Vergroot een betere bereikbaarheid de kans op werk? De rol van vervoer op de Nederlandse arbeidsmarkt.

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Bijdrage aan het Colloquium Vervoersplanologisch Speurwerk
21 en 22 november 2019, Leuven

Samenvatting

De voorbije decennia heeft in Nederland, net als in veel westerse landen, een sterke suburbanisatie van werkgelegenheid plaatsgevonden naar bedrijventerreinen aan stadsranden en langs snelwegen. De toegang tot banen is hierdoor voor autobezitters meestal veel hoger dan voor mensen die afhankelijk zijn van het openbaar vervoer, niet alleen vanwege de langere deur-tot-deur reistijden maar ook omdat veel van deze perifere werklocaties slecht bediend worden door traditionele openbaarvervoersdiensten.

De WRR concludeerde onlangs in *De sociale waarde van infrastructuur* dat beleidsaandacht op zijn plaats is, omdat deze ongelijkheid in toegang tot banen kan leiden tot beperkte ontplooiingsmogelijkheden voor vooral lagere inkomensgroepen en onderbenutting van het arbeidspotentieel. De veronderstelde relatie tussen de bereikbaarheid van banen en de kans op werk is in Nederland echter niet eerder onderzocht en het is ook onduidelijk in hoeverre verschillende groepen hiervan kunnen profiteren.

Dit is de eerste studie in Nederland waarin is onderzocht of een betere bereikbaarheid van banen ook daadwerkelijk de individuele kans op werk vergroot en welke gebieden en groepen hier baat bij hebben. Daarvoor zijn verschillende bereikbaarheidsmaatstaven voor de auto, het openbaar vervoer en fiets gecombineerd met nationale microdatasets van de beroepsbevolking en voertuigbezit in een werkgelegenheidsmodel voor Nederland. Ieder individu in het model kon hierdoor een uniek bereikbaarheidsniveau worden toegekend op basis van hun woonlocatie en voertuigbezit, terwijl daarbij corrigeerd is voor causaliteit en voor diverse persoons- en huishoudenskenmerken.

De studie laat zien dat zowel een betere openbaar vervoerbereikbaarheid als betere autobereikbaarheid van banen de individuele kans op werk vergroot, met name in (rand)stedelijke gebieden en bij huishoudens met een laag inkomen. In het landelijk gebied is de bereikbaarheid daarentegen vaak te laag om de kans op werk te vergroten, ook onder voertuigbezitters. Het laat verder zien dat vooral jongeren en laaggeschoolde groepen sterk kunnen profiteren van een betere openbaar vervoerbereikbaarheid, terwijl onder voertuigbezitters vooral oudere leeftijdsgroepen en zowel laag- als hoger opgeleiden kunnen profiteren van een betere autobereikbaarheid.

Deze bevindingen zijn belangrijk vanuit het oogpunt van overheidsbeleid en vervoersdiensten, omdat ze laten zien dat werkzoekenden kunnen profiteren van een verbeterde bereikbaarheid van banen, zeker wanneer dit aansluit op hun sociaal-economische profielen en woonlocatie. Overheidsinterventie kan hierbij nodig zijn, omdat vooral lagere inkomensgroepen die afhankelijk zijn van openbaar vervoersdiensten vaak niet zelf hun bereikbaarheid van banen kunnen verbeteren door bijvoorbeeld een auto aan te schaffen. Bovendien zouden ook mensen die nu nog met de auto reizen kunnen profiteren van verbeterde openbaar vervoersvoorzieningen.

1. Introduction

In recent decades the Netherlands, as many Western countries, has witnessed a strong suburbanisation of employment to peripheral locations and near motorways (Hamers and Nabielek, 2006). As a result, access to jobs for vehicle owners is typically much higher than for public transport users, not only due to higher door-to-door travel times but also because many of these peripheral job locations are often poorly served by traditional public transport services; only 16% of all jobs in the Netherlands are located within close proximity of public transport stops (PBL, 2012). For job seekers who rely on public transport it can therefore be more difficult to access and gain jobs (Bastiaanssen and Martens, 2013).

The Dutch Scientific Council for Government Policy (WRR) recently advised the Dutch government that poor access to jobs may reduce both the participation of people in society and the full utilization of the potential labour force, arguing that inequalities in job accessibility should be considered in public policies (WRR, 2018). To date, however, the assumed relationship between levels of job accessibility and employment outcomes has not been scientifically proven in the Netherlands, and it is also unclear whether both public transport users and vehicle owners benefit from better access to jobs, given the existing high levels of car job accessibility. This current study is the first micro-based study in the Dutch context to examine whether better job accessibility helps both public transport users and car owners to actually get a job, and identifies which areas and population groups would benefit the most.

The relationship between job accessibility and individual employment probabilities, i.e. job uptake, has been extensively studied in mainly US metropolitan areas and more recently in some EU cities, as previously discussed (Bastiaanssen et al., 2019b). In summary, while access to a car is typically found to significantly improve employment outcomes, in particular among welfare recipients (e.g. (Cervero et al., 2002, Shen and Sanchez, 2005, Blumenberg and Pierce, 2017), car-based job accessibility has been found mainly important for some low-educated groups and low- to middle income groups in US metropolitan areas (e.g. (Parks, 2004, Hu, 2016), while public transport job accessibility typically yields positive effects among public transport captives in European cities while these effects are mixed in the US (e.g. (Cervero and Tsai, 2003, Kawabata, 2003, Matas et al., 2010, Bastiaanssen et al., 2019a). It is, however, unclear whether the same patterns would hold in the Netherlands, which has less peripheral urbanization and decentralization, an extensive bicycle and public transport infrastructure, as well as a less polarized socio-economic structure compared to many US and European countries.

In this study, we have therefore combined detailed local-area car and public transport job accessibility measures with a national individual-level employment micro dataset and vehicle registration data, which was accessed by special permission from Statistics Netherlands under Secure Lab conditions, so that each individual in the dataset could be allocated a unique measure of job accessibility based on their access to a private vehicle.

Next, we corrected for transport endogeneity between car ownership, job accessibility and employment outcomes in our models by sorting all individuals in stratified samples of 'vehicle owners' and 'non-vehicle owners', and then applied an instrumental variable

approach to control for endogeneity between our job accessibility measures and individual employment probabilities. We further controlled for residential endogeneity by including only long-term residents in the sample. We then estimated the impact of job accessibility on individual employment probabilities in a locally-specific, national employment model for the Netherlands to examine differential impacts of job accessibility on employment for public transport users and vehicle owners in different area types and for various groups. This allowed us to address whether the employment probabilities of individual job seekers were influenced by accessibility and to what extent urban or rural areas and various population groups would benefit from public transport strategies targeted at providing better access to jobs.

2. Data and methods

In this section of the paper, we describe in paragraph 3.1 our individual employment probability model for the Netherlands, including controls for transport and residential endogeneity in paragraph 3.2.

2.1 Employment probability models

We use a cross-sectional employment micro dataset for the Netherlands to examine whether better job accessibility increases individual employment probabilities of public transport users and vehicle owners, and which areas and groups would benefit most. The usage of individual-level employment microdata allowed us to allocate each individual in the dataset a unique measure of their level of public transport accessibility to employment opportunities from their area of residence, while controlling for personal and local characteristics that may contribute to employment differentials.

Following previous studies (Matas et al., 2010; Bastiaanssen et al., 2019) we employed binomial probit models to explain the relationship between job accessibility and individual employment probabilities, which can be expressed as follows:

$$EP_{ik} = \int (I_i, N_i, A_{ik})$$

where EP_i represents the employment probability for individual i (1 = employed, 0 = unemployed) with mode k as a function of: I_i are individual and household characteristics for individual i; N_i are the neighbourhood characteristics for individual i; and A_{im} representing the local accessibility levels for individual i, by mode k.

The dependent variable and all individual and household explanatory variables were constructed from the Dutch Labour Force Survey (Enquête Beroepsbevolking, EBB) of 2016, which was accessed under Secure Lab conditions by special permission from Statistics Netherlands (CBS, 2019). The EBB micro dataset consists of a sample survey that annually covers approximately 394.000 individuals aged 15 and over and provides detailed information on current or past employment together along with detailed personal and household information. Since we are interested in the employment status of individuals, we excluded students and individuals outside the labour force (i.e. inactive individuals) from our dataset, as well as individuals who could not be assigned a PC4 code of residence, resulting in a total of 179,157 individuals. As the EBB includes annual

population weights, our employment model allows us to provide estimates of employment rates for the Netherlands.

Since access to jobs for vehicle owners is typically much higher than for public transport users, we examined the different employment sensitivities to accessibility (and other variables) for people with and without access to private vehicles. For this purpose, we matched the EBB with a national vehicle registration dataset (RDW) for 2016 to identify individuals with household access to a car, van or motorcycle ('vehicle owners'). Table 1 shows the explanatory variables that are included as dummy or continuous variables in the separate models for non-vehicle owners and vehicle owners. The non-vehicle owners experience substantially lower levels of employment, while being typically younger and more disadvantaged as compared to the vehicle owners.

Table 1. Descriptive statistics and expected effects of employment models

Variables		**Non-vehicle owners**	**Vehicle owners**	**Expected effects**
	Continuous or dummy measure	Mean (SD)	Mean (SD)	
Dependent variable				
Employed (1); unemployed (0)		87.7%	94.7%	
Individual & Household variables				
Age	*(continuous)*	37.1 (23.453)	42.8 (22.791)	**+**
Age squared	*(continuous)*	1534.3 (2163.845)	1979.9 (1899.275)	**-**
Female	*(dummy)*	45.7% (0.498)	45.5% (0.450)	**-**
Low educated	*(dummy)*	12.8% (0.423)	13.6% (0.422)	**-**
Non-Western migrant	*(dummy)*	13.5% (0.395)	7.1% (0.296)	**-**
Unemployment history	*(dummy)*	22.6% (0.376)	16.1% (0.318)	**-**
Young children < age 12	*(continuous)*	0.3 (0.834)	0.5 (0.931)	**-**
Single household	*(dummy)*	40.6% (0.492)	11.3% (0.308)	**-**
Single parent household	*(dummy)*	8.7% (0.247)	3.9% (0.157)	**-**
Neighbourhood & accessibility variables				
Percent unemployed (excl. students)	*(continuous)*	8.6% (0.067)	6.9% (0.056)	**-**
Public transport job accessibility	*(continuous)*	305.248 (0.160)		**+**
Car job accessibility	*(continuous)*		1.189.608 (0.548)	**+**
N		25.606	153.551	

Source: EBB 2016, CBS

In line with the Dutch labour force statistics (CBS, 2016), we expected age to increase individual employment probabilities as youth unemployment is relatively high in the Netherlands. This age effect is assumed to diminish with each additional year as reflected by the age squared variable, which we divided by 100 to normalise coefficients, as the overall gross labour participation decreases particularly from the age of 55. The employment prospects of women are likely to be lower than men, which follows from their relatively low gross labour participation; in 2016 this was 65.1% for women compared to 74.9 % for men (CBS, 2016). Being lower educated or a non-Western migrant is also related to a relatively low gross labour participation of respectively 47.0% and 56.3% (compared to 69.7% and 80.3% for middle- and higher educated, and 67.4% for Dutch-born), which is typically attached to less marketable employment skills and higher overall job competition. Other than previous studies, we also included a dummy for unemployment history (ever been unemployed since age 15), which is likely to lower employment prospects as it may make individuals less attractive for employers. The number of dependent children (aged < 12) in the household is further expected to reduce employment prospects due to increased caring responsibilities and we assess the differential effects of being a single household or single parent household, which are likely to increase financial constraints and decrease the size of the social networks that can be used for job search. We further constructed a neighbourhood variable based on the percent unemployed (excluding students) in each PC4 area, as increased job competition and adverse social effects are expected to decrease employment prospects.

We next used gravity-based car and public transport job accessibility models in this study[i], for which we combined a national employment micro dataset for 2016 (LISA, Landelijk Informatiesysteem Arbeidsplaatsen) with car and public transport travel time datasets developed by Pritchard et al. (2019) for all 4,071 four-digit postcode areas (PC4s) in the Netherlands. Note that our job accessibility measures do not include employment opportunities in neighbouring countries, as this would generate unrealistic results: in 2012, only 17.000 workers living in the Netherlands had a job in Belgium or Germany, which is less than 0.3% of the Dutch working population (CBS/PBL, 2015). We subsequently matched the accessibility models under Secure Lab conditions to each individuals' PC4 code of residence in our EBB dataset and divided these by 1,000,000 to normalise coefficients. The public transport job accessibility measure incorporates cycling as a potential access mode to the main train stations if this is faster than walking or public transport, and uses cycling as an alternative for public transport when destinations up to 30 minutes away can be reached in less travel time, which is a typical mode combination in the Netherlands (COS, 2010). The car accessibility measure is based on the road network and uses real traffic speeds for road segments provided by TomTom.

Since the EBB does not provide information on the actual mode use of individuals, we analysed the modal split for travel-to-work purposes by household vehicle-ownership using the 2016 National Travel Survey (OVIN, Onderzoek verplaatsingen in Nederland): this clearly showed that people with access to a household vehicle mainly use a vehicle for 56.8% of their work-related trips, and to a lesser extent a bicycle (20.1%) or public transport (16.5%), while people without household vehicles predominantly rely on public transport services for 52.8% or cycling (29.4%) and only to a small extent use (shared) vehicles (6.1%). The vehicle owners were therefore assigned the car job accessibility measure, whereas the non-vehicle owners were assigned the public transport job

accessibility measure. Note that this modal-split represents a rather conservative estimation of non-vehicle usage for work-related trips, as it underrepresents the unemployed who may rely more often on public transport services to travel to distant job interviews and employment locations.

Table 1 shows the substantial difference in job accessibility levels between non-vehicle owners and vehicle-owners: the number of jobs which can be accessed by public transport is on average a factor of 4 lower than by car, which clearly puts people without access to a private vehicle at a relative disadvantage in the labour market. As public transport usage varies between urban and rural areas and among different population segments we assigned our accessibility measures for subsequent subgroup-analysis based on their modal split. Both accessibility variables are included as continuous variables in the model.

2.2 Controlling for transport and residential endogeneity

To control for endogeneity between accessibility and employment, we followed a strategy used by Hu (2016) and Bastiaanssen et al. (2019a) by applying an instrumental variable (IV) approach. We used the percentage of the population without household vehicles in each PC4 as an instrument for car job accessibility and the population densities in each PC4 to instrument for public transport job accessibility. These instruments were exogenous to employment, a requirement for using the IV approach, and only correlated with employment through the accessibility measure. We also experimented with instruments for vehicle ownership based on car insurance premiums as applied by Raphael and Rice (2002), but this proved insignificant.

To assess the impact of job accessibility on individual employment probabilities, each employment model was estimated in two stages. In the first stage model accessibility A_i was estimated as a function of all individual and household variables I_i and the neighbourhood variable N_i plus our instrumental variable(s). In the second stage model, employment is estimated as a function of all I_i and N_i variables plus the predicted value of accessibility, A_i, from the first stage regression.

Linking individual employment outcomes to the effects of public transport job accessibility also raises the issue of residential endogeneity (Glaeser, 1996), also referred to as self-selection bias (Gao et al., 2007). Following previous studies (e.g. (Korsu and Wenglenski, 2010) we dealt with residential endogeneity by restricting our sample to long-term residents that have not changed housing locations over a period of 10 years, of which the residential location choice can be considered as exogenous to the current employment status.

3. Results and discussion

In this section of the paper, we report and discuss the inferences of the coefficients of the second stage probit models in which job accessibility is the predicted variable from the first stage model using our instrumental variable(s). Table 2 shows our employment models for non-vehicle owners and vehicle owners in the Netherlands. From the resulting Wald Chi-Squared statistics of exogeneity from these models we reject the null

hypothesis of exogeneity (i.e. job accessibility is found endogenous with employment) and report the estimates from the two stage model, which use the estimated job accessibility from the first stage model.

Table 2. Individual employment probabilities stratified by vehicle ownership

Variables	**Coefficients (SE)**		**Elasticities: +10% accessibility**
	Non-vehicle owners model	Vehicle owners model	
Dependent variable			
Employed (1); unemployed (0)			
Individual & Household variables			
Age	0.064*** (0.007)	0.084*** (0.003)	
Age squared/100	-0.076*** (0.000)	-0.101*** (0.000)	
Female	-0.124*** (0.027)	-0.239*** (0.013)	
Low educated	-0.230*** (0.037)	-0.145*** (0.017)	
Non-Western immigrant	-0.330*** (0.038)	-0.337*** (0.026)	
Unemployment history	-0.456*** (0.028)	-0.469*** (0.015)	
Young children (< age 12)	-0.004 (0.021)	0.036*** (0.009)	
Single household	-0.286*** (0.029)	-0.106*** (0.021)	
Single parent household	-0.380*** (0.042)	-0.158*** (0.030)	
Neighbourhood & accessibility variables			
Percent unemployed (excl. students)	-6.035*** (0.207)	-4.761*** (0.100)	
Estimated public transport job accessibility	0.493*** (0.087)		**0.015**
Estimated car job accessibility		0.283*** (0.031)	**0.018**
Constant	0.859*** (0.137)	0.283*** (0.031)	
Wald Chi-Squared statistic	1661.09***	4967.68***	
Wald Chi-Squared statistic of exogeneity	12.42***	82.51***	
N	25.606	153.551	
Mean job accessibility level	305.248	1.189.608	
Mean employment rate	87.7%	94.7%	

Significance levels: *: 0.05%, **: 0.01%, ***: 0.001%

In line with the Dutch labour force statistics (CBS, 2016), among the individual variables, a higher age slightly improves individual employment probabilities as young people may lack relevant work experience while competing for jobs, but this effect diminishes with each additional year of age, as indicated by the negative coefficient for age squared/100. Being a female also decreases employment prospects, which seems to follow from their

relatively low gross labour participation. This negative effect is stronger for vehicle owners, as women in this group are relatively older and lower educated.

Being low educated or a non-Western immigrant also lowers individual employment probabilities, but particularly unemployment history decreases the employment prospects of both groups. Having been unemployed in the past may make individuals less attractive for employers and is related to lower levels of education. Of the household variables, having more dependent children is not significant for the non-vehicle owners and even shows a positive sign for the vehicle owners, which seems to be in line with recent findings (CBS, 2016) that both women and men get children at a later age, and often only when a job is already secured. A more influential variable is whether a person is single or more importantly a single parent, which significantly decreases employment prospects of mainly non-vehicle owners. Having a partner may relieve some financial constraints and potentially provides a social network through which employment can be sought, while single parent households are clearly more constrained in their job uptake.

The percentage unemployed in each neighbourhood (excluding students) further significantly decreases employment prospects, in particular among non-vehicle owners. As they often reside in neighbourhoods with relatively high unemployment rates, they may experience higher job competition by other job seekers for relatively fewer employment opportunities.

The estimated job accessibility variables show a significant positive sign, indicating that both non-vehicle owners and vehicle owners would benefit from higher levels of job accessibility. We derived employment elasticities to illustrate how sensitive employment probabilities are to changes in accessibility based on a 10% increase in job accessibility levels[1]. For the non-vehicle owners, a 10% increase in public transport job accessibility yields an employment elasticity of 0.015, which would imply a 0.15% increase in their employment rate. For vehicle owners a corresponding employment elasticity of 0.018 was estimated based on a 10% increase in car job accessibility, which would be related to a 0.18% increase in their employment rate. These employment elasticities seem small, but this would imply that over 2,100 non-vehicle owners and 10,400 vehicle owners would move into employment following a 10% improvement in job accessibility. Note that the marginally higher employment sensitivity of vehicle owners follows from the much higher absolute (changes in) car job accessibility; while vehicle-owners are also sensitive to changes in public transport job accessibility this would yield a much lower employment elasticity of 0.005. The relatively lower sensitivity of non-vehicle owners to public transport job accessibility changes can further be explained by the relatively strong negative effects of being a single (parent) household and residing in disadvantaged neighbourhoods on their employment probabilities. This raises the question which areas and population groups would be most sensitive to job accessibility changes, and to what extent both vehicle owners and non-vehicle owners would benefit.

[1] Employment elasticities were calculated in STATA 15 using the model coefficients for the average individual in the models of non-vehicle owners and vehicle owners, in which we increased the estimated job accessibility levels by 10% while keeping all other variables constant.

Since public transport services are mainly concentred in the main corridors of city centres while people in rural areas often depend on their private vehicle, we may assume that public transport job accessibility yields the largest effects in urban areas, while car job accessibility could be more important in rural areas. We examined the role of job accessibility in different area types in the Netherlands, based on the official levels of urbanisation[2] distinguished by Statistics Netherlands. For all employment models in the highly urban to moderately urban areas we were able to reject the null hypothesis of exogeneity and report the estimates from the two stage model which use the estimated job accessibility from the first stage model (Table 3).

Table 3. Individual employment probabilities by urbanisation level

	Non-vehicle owners models	**Vehicle owners models**
Very high urban	0.037	0.068
High urban	0.050	0.156
Moderate urban	0.044	0.155
Low urban	NA	NA
Non-urban	NA	NA

For non-vehicle owners a 10% increase in public transport job accessibility yields an employment elasticity of 0.037 in very highly urban areas, which further increases in highly urban and moderately urban areas with respective employment elasticities of 0.050 and 0.040. This pattern seems to follow from the relatively low public transport job accessibility levels in highly urban and moderately urban areas, while employment rates are only marginally higher. Public transport job accessibility is non-significant in low urban and non-urban areas, where job accessibility levels may simply be too low to yield differential employment effects. For the vehicle owners we find a similar pattern, with an employment elasticity of 0.068 in very highly urban areas following a 10% car job accessibility increase, which increases in highly urban and moderately urban areas with respective employment elasticities of 0.156 and 0.155, whereas job accessibility levels in low urban and non-urban areas are non-significant. While people who reside in the urban periphery thus appear most sensitive to job accessibility changes, we may assume that this varies for different population groups, which we examine in the next sections.

3.1 The impact of job accessibility by household income quintile

As people from low-income households often experience higher unemployment rates and are more likely to reside in disadvantaged neighbourhoods, where poor transport services and lack of employment opportunities can further decrease their employment prospects, we may assume that individuals in the lowest income quintiles are more sensitive to job accessibility changes. To assess the effect of job accessibility by household income quintile we used a matching income dataset from Statistics Netherlands to group each individual in national income quintiles, based on their net disposable income.

For all employment models we reject the null hypothesis of exogeneity and report the estimates from the two stage model, which use the estimated job accessibility from the

[2] The urbanisation levels rank from 5 (very highly urban) to 1 (non-urban), based on the number of addresses per km2.

first stage model (Table 4). The variables in the models demonstrate a significance in line with the findings in our previous models, but with non-significant associations between employment and age and low education for mainly the lower income quintiles. As age and level of education increase with the level of income, this could mean that these associations are poorly estimated. For the non-vehicle owners, a 10% increase in public transport job accessibility yields the largest employment elasticity of 0.097 for the lowest income quintile, for whom from their very low employment rate of 70.7% will be more sensitive to job accessibility changes. The second income quintile is the only group where public transport job accessibility is non-significant, and for whom having young children and a higher age have a negative association with employment, which may result from a stronger job competition by younger age groups and a higher a (financial) burden of child care. This group may also benefit less from income-based subsidies, including social housing, as these tend to be restricted to the lowest income quintile. For the third and fourth income quintiles, we find a significant but decreasing importance of public transport job accessibility which yields employment elasticities of 0.016 and 0.014, while this is non-significant for individuals in the fifth income quintile. This is likely to result from their much higher employment rates that will be insensitive to job accessibility changes.

Table 4. Individual employment probabilities by household income quintile

	Non-vehicle owners models	**Vehicle owners models**
80-100% quintile	NA	0.009
60-80% quintile	0.014	0.016
40-60% quintile	0.016	0.038
20-40% quintile	NA	0.048
0-20% quintile	0.097	0.108

For the vehicle-owners we find a similar pattern, with a 10% increase in car job accessibility yielding the largest employment elasticity of 0.108 for the lowest income quintile (for whom the employment rate is only 70.7%), while this decreases with increasing employment rates to respectively 0.048 and 0.038 for the second and third income group and to 0.016 and 0.009 for the fourth and fifth income group. This clearly shows the decreasing importance of job accessibility with increasing income levels.

3.2 The impact of job accessibility by age and education

To further scrutinize the impact of job accessibility on individual employment probabilities, we conducted population subgroup analyses based on different age groups (15-24, 25-39, 40-54, 55-67) and three different educational levels (low-, middle-, high educated), based on the official educational categorisation (CBS, 2016).

As for the age groups for non-vehicle owners, a 10% increase in public transport job accessibility yields an employment elasticity of 0.051 for youths aged 15-24 and 0.513 for young people aged 25-39, while this is non-significant for the older age groups (Table 5). This would imply that over 1,200 youths aged 15-24 and 30,500 young people aged 25-39 could move into employment, following a uniform 10% increase in public transport job accessibility. We assume that other factors such as skills-mismatches may be more important for older age groups. For the vehicle owners, on the other hand, a 10% increase in car job accessibility is non-significant for youth aged 15-24, for whom other factors than

transport such as lack of work experience and education may be more important (we also found non-significance for those aged 18-24 and when using an individual vehicle dummy). A 10% increase in car job accessibility does yield small positive employment elasticities of respectively 0.016 for young people aged 25-39 and 0.010 for those aged 40-54, and increases to 0.028 for those aged 55-67. This clearly shows that youth and young people without a household vehicle could benefit from improved public transport job accessibility, while older age groups with access to a household vehicle seem to benefit most from improved car job accessibility.

Table 5. Individual employment probabilities by age group

	Non-vehicle owners models	Vehicle owners models
Age 55-67	NA	0.028
Age 40-54	NA	0.010
Age 25-39	0.513	0.016
Age 15-24	0.051	NA

When looking at the education levels for non-vehicle owners, a 10% increase in public transport job accessibility yields the highest employment elasticity of 0.033 for low-educated individuals, for whom from their relatively low employment rate of 83.1% will be more sensitive to job accessibility changes (Table 6). The employment elasticities for middle and higher educated individuals are somewhat lower with respectively 0.005 and 0.015, who experience on average higher employment rates and job accessibility levels.

Table 6. Individual employment probabilities by educational level

	Non-vehicle owners models	Vehicle owners models
High educated	0.015	0.020
Middle educated	0.005	0.014
Low educated	0.033	0.023

For vehicle owners we find a similar but less clear pattern, with an employment elasticity of 0.023 for low-educated individuals in response to a 10% increase in car job accessibility, who experience a relatively low employment rate of 92.2%, while the employment elasticities of middle and higher educated individuals are respectively 0.014 and 0.020. We may therefore infer that in particular low-educated individuals without a household vehicle are sensitive to public transport job accessibility changes, whereas among the vehicle owners both low educated and higher educated individuals are most sensitive to car job accessibility changes.

4. Conclusions: Public policy implications

This study aimed to examine whether better job accessibility helped both public transport users and vehicle owners to get a job, using individual micro-level employment data of the Netherlands. The combination of national employment microdata with a vehicle registration dataset is unique to this study. It allowed us to assess the differential employment effects of job accessibility for individuals with and without household vehicles within our models. The nature of the dataset further allowed us to examine which areas and subgroups would benefit most from better job accessibility.

The key findings of our study are that while individuals with access to private vehicles are more likely to be employed, higher levels of car and public transport job accessibility could increase the employment probabilities of both individuals with and without vehicles. We also find similar patterns of employment sensitivities to job accessibility changes for individuals with and without vehicles when looking at different areas and population groups. In particular individuals residing in highly urban to moderately urban areas are found to benefit from higher levels of car and public transport job accessibility, while in low urban and non-urban areas job accessibility levels seem too low to have differential employment effects, even among the vehicle-owners.

Our study further shows that in particular individuals in the lowest household income quintiles benefit from better car and public transport job accessibility, for whom the relatively low employment rates among both non-vehicle owners and vehicle owners are more sensitive to job accessibility changes. In both groups the employment effects of job accessibility decrease with increasing income levels.

In terms of age, youth and young people without a household vehicle could strongly benefit from improved public transport job accessibility, while older age groups with access to a household vehicle seem to benefit most from improved car job accessibility. We also find that in particular low-educated individuals without a household vehicle are sensitive to public transport job accessibility changes, whereas among the vehicle owners both low- and higher educated individuals are sensitive to car job accessibility changes.

The findings of our study are particularly important from a public policy and service operation point of view because they imply that job seekers may benefit from tailored public policies to improve their public transport and car accessibility to employment when fitting their demographic profiles and residential location. In turn, this could increase both the participation of people in society and the full utilization of the potential labour force, as alluded to by the Dutch Scientific Council for Government Policy (WRR, 2018).

As our job accessibility measures reflect both the quality of the transport and land use system, an increase in job accessibility levels could potentially be achieved through improvements in routing, speeds and frequencies, and integration of transport as well as by bringing employment opportunities closer to unemployed people. This also relates to the cost of public transport fares and vehicle-related costs that can be a significant barrier for job uptake, in particular among lower income groups. It can be argued that public intervention is necessary, as in particular those who are dependent on public transport services often cannot personally increase their accessibility by purchasing cars. It would require further case study research to establish for which specific areas and population groups such measures would derive the greatest benefit.

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[i] The standard gravity-based accessibility measure was implemented that can be expressed as follows:

$$A_{ik(t)} = \sum_{j} E_{jk(t)} f\left(C_{ijk}\right)$$

Where Aik is the level of job accessibility in neighbourhood i, by mode k, at time t; Eik(t) reflects the number of employment opportunities (total employment) available in destination areas j, at time t, by mode k; and f(Cijk) represents the distance decay function of travel time between area i and area j, by mode k.
Public transport job accessibility is estimated using a general transit feed specification (GTFS) dataset ArcGIS to compute optimal routing algorithms for journeys between all population weighted PC4s, including access time to a stop/ station, waiting time at a stop or station, in-vehicle travel time, transfer time, and egress times to the final destination (employment location). The cycling speeds are calculated based on network geometry and variable average speeds for each segment of the Dutch cycling network. Car accessibility is estimated considering network geometry, speed limits, free flow speeds during uncongested times, and speed profiles of real traffic speeds for road segments provided by TomTom.
The travel impedance functions in the accessibility models were estimated per mode based on a (best fit) log-logistic function using detailed empirical commute time data from the Dutch national travel survey (OViN).