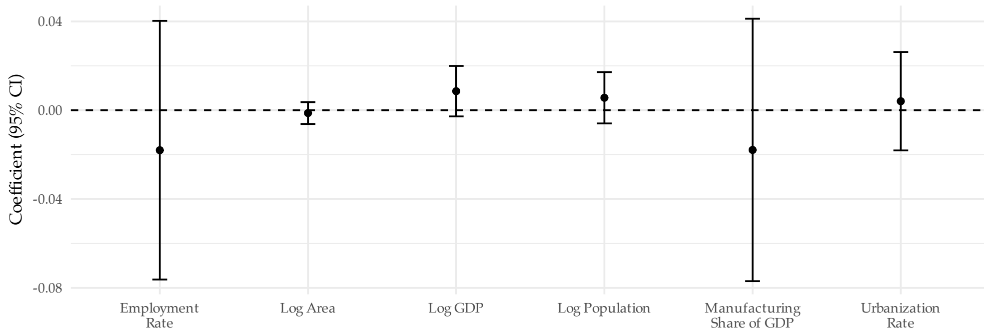
A Additional Tables and Figures

Figure A1: **Correlation of Fiber Intensity with Upload and Download Speeds**



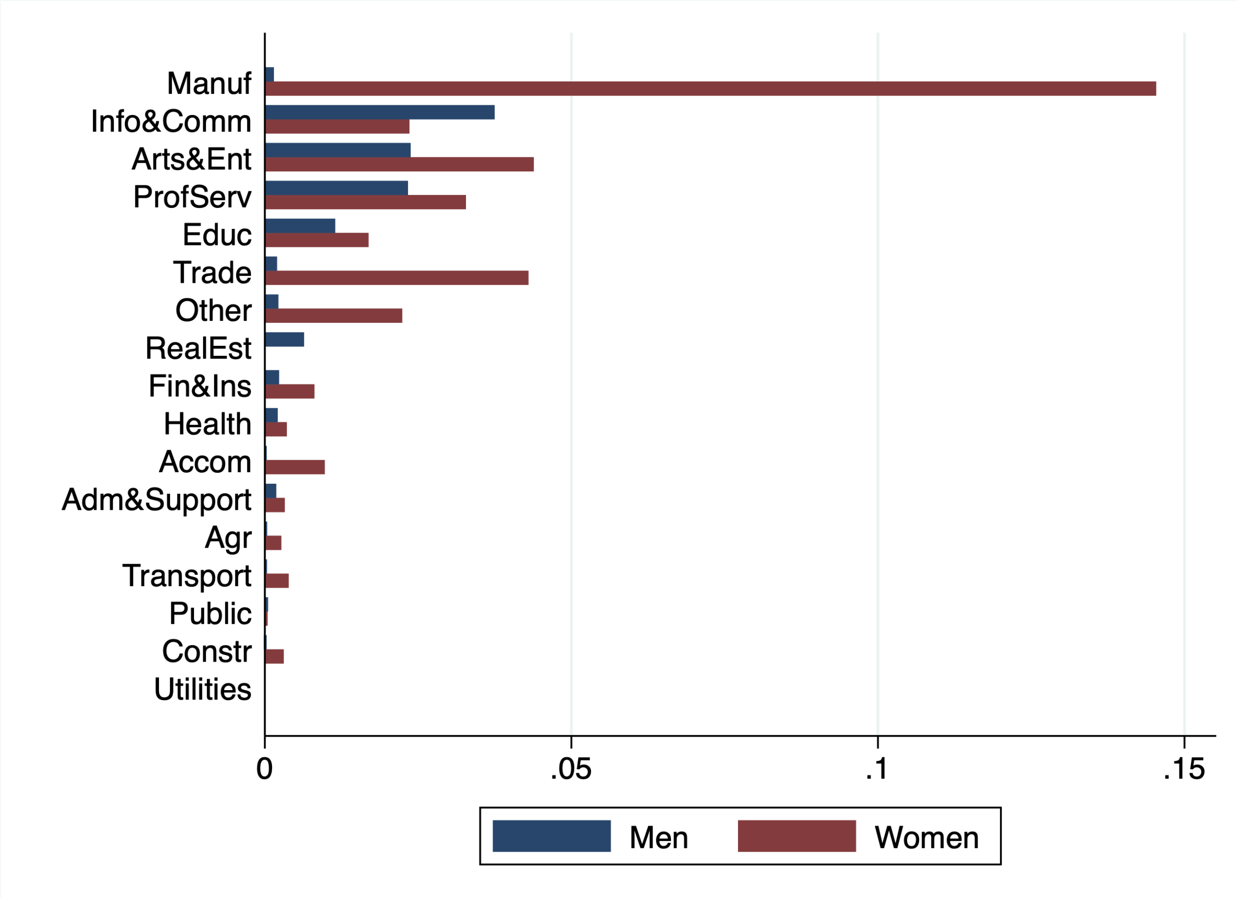
Note: The left panel depicts how change in measured fiber intensity correlates with change in reported upload speeds during the period 2016-2019. The right panel depicts correlation of fiber intensity with reported download speeds. Data on upload and download speeds across Turkish provinces during 2016-2019 was obtained from Ookla, a private firm.

Figure A2: Distance to BOTAS pipelines and Initial Province Characteristics



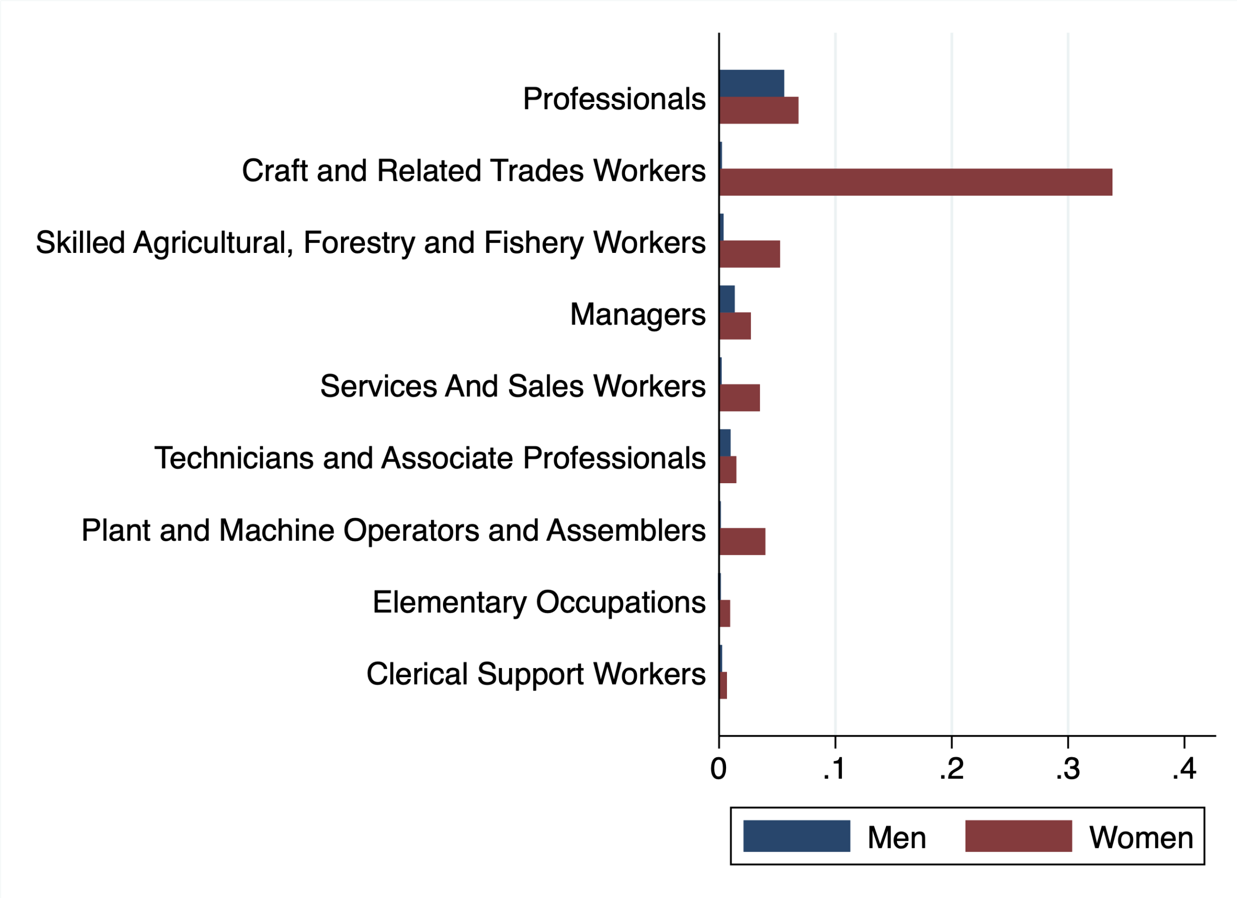
Note: The distance of a province to BOTAS pipelines is constructed as the weighted average of the distances of districts within the province where the district population are used as weights. This figure plots the coefficient estimates and the corresponding 95% confidence intervals obtained from regressing this distance on initial provincial characteristics (pertaining to 2011), controlling for NUTS2 level fixed effects.

Figure A3: WFH Intensity by Industry and Sex



Note: The figure shows the fraction of respondents to the Household labor Survey, who, at least, partly work-from-home.

Figure A4: WFH Intensity by Occupation and Sex



Note: The figure shows the fraction of respondents to the Household labor Survey, who, at least, partly work-from-home.

Table A1: Labor Market Outcomes and High-Speed Internet: Role of Teleworkability

Dependent Variable:	Total employment 2SLS (1)	Average earnings 2SLS (2)	Total employment 2SLS (3)	Average earnings 2SLS (4)
Fiber	1.025***	0.466**		
	(0.341)	(0.203)		
Teleworkability × Fiber	0.143***	0.0598***	0.142***	0.0592***
	(0.005)	(0.006)	(0.005)	(0.006)
Fixed Effects:				
Industry × Occupation × Time	✓	✓	✓	✓
Region × Industry	✓	✓	✓	✓
Region × Time			✓	✓
Observations	3,490,367	3,490,367	3,490,367	3,490,367

Note: * 10%, ** 5%, *** 1% significance levels. Standard errors, clustered at the province level, are reported in parentheses.

Table A2: Female Employment and High-Speed Internet

Dependent Variable: Log of employment						
	OLS		2SLS		2SLS	
	Full sample		Full sample		TW occupations	Non-TW occupations
	(1)	(2)	(3)	(4)	(5)	(6)
Fiber	0.378***		0.834***			
	(0.0844)		(0.275)			
Female × Fiber	0.0364	0.0367	0.0103	0.0105	0.0306***	-0.00998
	(0.0293)	(0.0294)	(0.0122)	(0.0123)	(0.0103)	(0.0151)
Fixed Effects:						
Gender × Occupation × Time	✓	✓	✓	✓	✓	✓
Industry × Occupation × Time	✓	✓	✓	✓	✓	✓
Region × Industry	✓	✓	✓	✓	✓	✓
Region × Time		✓		✓	✓	✓
Observations	3,490,367	3,490,367	3,490,367	3,490,367	1,208,553	2,109,946

Note: Columns 1 and 3 also include time-varying regional characteristics such as GDP per capita. They are not reported to save space. * 10%, ** 5%, *** 1% significance levels. Standard errors, clustered at the province level, are reported in parentheses.

Table A3: Female labor Market Outcomes and High-Speed Internet: Robustness checks

	2SLS	2SLS	2SLS
	(1)	(2)	(3)
Panel A			
Dependent Variable: Share of female employment			
Teleworkability×Fiber	0.0154***	0.025***	0.0289***
	(0.00199)	(0.006)	(0.00666)
Female intensity×Fiber	-0.0178		
	(0.0158)		
High skill×Fiber			0.00143
			(0.00462)
Panel B			
Dependent Variable: Relative female earnings			
Teleworkability×Fiber	0.0327**	0.035**	0.0121
	(0.0134)	(0.014)	(0.0115)
Female intensity×Fiber	0.0653***		
	(0.0143)		
High skill×Fiber			0.0639***
			(0.0108)
Fixed Effects:			
Industry×Occupation×Time	✓	✓	✓
Region×Industry	✓		✓
Region×Time	✓	✓	✓
Region×Industry×Occupation		✓	
Observations	3,490,367	3,490,367	3,490,367

Note: * 10%, ** 5%, *** 1% significance levels. Standard errors, clustered at the province level, are reported

Table A4: Work-from-Home and High-Speed Internet: Effect on women

Dependent Variable:	WFH	Employment	Log of wage
	2SLS	2SLS	2SLS
	(1)	(2)	(3)
Female×Fiber	0.00670***	-0.0262***	0.00664
	(0.00175)	(0.00403)	(0.00607)
Fixed Effects:			
Industry×Occupation×Time	✓	✓	✓
Gender×Occupation×Time	✓	✓	✓
Region×Industry	✓	✓	✓
Region×Time	✓	✓	✓
Observations	650,071	3,595,465	650,071
KP Test stat.	30.05	18.19	30.05

Note: All specifications control for individual characteristics such as gender, age, age squared, education, marital status. They also control for initial income per capita, interacted with annual dummies and with time-varying gender dummies. They are not reported to save space. * 10%, ** 5%, *** 1% significance levels. Standard errors, clustered at the regional-time level, are reported in parentheses.

B Road Infrastructure and Female Employment

In this section, we investigate whether other types of infrastructure investments generate similar effects for women in the labor market. To do so, we exploit the large-scale public investment in roads in Türkiye during 2000s. The aim of the investment project was to expand the lane capacity of existing roads to improve safety and the reliability of travel times on the national transportation network through investments across the country. Specifically, a substantial share of existing two-lane single-carriageways with two-way traffic were upgraded to dual carriageways separated by a small earthen medium, with two-lane one-way traffic on each carriageway.[13]

Such large-scale public investment program could potentially trigger gendered changes in labor market outcomes through a number of channels. *First*, there could be an overall scale effect in Turkish regions, which benefited more from this investment due to improved *market access*. To the extent that the newly generated employment opportunities have a gender bias, this could affect relative female employment and wages. *Second*, road investments could lead to across district *agglomeration spillovers* because shorter inter-district commuting times increase women's ability to engage in employment opportunities outside of their home districts. *Lastly*, if better connected districts are in the vicinity of other populated districts, then it may crowd out opportunities for local females due to *competition effect*. Therefore, the overall effect of reductions in travel times generated by this large-scale road investment project on female labor market outcomes is ambiguous.

To investigate whether the road investment program generated heterogeneous employment effects for men and women, we estimate the following specification:

$$\begin{aligned} \Delta(\text{Share of female employment})_{ds} &= \mu_1 \Delta \ln(\text{Travel time})_d^{Wgt} + \mu_2 \ln \text{Distance}_d^{Wgt} \quad (10) \\ &+ \mu_3 \Delta \ln(\text{Commute time})_d \\ &+ \mu_4 \Delta \ln(\text{Population within 2hr commute time})_d \end{aligned}$$

[13] See Cosar et al. (2021) for details of the investment program.

$$+ \quad \alpha_s + \alpha_p + \epsilon_{ds},$$

where the dependent variable is the period change (i.e. 2006-2016) in the ratio of female employment to total employment in industry s and district d.[14] Aggregate province- and industry-level changes are controlled by including α_p and α_s. $\ln \text{Distance}_d^{Wgt}$ and $\ln (\text{Travel time})_d^{Wgt}$ denote the population-weighted average of bilateral distance and period-change in bilateral travel times at the district level.[15] The former controls for the initial connectivity of districts while the latter is one of our variable of interest which is inversely related to changes in market access. Since our specification controls for provincial fixed effects and initial remoteness of the district, we exploit "unexpected" or "random" variation in improvements in remoteness of the district due to the road infrastructure investments.

The third variable, $\Delta \ln (\text{Commute time})_d$, is the change in the logarithm of travel time to the most populated district within a two-hour commute time. This captures the improvements in job opportunities nearby for individuals living in district d. The last variable, $\Delta \ln (\text{Population within 2hr commute time})_d$, captures the change in the potential workforce living within a two-hour commute from district d. We expect $\mu_3 > 0$ as women could be more sensitive to commute times than men. The sign of μ_4 is ambiguous as it captures the competition in the labor market. If female workers are less able to stand competition from nearby districts, the sign of the coefficient would be negative.

We exclude from the estimation sample the four provinces with highways in the beginning of the period, namely Ankara, Istanbul, Izmir, and Mersin. Standard errors are clustered at the province level.

Results are presented in Table A5. In the first two columns, the outcome of interest is the period change in the share of female employment. The first column only includes our proxy for change in the weighted average of travel times and initial remoteness of

[14] Türkiye is administratively divided into 81 provinces, which are further divided into districts.

[15] The empirical specification as well as the construction of variables of interest follow the approach in Cosar et al. (2021).

Table A5: Share of Female Employment and Improvements in Market Access

Dependent Variable: Change in female	employment share (1)	employment share (2)	relative earnings (3)	relative earnings (4)
Δ ln (Travel time)^{Wgt}	-0.133	-0.605**	-0.429	-0.584
	(0.246)	(0.279)	(0.325)	(0.464)
ln Distance^{Wgt}	-0.00423	-0.0122**	-0.00938	-0.0126
	(0.00593)	(0.00603)	(0.0112)	(0.0115)
Δ ln (Commute time)		0.0833***		0.0189
		(0.0297)		(0.0407)
Δ ln (Population within 2hr commute time)		-0.0157*		-0.00807
		(0.00935)		(0.0167)
Fixed Effects:				
Province	✓	✓	✓	✓
Industry	✓	✓	✓	✓
Observations	6292	6292	6292	6292

Note: * 10%, ** 5%, *** 1% significance levels. Standard errors, clustered at the province level, are reported in parentheses.

district. The estimated coefficient on the former has the expected sign but it is not statistically significant. This could be due to the omission of measures that capture changes in commuting costs as they are correlated with the change in market access. The second column shows the estimated coefficients from the full model. The coefficient on the market access variable is negative and statistically significant, implying that improvements in market access are associated with an increase in female employment share. By comparison, shorter commute times to the most populated district increase women's employment opportunities across districts, thereby reducing their share within the home district. This is consistent with the hypothesis that women are more sensitive to commute times and can seek employment opportunities in nearby locations when commute times improve. Finally, the competition effect, induced by reductions in commuting times to d from nearby districts, seems to hurt female workers more. The crowding out effect we find in our empirical setting is consistent with the existing literature, e.g. Chandra and Thompson (2000) – despite the lack of focus on gender-specific effects, and more recently with the results in Erten and Keskin (2021).

Using the estimates, we calculate a size-weighted, that is, size being measured in terms of the initial district-level population, aggregate effect of reduced inter-district travel times on the share of female employment. We find the effect to be about 6 percentage points, which is slightly less than a third of the aggregate female employment share in Türkiye.

In columns 3-4 of Table A5, the dependent variable is the period change in relative earnings of female workers in an industry-district pair. The estimated effects on wages have the same sign as those on employment. However, they are imprecisely estimated.

Overall, what we learn from this exercise is that when comparing the effects of road infrastructure investments with that of digital infrastructure in reducing gender disparities, our analysis suggests that the latter has a clear positive impact on female labor market outcomes, the impact of road infrastructure is more nuanced. Improvements in market access through road infrastructure are associated with an increase in female employment share, shorter commute times to the most populated district and competition effects from proximate districts can reduce female employment share within the district.