

Are workers' commutes sensitive to changes in the labour market situation?

David Martín-Barroso^{b,c,d,1}, Juan A. Núñez-Serrano^{a,c,2,*}, Jaime Turrión^{a,c,2},
Francisco J. Velázquez^{b,c,d,1}

^a Universidad Autónoma de Madrid, Madrid, Spain

^b Universidad Complutense de Madrid, Madrid, Spain

^c Group for Research on Productivity, Innovation and Competitiveness (GRIPICO), Madrid, Spain

^d Complutense Institute for International Studies (ICEI-UCM), Madrid, Spain

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ABSTRACT

The present paper analyses the temporary stability of commuting to workplace functions in the face of changes in workers' and firms' characteristics and the local labour market conditions. To do this, we estimate commuting functions by incorporating four types of determinants: the characteristics of the workers, the jobs (or hiring firms), and the municipalities where the workers reside and work, including the unemployment rates to account for disequilibria in their respective local labour markets. After developing a simple model, we estimate these functions based on labour commuting microdata obtained from the population census of Spain for the years 2001 and 2011, periods with important changes in the labour market situation. We estimate commuting functions by means of ordered probit functions. The results show that the duration of commutes has not changed drastically. Additionally, most of the incorporated determinants maintain their sign and change their intensity only slightly over time. The duration of commutes is greater in the case of men, singles, educated and foreign workers, living in rented housing, using public transport, living or working in large cities, and working in large firms. In the same way, commutes are longer when the worker's municipality of residence has a high unemployment rate, and they turn out to be shorter when the municipality of the workplace has a low unemployment rate. Finally, the changes in the unemployment rate, especially in the municipality of residence, have been compensated by variation in their respective parameters, consequently offsetting their effects on commute times.

1. Introduction

The willingness of workers to commute to their workplaces and the distance and duration of these commutes determine some of the structural characteristics of the labour market. Specifically, they affect reserve wages, the geographic segmentation of labour markets, and the response velocity of labour markets to geographically located exogenous shocks, such as industrial reconversion phenomena or the shutdown of large firms (Amior and Manning, 2019). In the literature on agglomeration, the nature of commuting is both the cause and the effect of the concentration of productive activity. It also plays a particularly important role in determining the productivity gains associated with

appropriate matching in the labour market (Martinus et al., 2020), with losses of labour productivity if commutes become too long (Xiao et al., 2011). More recently, labour commuting has gained relevance in policy-oriented discussions on how to increase balance between work and family life (Lee and McDonald, 2003; Denstadli et al., 2017). It has also been an element of discussion in debates about the maintenance of unemployment benefits across close geographical contexts where strong labour market disequilibria take place (Guglielminetti et al., 2018).

The economic literature includes a wide variety of empirical articles that, through the use of different statistical methodologies, raise an interesting debate regarding the stability of the duration of commutes over time. Thus, some papers (Reschovsky, 2004; McGuckin and

* Corresponding author at: Universidad Autónoma de Madrid, Madrid, Spain.

E-mail addresses: dmartin@ccee.ucm.es (D. Martín-Barroso), juanandres.nunez@uam.es (J.A. Núñez-Serrano), jaimeturri@uam.es (J. Turrión), javel@ccee.ucm.es (F.J. Velázquez).

¹ Department of Applied & Structural Economics and History, Faculty of Economics and Business, Universidad Complutense de Madrid, Campus de Somosaguas, s/n, E28223 POZUELO DE ALARCÓN, MADRID (SPAIN)

² Department of Applied Economics, Faculty of Economics and Business, Universidad Autónoma de Madrid, Francisco Tomás y Valiente, 5, E28049 MADRID (SPAIN)

Srinivasan, 2003; Kirby and LeSage, 2009) show evidence of changes in commute times, associated with demographic changes and increases in the size of cities and congestion. Above all, the most significant change occurs in the percentage of workers who travel longer distances (Green et al., 1999; and Aguilera, 2005). For these authors, the commuting function is structural, i.e., the function parameters are often stable over time, so changes in commuting patterns are due to changes in the variables that determine them.

On the contrary, and despite these changes, Burchfield et al. (2006), Gordon et al. (1991), Kim (2008), Sarzynsky et al. (2006) and Anas (2015), state that, once the levels of congestion are controlled, the average duration of commutes remains practically stable over time despite the increase in the size of cities. In this sense, Zahavi (1974) raises the idea of the existence of an individual travel time budget that would limit the duration of commutes. Van Ommeren et al. (1998), and more recently Hu, Zhao and He et al. (2016), note the existence of commuting tolerances whereby workers, in order not to exceed these maximum times, change their residence or workplace. These ideas underpin the rational locator theory and the job search theory, so either sequentially or simultaneously the choice of the places of work and residence are related to the objective of maintaining a certain stability in the duration of commutes (Levinson and Wu, 2005). There are other types of responses from workers, firms and public administrations oriented to keep these commute times stable over time. These include construction of new infrastructures, changes in means of transport, alteration in the location of firms, workers' selection mechanisms in the neighbourhood of the firm, modifications of schedules, etc. (Baum-Snow, 2010). These and other reasons may justify the existence of commuting functions that show temporal stability in commute times. It could also happen that individuals react to changes in their personal circumstances and their own relevant environment in order to maintain their commute times under desired levels. Individuals' reactions thus materialise in the commuting functions through changes in the values of the parameters estimated at different time periods. In this way, the cross-section commuting functions that account for the differences between workers would not be stable over time, especially in the face of large-scale shocks in the labour market.

Surprisingly, among the papers that estimate commuting functions, only a few incorporate the effects that the labour market situation has on commuting (Hazans, 2004; Romaní et al., 2003). In this respect, Thomas (1998) and Kunz (2011) argue that although there is a certain relationship between the duration of commutes and unemployment rates, it is not strong enough to eliminate their differences in relatively close neighbourhoods.

As a result, there are still certain doubts about the role played by certain factors and associated dynamic changes in the configuration of commuting. These factors include the geographical configuration of the economic activity, the urban structure, and labour market conditions. For this reason, this paper poses two objectives. First, from a theoretical as well as an empirical perspective, we incorporate in the commuting functions a wide range of characteristics that influence commuting decisions, and in particular, those related to the labour market situation. Second, and derived from the estimation of the commuting functions in two different years, we investigate an important research question, i.e., whether there is a structural commuting function which is therefore temporally persistent. If they occurred, changes in the productive conditions would have a remarkable and almost immediate impact on commute times and distances, acting as a correction mechanism for geographic disequilibria in economic variables, especially those of the labour market. On the contrary, if this were not the case, the practical usefulness of estimating commuting functions would be partially undermined, since they could be questioned as useful tools for the formulation of economic policies where the daily mobility of workers is relevant.

In this respect, Spain is a good case study of this phenomenon for at least four reasons. First, it is a country that is always mentioned for

having problems of rigidity (including geographical rigidity) in the labour market (Sala and Trivin, 2014). In the second place, its economic conditions have drastically changed as a consequence of the global financial crisis. While Spain was enjoying economic expansion in 2001, the situation was completely different ten years later, with the country enduring both an internal and an international economic crisis. As an example of this drastic change suffered by the Spanish economy, the unemployment rate doubled from 10.5% in 2001 to 21.4% in 2011. The third reason has to do with the economic differences across close regions, in particular those that pertain to the labour market, which remained very important in Spain throughout the economic crisis. A close look at the information at the municipal level in the year 2011 reveals that, on average, there was a municipality situated less than an hour's drive holding half the unemployment rate of the municipality of residence of the worker. This relationship was equal to a third of the unemployment rate before the economic crises.³ Finally, Spain has abundant, detailed and similar information in two crucial moments of time, 2001 and 2011, which correspond to the moment before and during the economic crisis. This allows us to test the dynamic stability of the commuting function parameters and answers the controversial question raised before, at least for the Spanish case.

In order to fulfil the aim of this paper, the following section presents a review of the literature related to the estimation of commuting functions. In Section 3, a basic theoretical model is formulated and simulated. The fourth section describes the microdata used. The fifth section presents the results, which are subsequently discussed in Section 6. The paper ends with a section of conclusions and final considerations.

2. Literature review

During the last years of the 20th century, a significant amount of research was dedicated to analysing the determinants of the time spent by workers on commuting (White, 1988; Gordon et al., 1989; McLafferty and Preston, 1991; Rouwendal and Rietveld, 1994; Giuliano, 1998). Nonetheless, this literature did not gain much relevance until the beginning of the 21st century, with the appearance of numerous papers oriented to analysing the determinants and implications of different economic and social aspects of the duration of commutes (Wang, 2001; Lee and McDonald, 2003; Schwanen et al., 2004). Two different main perspectives should be highlighted among this literature. First, some of these papers focus on the causes behind excessive commute times (Buliung and Kanaroglou, 2002; Charron, 2008; Murphy, 2009).⁴ Second, others provide empirical evidence about workers' commuting strategies through different demographic and socioeconomic factors (refer to the bibliographic references in Table 1). The present paper falls under this stream of research.

The set of factors that determine the time dedicated to commuting could be classified into three differentiated groups: the characteristics of the worker and their commuting decisions (gender, family structure, age, nationality or race, education, means of transport used, property of the home, etc.); the characteristics of the job (size of the firm, type of contract, qualification required, sector of activity, etc.); and the characteristics associated with the place of residence of the worker and the location of the firm (size, unemployment rate, transport infrastructures, etc.). Table 1 lists 22 papers that are representative of the literature available.

Gender is one of the characteristics of workers that is most analysed by the literature. There is clear evidence that women spend less time on

³ This information comes from the unemployment rates calculated at the municipal level from the population census data for the years 2001 and 2011. Commuting times by road have been computed for each pair of municipalities' centroids, considering only municipalities with more than 1000 inhabitants.

⁴ Refer to Ma and Banister (2006) and Kanaroglou et al. (2015) for an exhaustive review of the literature on excess commuting.

Table 1
Main characteristics used in previous literature as determinants of the length of workers' commutes.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
<i>Characteristics of the worker</i>																						
Gender	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X		X	X	X	X
Household structure	X	X	X	X	X	X		X	X		X	X			X	X	X	X	X	X	X	X
Children	X	X	X		X	X		X	X			X			X	X	X					X
Age	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Nationality/race		X	X		X	X					X					X					X	X
Education level		X	X	X	X	X		X	X	X	X	X				X	X	X	X	X	X	X
Means of transport				X	X	X	X		X	X	X			X	X		X	X	X	X	X	X
Income	X	X	X	X	X				X	X	X		X		X	X	X	X	X	X	X	X
Home ownership							X			X		X				X		X				
Movers	X	X	X									X		X				X	X			
Others	X	X	X		X		X		X	X		X				X	X	X		X		
<i>Characteristics of the job</i>																						
Type of contract	X			X	X		X				X	X	X	X		X						X
Type of employment	X			X	X							X	X						X	X		
Sector			X								X	X				X	X	X				X
Others						X	X						X			X			X			X
<i>Characteristics of the municipalities where the company is located and the worker resides</i>																						
Size				X	X						X									X		
Unemployment rate								X										X				
Others	X	X	X		X			X	X	X	X		X	X	X			X	X	X		

1. Axisa et al. (2012); 2. Crane (2007); 3. Crane and Chatman (2003); 4. Chidambaran and Scheiner (2020); 5. Fan (2017); 6. Gimenez-Nadal et al. (2018); 7. Giuliano (1998); 8. Hazans (2004); 9. He et al. (2016); 10. Hu et al. (2018); 11. Hu (2020); 12. Lee and McDonald (2003); 13. Manaugh et al. (2010); 14. Maoh and Tang (2012); 15. Miranda and Domingues (2010); 16. Neto et al. (2015); 17. Rapino and Cooke (2011); 18. Romaní et al. (2003); 19. Rouwendal and Rietveld (1994); 20. Schwanen et al. (2004); 21. Wang (2001); 22. Zolnik (2010).

getting to their jobs (Lee and McDonald, 2003; Neto et al., 2015; Fan, 2017; Hu, 2020). MacDonald (1999) points out that this circumstance may be due to the fact that women usually perform more domestic tasks than men and assume a greater degree of responsibility in the care of the family, so they tend to look for jobs closer to home (Chapple, 2001). In addition, the existence of a wage gap against women has also been evidenced, so this could be a cause of their lower willingness to move (Madden and Chiu, 1990, and Hu, 2020). Another characteristic of workers, related to the previous one, is their family context. Workers with young children make shorter trips to the workplace, especially in the case of women (Lee and McDonald, 2003; Crane, 2007). In addition, living with a companion has also been related to a reduction in the time taken to get to the job (Elliott and Joyce, 2004; Fan, 2017). However, Chidambaran and Scheiner (2020) point out that decision making is more complex in the case of dual-earner families, so location decisions of the oldest earner are often prioritised over the second, which in many cases corresponds to women.

Another recurring characteristic of the worker is their nationality (or ethnic group), which positively affects the commute time when they are a foreigner or belong to a minority ethnic group (Kimbrough, 2019; Fan, 2017 and Gimenez-Nadal et al., 2018). The age of the worker has a negative effect on the commute time (Schwanen et al., 2004; Manaugh et al., 2010; Rapino and Cooke, 2011). In turn, the worker's level of studies also influences the time spent on reaching the workplace. Skilled workers show longer commute times, which result from both higher salaries and larger wage increases associated with longer commutes as a consequence of more complex matching processes (Lee and McDonald, 2003; Schwanen et al., 2004; Gimenez-Nadal et al., 2018). The means of transport used to reach the workplace is also important. This aspect is first subject to the distance to the workplace (for example, if the distance is short, it is possible to go on foot). Secondly, it also depends on the existence of an adequate network of public transport and the possession of a vehicle (Rapino and Cooke, 2011; Maoh and Tang, 2012; He et al., 2016). Similarly, the existence of high-speed trains or heavy rail systems can increase the speed of travelling, reducing commuting time. However, an increase in travelling distance could occur and overall gains could consequently vanish (Chen and Hall, 2012; Levinson and Wu,

2005). The distance travelled in private vehicles could also increase as a result of connecting from areas outside these transport networks. However, Van de Coevering and Schwanen (2006) find no evidence of these facts using data from European and North American cities.

Another characteristic often analysed is the increase in the wage obtained by the worker with their particular commute; there is a positive relationship between wages and commute time (Manaugh et al., 2010; Zolnik, 2010). Home ownership is usually associated with longer commutes when compared with workers who live in rented homes (Lee and McDonald, 2003; Hu et al., 2018). Renters are naturally more flexible and can adapt their place of residence closer to their workplace more easily. Lastly, among this group of worker's characteristics, it is important to highlight papers that consider changes of workers' place of residence. The evidence shows longer commute times, which are possibly associated with movements towards the outskirts of cities in an effort to find cheaper, larger houses or lifestyles different than those in city centres. In urban areas with high degrees of gentrification, suburbanisation can occur because of the expulsion of the population towards the outskirts, especially people with lower purchasing power (Romaní et al., 2003; Axisa et al., 2012 and Maoh and Tang, 2012). In this sense, there are some papers that suggest simultaneity between the decisions to choose the place of residence and the duration of commutes. This is the case of the job search theory (Rouwendal and Rietveld, 1994, and van Ommeren et al., 2000). The rational locator hypothesis has a similar vision. It argues that there is a commuting tolerance or threshold in the duration of commutes that, if exceeded, produces a readjustment in the place of residence or workplace (Levinson and Kumar, 1994; Levinson and Wu, 2005). A similar conclusion derives from Zahavi's (1974) hypothesis about the existence of individual commuting budgets to explain the stability in commuting times, a theory which has been widely criticised for the rigidity of the approach (Mokhtarian and Chen, 2004 and Levinson and Wu, 2005).

With regard to job characteristics, the variable working hours constitutes an important determinant. Workers with a full-time contract often show longer commutes, although this result also depends on the availability of this type of job and the possibility of the worker to choose between part-/full-time work (Lee and McDonald, 2003; Axisa et al.,

2012; Maoh and Tang, 2012). The qualification of the job affects the length of the commute. However, the heterogeneity with which this variable has been included does not allow a neat and sharp identification of the sign of the existing relationship (Axisa et al., 2012; Maoh and Tang, 2012; Fan, 2017). The sector of economic activity in which the firm operates is also frequently included to control for differences in the degree of location dispersion, qualification levels and firm sizes (Lee and McDonald, 2003; Rapino and Cooke, 2011; Neto et al., 2015).

Finally, there are not many papers that analyse the characteristics associated with the place of the worker's residence and the location of the firms. Thus, the size of the city could increase the commute time, although its urban structure seems even more relevant (Rouwendal and Rietveld, 1994, and Fan, 2017). In this sense, as cities become larger, transport services improve because of the availability of new infrastructures. Thus, commuting times may also decrease, although not proportionally because of congestion, which in some cases may result in net increases in commute times.

Only a few papers have analysed the effect the unemployment rate has on commute times (Hazans, 2004; Romaní et al., 2003). It is true that it would be expected that as the rate of unemployment in the city of residence increases, commute times could be expected to increase. However, factors such as the existence of unemployment subsidies, home ownership, neighbourhoods with concentrations of ethnic minorities or the presence of intense social conflict, the family structure with several workers and strong family roots can all neutralise the effects of labour market conditions on commuting.

3. The model and simulation

There are some theoretical models that attempt to explain how certain characteristics of workers, jobs and the geographical environment affect the duration of commutes. However, there is no unique and broad, comprehensive model that synthesises the complex mechanisms behind the decision to commute. For example, the most common models, based on the job search theory (Rouwendal and Rietveld, 1994, and Romaní et al., 2003), or based on New Urban Economics (e.g., Miranda and Domingues, 2010), tend to incorporate joint decisions of location of place of residence and job. Nonetheless, they do not explain long commuting distances and they include only a limited number of characteristics of workers, jobs and associated relevant environments. Especially relevant is the omission of the labour market situation around the worker residence. A similar problem occurs with the models based on the idea of the existence of a commuting budget or a commuting tolerance. These models impose "theoretical" limits to commuting times and distances (Van Ommeren et al., 1998).

The model presented below focuses on the decision to commute where the only limit to commuting times or distances is the absence of net gains associated with a location alternative. The implicit assumption is that the family place of residence remains geographically fixed. This assumption is motivated in the Spanish⁵ case according to the following factors: (i) the existence of two or more workers in the family, especially in the younger population cohorts; (ii) the possible preference for home ownership rather than home rental; (iii) geographic rigidities in the labour market, along with high structural unemployment rates and high job rotation rates due to high levels of temporary employment; and (iv) other socio-cultural aspects such as strong family roots. In addition, recent research shows a great resistance of workers to change their place

⁵ According to data from the 2011 census, 5.2% of workers change their address each year. However, of those who change, 60.5% do so because they leave their parents' home. Of those that remain, 44.2% change municipality, but only 21.9% move to another region (the average Spanish region has an area of 30,000 km², equivalent to the area of a 100 km radius circumference). Consequently, only 0.45% of workers make a long-distance change of address that could be due to a change of workplace.

of residence, and only when the change in workplace results in excessive commute times or distances do these changes in address possibly take place (Guo et al., 2020).

This section addresses this question with a basic model that explains how these characteristics shape commuting.

Let $W_{i,d}$ of expression [1] represent the expected wage of worker i at distance d from their place of residence, denoted by 0. This expected wage corresponds to the product between the probability $p_{i,d}$ that worker i finds a job at distance d from their place of residence, and the wage $\omega_{i,d}$ that the worker could obtain at such a distance in the case of successful contracting.

$$W_{i,d} = p_{i,d}\omega_{i,d} \tag{1}$$

Additionally, $p_{i,d}$ can be defined as in expression [2]: the product of the probability $p_{i,0}$ that worker i is hired in their place of residence times a distance premium d^{δ_i} . The distance premium captures the increase in job opportunities and better matching associated with the increased area of job searching. Furthermore, $\omega_{i,d}$ can be decomposed as the product between the average wage level ω_d attained at distance d and a parameter $\tau_{i,d}$ that synthesises worker i 's wage differential (wage premium or penalty) at that distance d as a result of their own characteristics (expression [3]). This parameter could be regarded as a measure of the worker's skills relative to average skill endowments across the reference area with radius d .

$$p_{i,d} = p_{i,0}d^{\delta_i} \forall d > 0, 0 < \delta_i < 1 \tag{2}$$

$$\omega_{i,d} = \tau_{i,d}\omega_d \tag{3}$$

Both $\omega_{i,d}$ components can be expressed as a function of their corresponding values at the worker's place of residence, as shown by expressions [4] and [5].

$$\tau_{i,d} = \tau_{i,0}d^{\rho_i} \forall d > 0, 0 < \rho_i < 1 \tag{4}$$

$$\omega_d = \omega_0d^{\alpha_i} \forall d > 0, 0 < \alpha_i < 1 \tag{5}$$

Thus, worker i 's wage differential at distance d , $\tau_{i,d}$, is the product between the corresponding wage differential of the worker at their place of residence $\tau_{i,0}$ times d^{ρ_i} . This captures the changes that may occur in that wage differential as a consequence of the non-random geographical distribution of the available jobs and the labour market matching processes that modify each worker's premium or penalty at each location. Similarly, the average wage level, ω_d , may be further decomposed as the product between the average wage level in the place of residence, ω_0 , and a parameter d^{α_i} which captures the changes in the wage level derived from the geographical differences in the spatial concentration of economic activity. Evidently, the effect of this parameter will be lower if the worker's place of residence shows high wage levels.

Substituting expressions [4] and [5] into expressions [3], [2] and [1], we obtain expression [6], which identifies the expected wage of worker i at a distance d from their place of residence.

$$W_{i,d} = p_{i,0}d^{(\delta_i+\lambda_i)}\tau_{i,0}\omega_0 \forall d > 0, 0 < \delta_i + \lambda_i < 1 \tag{6}$$

where $\lambda_i = \rho_i + \alpha_i$ incorporates two types of possible wage increases that accompany commuting: (i) those associated with the specific characteristics of the worker, ρ_i , and (ii) those that arise because of the different economic features across geographical locations, α_i . The analysis assumes that commuting improves or at least maintains the labour conditions at the worker's place of residence.

The expected wage at the place of residence takes the form of expression [7].

$$W_{i,0} = p_{i,0}\tau_{i,0}\omega_0, d = 0 \tag{7}$$

Commuting incurs an economic cost because of the use of a private/public means of transport, which depends on the distance and the time taken to arrive at the workplace. This cost can be valued in terms of the

wage that could be earned in the place of residence (Dauth and Haller, 2020). Thus, the cost of commuting can be measured by expression [8].

$$C_{i,d} = t_i d + a W_{i,0} d^{\gamma_i} \quad (8)$$

where $C_{i,d}$ represents the total cost of commuting to distance d for worker i . The cost per unit of distance is measured by t , a is just a scalar, and γ_i captures the subjective valuation of the worker for the time taken to their workplace. We assume that the valuation of time increases with distance, which illustrates the rising disutility of time dedicated to commuting, which reduces opportunities for leisure.⁶ The functions for the expected wage, $W_{i,d}$, the wage increase with respect to the origin, $W_{i,d} - W_{i,0}$ (a curve shifted down by an amount equal to the effective wage at the origin), and the cost of commuting, $C_{i,d}$, with respect to the duration of commuting are all illustrated in Fig. 1 (top panel).

The individual makes their decision about optimal commuting according to the net gain associated with each commute, $G_{i,d}$, in expression [9], which will be equal to the increase in the wage obtained by the corresponding commute minus resulting commuting costs,

$$G_{i,d} = W_{i,d} - W_{i,0} - C_{i,d} \quad (9)$$

This function behaves as depicted in Fig. 1 (bottom panel with the y-axis scale augmented with respect to the figure on the top panel). The worker will consider undertaking the maximum commute from their residence, which corresponds to the distance where the gain associated with commuting is zero. The optimal choice will be the one in which the net gain of commuting is maximised.

Maximising expression [9] with respect to the distance is not trivial and resulting equations cannot be easily interpreted. For this reason, in order to solve the model and determine the effect that the individual's characteristics have on their commuting decisions, we carry out a two-stage numerical simulation process. The first stage evaluates the sensitivity of the optimal commuting solution to changes, one by one, in the parameters of the model. The second stage establishes how the characteristics of individuals, jobs, and their associated relevant environment affect the model parameters, in order to predict the expected effects that the possible modifications in these characteristics have on optimal commuting. In particular, the hypotheses considered are tested in the empirical application of our research (refer to Annex 1 for detailed information on the simulation carried out).

The results of the first stage of the simulation are registered in the first row of Table 2. The parameters of the wage equation that capture the distance sensitivity of the other variables, i.e., δ_i and λ_i , show a positive effect on the distance of the commute.⁷ However, the parameters that describe the conditions of the place of residence, i.e., $p_{i,0}$ and ω_0 , exert a negative effect. The individual's wage differential, $\tau_{i,0}$, which depends on the worker's characteristics, shows a positive effect. Conversely, a negative effect is observed for parameters that affect the cost of commuting (t_i and γ_i).

From these results, we have simulated the effects that the specific characteristics of workers, jobs, and the associated relevant environment have on commuting. First, we establish the degree to which changes in the characteristics modify the model parameters (rows [2] to [14] in Table 2). For instance, in the case of gender, (row [3] in Table 2), we assume that women, in relation to men, are less likely to be employed

⁶ The monetary cost of commuting is related to distance. On the contrary, disutility is often associated with the time spent on the journey. To simplify the model, we introduce the assumption that time and distance are proportionally related through the scalar a . Gordon et al. (1989) assume the equivalence between time and distance when they define the disutility of commuting. Alonso (1964) incorporates the same idea. Rietveld et al. (1999) analyse this relationship in depth.

⁷ A positive (negative) relationship implies that changes in the value of the corresponding parameter induce shifts in the optimal commuting distance in the same (opposite) direction.

in the place of residence, have a negative wage differential, and have lower wage increases associated with commuting distance. Women are also more cost-sensitive than men in terms of commuting time because, to date, they dedicate more time to domestic work. In the three remaining parameters, we do not believe that there are differences in relation to men. Consequently, women end up having shorter commutes. Furthermore, in order to evaluate the extent to which the results derive from the assumptions made, the procedure is repeated, ignoring one by one each of the assumptions and then checking that the resulting optimal commute remains unchanged.

According to the results derived from the simulations (last column in Table 2), which represent our starting hypothesis to be tested through the empirical application, there are certain characteristics that tend to increase the duration of commutes. These features are being male, being a foreigner, being highly qualified, living alone, being a public transport user, being a worker in a large firm, having a specialised job, living and working in large cities, high unemployment rates in the municipality of residence and low unemployment rates in the workplace municipality. The simulations concerning age and dedication (full- or part-time) are inconclusive.

4. Data

We use data on workers' daily mobility to estimate commuting functions. In this type of statistical database, information is collected in the form of microdata, including commuting times, the mode of transport and the characteristics of the individual, their job, and their respective locations. In the case of Spain, the microdata samples of the INE Population Census⁸ are appropriate, so we use them for the years 2001 and 2011. In both years, individuals who are not working and those who either work at home or in several municipalities or abroad have been excluded, since they do not offer commute times. In addition, we have omitted people who reside or work outside of mainland Spain. The final size of the samples used for the estimation of commuting functions are 656,748 individuals for the year 2001, and 1,071,000 individuals for 2011. The samples available do not allow for a panel data structure as individuals are anonymised. Furthermore, the questionnaire is not equivalent, preventing consideration of certain variables and defining others in a broad sense in order to guarantee comparability.

Information on daily commutes is offered as a discrete variable in seven different time classes: less than 10 min, between 10 and 20 min, between 20 and 30 min, between 30 and 45 min, between 45 and 60 min, between 60 and 90 min and more than 90 min. Table 3 shows some statistics and the distribution of workers' commutes for each time class. More than a quarter of daily commutes occur in less than 10 min. It should be noted that this proportion diminished by just over 1% between 2001 and 2011. In addition, approximately 60.7% of commutes took less than 20 min in 2001, a value that also diminished, to 57.0% in 2011. On the contrary, 9.4% of the individuals were classified in 2001 in the three upper time interval classes, which implies commute times longer than 45 min. This proportion increased to 10.4% in the year 2011. It can be observed that commute times slightly increased in 2011 compared with 2001. Thus, taking the middle value of each time interval class, while in 2001 the average time to arrive at the workplace was about 20' 36", this time increased by just over one minute in 2011.

Regarding the determinants of commuting, we take into account homogeneous characteristics for the two available time periods: a) characteristics of the worker such as *gender*, *age* (four age groups: 15–24 years, 25–39 years, 40–54 years and 55 years or older), *level of studies* (measured by the number of years of schooling, 6 years for primary

⁸ For the 2001 census, the microdata offered by the INE correspond to a representative sample of 5%. In 2011, a census was not carried out, but only a representative sample of 10% of the population was surveyed. This sample is precisely the one used here.

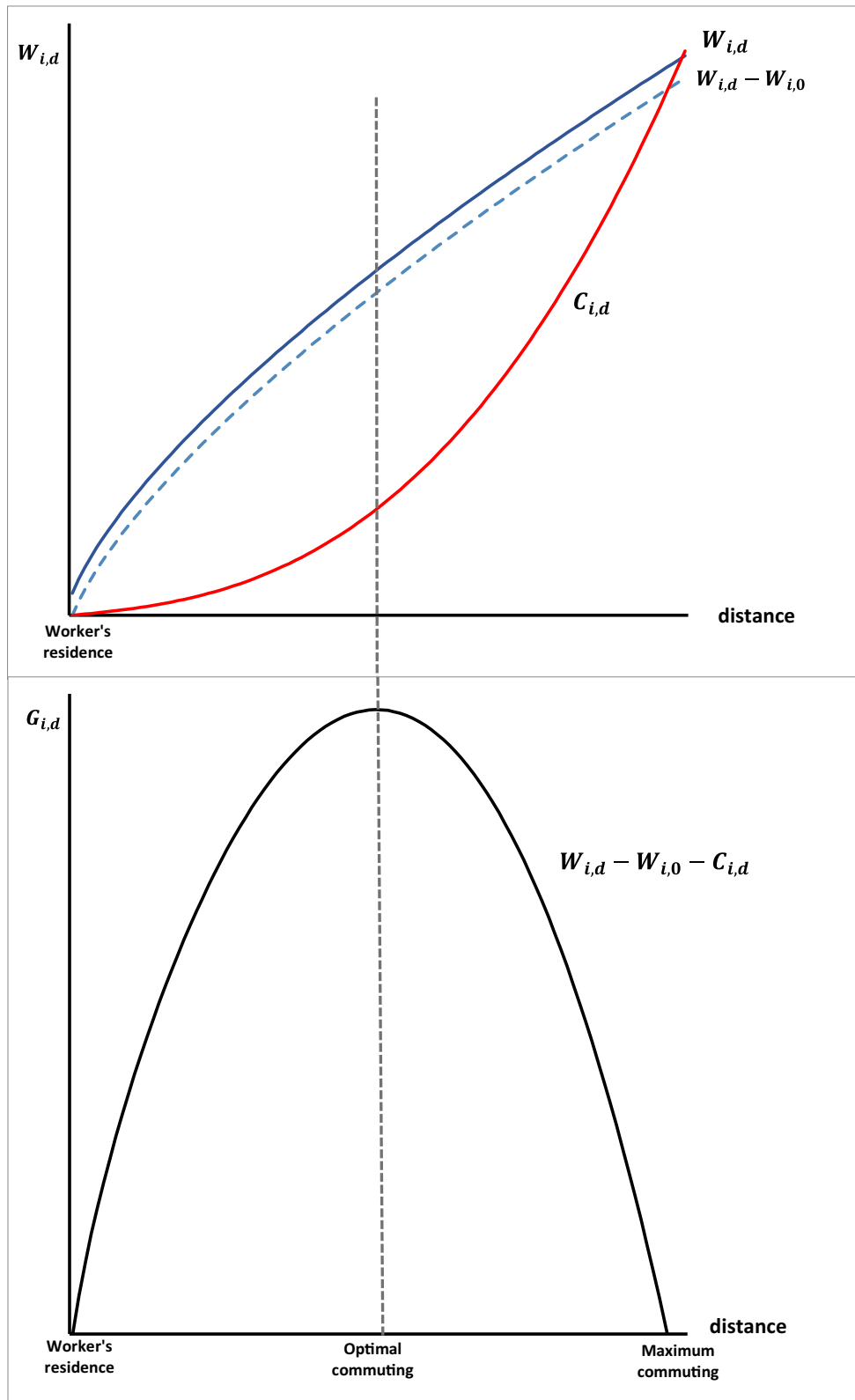


Fig. 1. Optimal commuting decision.

school, 12 for secondary education and vocational training, 17 for university studies), *living in a family* (including every type of couple and people living with children), *nationality* (Spanish and other), *means of travel* (private using motor vehicles, public, on foot, and other means), and *housing tenure system* (own, rented, assigned free or at a low price,

and other); b) characteristics of the job such as the *size of the firm* (approximated by the distribution of the following size classes: fewer than 10 workers, between 10 and 49 workers, between 50 and 199 workers, and more than 200 workers) in each municipality and sector according to the sample of firms used from the SABI database (System of

Table 2
Results of the model simulation and assumptions on parameter changes due to changes in worker, job and environment characteristics.

		Parameters							
		$p_{i,0}$	δ_i	$\tau_{i,0}$ ^a	ω_0 ^{a,b}	λ_i ^b	t_i	γ_i	
		Effects of changes in parameter values on length of commute							
[1] Isolated effect ^c		-	+	+	-	+	-	-	
Characteristic	Change in the characteristic	Assumptions on parameter changes due to variations in characteristics ^d							Effects of changes in characteristics on length of commute ^e
[2] Age	Young to Elder	+	=	+	=	-	=	+	?
[3] Gender	Man to Woman	-	=	-	=	-	=	+	-
[4] Education	Primary to Tertiary	+	+	+	=	+	=	=	+
[5] Nationality	National to Foreigner	-	+	-	=	+	=	-	(+)
[6] Family	No family to Family	=	=	=	=	=	=	+	-
[7] Transport	Private to Public	=	=	=	=	=	-	-	+
[8] Firm size	Small to Large	=	+	=	=	+	=	=	(+)
[9] Working time	Part-time to Full-time	+	-	+	=	+	=	=	?
[10] Occupation	Not qualified to Qualified	-	+	+	=	+	=	=	+
[11] Residence city size	Small to Large	+	+	=	+	+	=	-	+
[12] Job city size	Small to Large	=	+	=	-	+	=	-	+
[13] Unemployment in residence city	Low to High	-	+	=	-	+	=	=	+
[14] Unemployment in job city	Low to High	=	-	=	+	-	=	=	-

^a In the simulations assuming an isolated effect, τ_i represents both the differences in wage due to individual characteristics and the wage level of the municipality of residence. The signs of the first effect in the τ_i column are obtained in the simulations with strong restrictions. The signs for the second are obtained with the smooth restrictions and appear in the W_i column. In the simulations of the effect of the characteristics, τ_i captures only the first one.

^b In the simulations for the isolated effect, λ_i captures the increase in wages due to ρ_i and α_i . The first effect is obtained in the simulations with strong restrictions and is registered in the λ_i column. The second effect is obtained in the simulation with smooth restrictions and refers to W_i but with a different sign. In the simulation of the effect of the characteristics, the λ_i column refers to ρ_i .

^c Effect on the length of the commute due to an increase in each parameter of the model.

^d Each column shows how each individual characteristic affects the parameters included in wage and commuting cost equations. A positive (negative) sign indicates that the change in the characteristic increases (decreases) the corresponding parameter.

^e This column indicates the global effect of the change in the characteristics on the length of the commute.

Analysis of Iberian Balance Sheets), the *qualification of employment* (to be consistent across different occupations, it has been measured as the mode of workers' years of schooling for each occupation in the National Classification of Occupations, two-digit CNO-94), the *working time*, either full- or part-time employment, and the sector of economic activity of the firm; c) characteristics of the municipalities where the job is located and the worker resides such as the *size of the municipality* (the census has nine different size classes⁹ that have been grouped into three categories: fewer than 20,000 inhabitants, between 20,000 and 250,000, and more than 250,000 inhabitants), the *province of the municipalities* where the worker lives, the *location of the company* (computed as indicator variables) and the *rates of unemployment of the municipalities of the worker's residence and company location*.

The samples from both censuses are anonymous and independent, so there is no possibility of identifying the individuals. However, the sample that corresponds to 2011 provides information on whether the individual has changed their address in the last ten years, that is, since the previous census. This characteristic makes it possible to differentiate movers from those who have remained at the same address (non-movers) during this period of analysis.

Table 4 shows the descriptive statistics of commute times for the years 2001 and 2011 as a function of the variables just described. It can be highlighted that workers who are between 25 and 40 years old, foreigners (who present scores far from national workers), and skilled workers show longer commute times to their workplace. With regard to gender, commute times of women and men do not show very significant

differences. Regarding the means of transport used to get to the workplace, workers who take public transport are those who spend longer times, while workers who decide to commute on foot have the shortest commute times. In addition, individuals who live in rented houses spend more time getting to their jobs, while lower commute times are associated with workers who have their house assigned free, usually by the company itself. As would be expected, individuals who live with a companion show lower commute times.

This same table also registers minor changes in commute times between the two years of study. However, it can be observed that although the difference in time between Spanish and foreign workers remains very large, it diminished by approximately one minute since Spanish workers saw their commute times increased. It is also worth mentioning that workers with higher qualifications also increased their commute times to a higher extent. On the other hand, the differences diminished considerably for the different means of transport used. While in public transport commute times diminished, commuting on foot increased. Finally, the descriptive analysis is surprising given that the relationship between workers' commute times and unemployment rates followed an inverted U shape in 2001. This relationship became negative in 2011. This change occurred because of the increase in commuting time in areas with lower relative unemployment rates, which are areas that seem to show greater sensitivity to the increase in unemployment levels. This can be understood by the fact that both the economic activity and the population with greater capacities are not randomly distributed. Also, workers in depressed areas with high unemployment rates likely perceive that their commuting would not generate greater probabilities of finding a job. Furthermore, the Spanish unemployment protection scheme does not promote functional and geographic mobility in employment.

⁹ Fewer than 2000 inhabitants, between 2000 and 5000 inhabitants, between 5000 and 10,000 inhabitants, between 10,000 and 20,000 inhabitants, between 20,000 and 50,000 inhabitants, between 50,000 and 100,000 inhabitants, between 100,000 and 250,000 inhabitants, between 250,000 and 500,000 inhabitants and more than 500,000 inhabitants.

Table 3
Commuting. Summary statistics and distribution by time interval classes^(a).

	2001	2011	Dif. 2011–2001
Observations	661,731	1,080,527	
Mean	20'36"	21'40"	01'04"
Median	16'48"	17'36"	49"
Standard deviation	16'04"	16'42"	38"
Asymmetry	1.48	1.36	−0.12
Kurtosis	2.21	1.73	−0.48
Percentage distribution by time interval classes			
0–10	27.08	26.03	−1.05
10–20	33.19	30.95	−2.24
20–30	19.79	19.83	0.04
30–45	10.5	12.82	2.32
45–60	5.7	6.01	0.31
60–90	2.98	3.48	0.50
>90	0.75	0.88	0.13

Source: INE and own elaboration.

^a Statistics have been calculated omitting commutes longer than 90 min.

5. Results

The empirical estimation of the commuting function takes the form of expression [10],

$$y^* = x' \beta + \varepsilon \quad (10)$$

As has already been pointed out, available data does not indicate the exact duration of commutes. Commute times are available in time segments which are codified as follows: $y \in \{0, 1, 2, 3, 4, 5, 6\}$. Thus, y^* is a latent variable, and hence, not observable, that represents the time it takes to commute to work. The independent variables are the determinants of these commutes, and are grouped into four different categories of characteristics: (i) workers' features and decisions about commuting (age, sex, nationality, educational level, type of commuting, housing tenure regime, family structure), (ii) features of the job (activity sector, level of studies required, size of the company, working hours), (iii) features of the residence, and (iv) features of work locations (size of the municipality, which captures possible problems of congestion and the agglomeration of activities, unemployment rate, province, which controls for the urban structure and the provision of transport infrastructure).

Consequently, the estimation of the commuting function for each of the years 2001 and 2011 is carried out by means of multivariate ordered probit models. After the estimation¹⁰ of both models, we compute the relative probabilities for each characteristic and the different values that the dependent variable can take (Annex 2). Consequently, it is possible to compare in each year the cross-section sensitivity of individuals who share the same characteristics in the two years (comparative statics).

When these variables are dichotomous, the marginal effect measures the loss or increase in the probability of commuting associated with the presence of the characteristic identified by the variable, conditioned on the fact that the rest of the regressors are evaluated in their mean values. When an independent variable has been split up into a set of dichotomous variables, one of them is eliminated in order to avoid perfect multicollinearity. The marginal effects consequently register the impact on the probability of commuting associated with the observation's switching from presenting the characteristic identified by the omitted group to having the characteristic of the group for which the marginal

effect is calculated.¹¹ In the case of continuous variables, the marginal effects measure the increase in the probability of commuting derived from a unit increase in the value of the corresponding regressor. Finally, the estimation for the year 2011 takes into account changes in the location of the worker's residence over the time horizon considered (2001 to 2011) in order to control for the possible relationship between the duration of commutes and the place of residence. Consequently, for the year 2011, in addition to the estimations for all available individuals, we have estimated commuting functions for workers who change location (movers) and those who remain at the same address (non-movers). The distinction is made in order to evaluate the extent to which workers' choice of residence depends on job location. Given the specific peculiarities of the Spanish economy—such as a high percentage of households with at least two workers, a preference for home ownership over home rental, the rigidities in the labour market with a high rate of structural unemployment, high temporary employment and high job rotation rates—the location decisions of the place of residence and workplace are not taken simultaneously, but the former could occur after the latter. The comparability between the two years is restricted to this type of comparative statics, as there are only two independent cross-sectional samples in which observed individuals cannot be identified.

The reference features in each characteristic codified as a set of dummies are (i) with respect to workers' characteristics, women, young workers (under 25 years old), Spanish nationality, using a privately owned car, living in an owned house and living with a companion; (ii) in relation to job characteristics, micro firms (fewer than 10 workers) and part-time employment; (iii) in relation to the municipalities of the worker's residence and firm location, the first size class (up to 20,000 inhabitants). Both the years of the worker's education and the unemployment rate of both the worker's residence and job location are included as continuous variables.

Let us create a figure that represents the marginal probabilities estimated for each characteristic at the different values that the dependent variable can take (Fig. 2). A convex (concave) probability curve (from above) will indicate that shorter commute times are less (more) probable than longer ones. Likewise, that given characteristic shows longer (shorter) commute times than the value set as the reference. In other words, the characteristics have a relative positive (negative) effect with regard to commute times (Fig. 2a and b). Therefore, a decrease in the curve convexity (concavity) between the two periods analysed will imply a decrease in the intensity with which that given characteristic positively (negatively) affects the length of commutes (Fig. 2c and d). By construction, the area from below the x-axis to the probability curve should be equal to the area between the probability curve and the x-axis from above.

In relation to the workers' characteristics (Fig. 3), an important change between 2001 and 2011 with regard to age is observed. In the first period, the relationship seems to be positive with age, except in the 40 to 55 age class. In the year 2011, this relationship disappears, and age no longer has a statistically significant effect. Interestingly, when the individuals of this second year are disaggregated into movers and non-movers, the former group shows a stronger positive relationship with age. As documented by an important part of the literature reviewed in the second section of this paper and as our theoretical model predicts, men show longer commute times, a difference that increases over time, especially for non-movers. In this same way, more skilled workers also have longer commute times, which increase over time, in this case because of the movers. Foreign workers also offer the same profile. Longer commute times are found for the year 2011, especially in the case

¹⁰ The empirical model is estimated using STATA software.

¹¹ For example, in the case of age, four age groups are constructed and hence four dichotomous variables (less than 25 years old, between 25 and 40 years old, between 40 and 55 years old and over 55 years old). In this case, to avoid perfect multicollinearity, the first of the age groups is omitted, so the rest of the results must be interpreted with respect to it.

Table 4
Descriptive statistics on commuting by characteristics of workers, jobs and associated environments (°).

		2001				2011				Dif. 2011–2001
		%	Mean	Median	S.d.	%	Mean	Median	S.d.	Mean
<i>Workers' characteristics</i>										
Sex	Women	39.76	20'39"	16'43"	16'17"	46.52	21'33"	17'30"	16'41"	00'55"
	Men	60.24	20'34"	16'50"	15'56"	53.48	21'46"	17'42"	16'43"	01'11"
Age	years > 25	12.43	20'43"	16'49"	16'13"	5.06	21'51"	17'48"	16'44"	01'08"
	25 ≤ years < 40	44.63	21'18"	17'18"	16'27"	36.67	22'38"	18'24"	17'07"	01'20"
	40 ≤ years < 55	32.77	20'02"	16'26"	15'39"	43.30	21'13"	17'16"	16'27"	01'11"
	55 ≤ years	10.17	19'12"	15'41"	15'23"	14.97	20'30"	16'38"	16'15"	01'18"
Years of schooling	6 years	51.9	18'57"	15'28"	15'21"	37.37	19'10"	15'23"	15'49"	00'13"
	12 years	26.89	21'24"	17'32"	16'14"	32.40	21'43"	17'44"	16'32"	00'19"
	17 years	21.21	23'37"	19'24"	17'03"	30.23	24'42"	20'30"	17'26"	01'05"
Means of transport	Private motor	62.71	20'15"	17'06"	14'36"	65.33	22'03"	18'10"	16'18"	01'48"
	Public	16.11	35'28"	20'39"	18'18"	14.76	29'33"	25'36"	19'03"	-06'13"
	On foot	20.10	10'03"	08'17"	07'20"	16.30	13'30"	09'59"	11'53"	03'27"
Nationality	Other	1.08	15'18"	13'23"	11'39"	3.61	19'19"	15'49"	15'18"	04'00"
	Spanish	95.58	20'27"	16'42"	15'56"	94.76	21'32"	17'32"	16'34"	01'05"
	Other	4.42	24'03"	19'05"	18'24"	5.24	24'10"	19'05"	18'42"	00'08"
Home ownership	Own	83.43	20'30"	16'44"	15'59"	83.76	21'36"	17'35"	16'35"	01'05"
	Rented	11.01	22'18"	18'09"	16'56"	8.76	23'15"	18'49"	17'36"	00'57"
	Free/low price	2.37	17'57"	14'17"	15'11"	2.18	19'16"	14'54"	16'31"	01'18"
Family	Other	3.19	19'10"	15'45"	15'21"	5.31	21'08"	17'02"	16'48"	01'58"
	Family	57.74	20'01"	16'20"	15'45"	65.83	20'59"	17'04"	16'21"	00'58"
	Other	42.26	21'24"	17'26"	16'27"	34.17	22'59"	18'43"	17'17"	01'34"
<i>Job characteristics</i>										
Years of schooling	6 years	63.32	19'00"	15'32"	15'18"	45.18	19'12"	15'28"	15'46"	00'13"
	12 years	20.58	23'05"	18'51"	16'54"	33.72	23'11"	18'59"	17'03"	00'06"
	17 years	16.10	23'44"	19'31"	17'02"	21.10	24'30"	20'16"	17'21"	00'46"
Employment	Part-time	8.53	20'49"	16'46"	16'30"	14.98	20'28"	16'33"	16'18"	-00'24"
	Full-time	91.47	20'35"	16'48"	16'02"	85.02	21'53"	17'48"	16'46"	01'18"
<i>Characteristics of the municipality of worker's residence</i>										
Size	1	20.29	16'33"	12'20"	15'08"	36.22	19'22"	15'03"	16'36"	02'49"
	2	36.10	18'31"	14'55"	15'17"	28.82	20'45"	16'35"	16'32"	02'15"
	3	43.62	24'13"	20'17"	16'22"	34.96	24'47"	21'01"	16'28"	00'34"
Rate of unemployment	1 quartile		17'27"	13'51"	14'56"		24'40"	21'14"	16'56"	07'13"
	2 quartile		20'44"	17'09"	15'44"		21'22"	17'07"	16'54"	00'38"
	3 quartile		25'57"	21'42"	18'02"		21'55"	17'40"	17'01"	-04'14"
	4 quartile		18'32"	15'43"	14'07"		18'43"	15'08"	15'22"	00'11"
<i>Characteristics of the municipality of firm location</i>										
SIZE	1	19.02	15'26"	11'34"	13'55"	26.91	16'12"	11'58"	14'40"	00'45"
	2	34.62	17'42"	14'24"	14'44"	31.52	20'12"	16'29"	15'43"	02'29"
	3	46.36	24'53"	20'55"	16'44"	41.56	26'19"	22'21"	17'22"	01'26"
Rate of unemployment	1 quartile		17'15"	13'44"	14'49"		28'13"	24'18"	19'10"	10'58"
	2 quartile		24'59"	20'29"	18'07"		20'05"	16'43"	15'17"	-05'09"
	3 quartile		19'57"	16'54"	14'34"		20'08"	16'39"	15'28"	00'11"
	4 quartile		18'00"	15'34"	13'18"		18'16"	15'02"	14'42"	00'16"

Source: INE and own elaboration.

^a Statistics have been calculated omitting commutes longer than 90 min.

of movers, who might be classified as workers who arrived after 2001 or those who are willing to move to improve their working conditions and acquire housing in the cheapest areas. Non-movers are most integrated immigrants or those who arrived throughout the 1990s and settled in central areas, occasionally in some depressed districts.

The mode of transport chosen also determines significant differences in the duration of commutes. Thus, the use of public transport increases the duration of commutes compared with the use of private vehicles. However, a downward trend is observed in this difference, probably because of the improvement of urban transport infrastructures. Just the opposite occurs with commuting on foot, usually related to shorter commute times, and shows an increasing trend over time. People who live in rented houses show longer commute times compared with people who own their houses, although a downward trend is observed mainly because of movers. Family life is associated with shorter commute times in relation to people who do not live in a family, and this difference increases especially in non-movers.

Regarding the characteristics of the firm and the job (Fig. 4), firm size shows a positive effect on the duration of commutes, although some inconsistencies in medium-sized firms arise. What seems to be fulfilled is that the differences with respect to micro firms increase over time. This result, which is new in this literature, would show that the employment matching process is more complex for large companies, probably because of their employment requirements for more qualified and specialised labour. Having full-time employment, as opposed to part-time, has no statistically significant effect in 2001, and turns out to have a statistically negative effect over the duration of commutes in the year 2011. In fact, the change over time is observed for full-time movers. On the other hand, jobs that require high qualifications, as occurs with the worker's qualification, imply longer commute times, although this effect levels out over time.

Finally, Fig. 5 identifies some interesting effects regarding the characteristics of the municipalities where the worker resides and where the firm is located. When one's residence and work are in the same

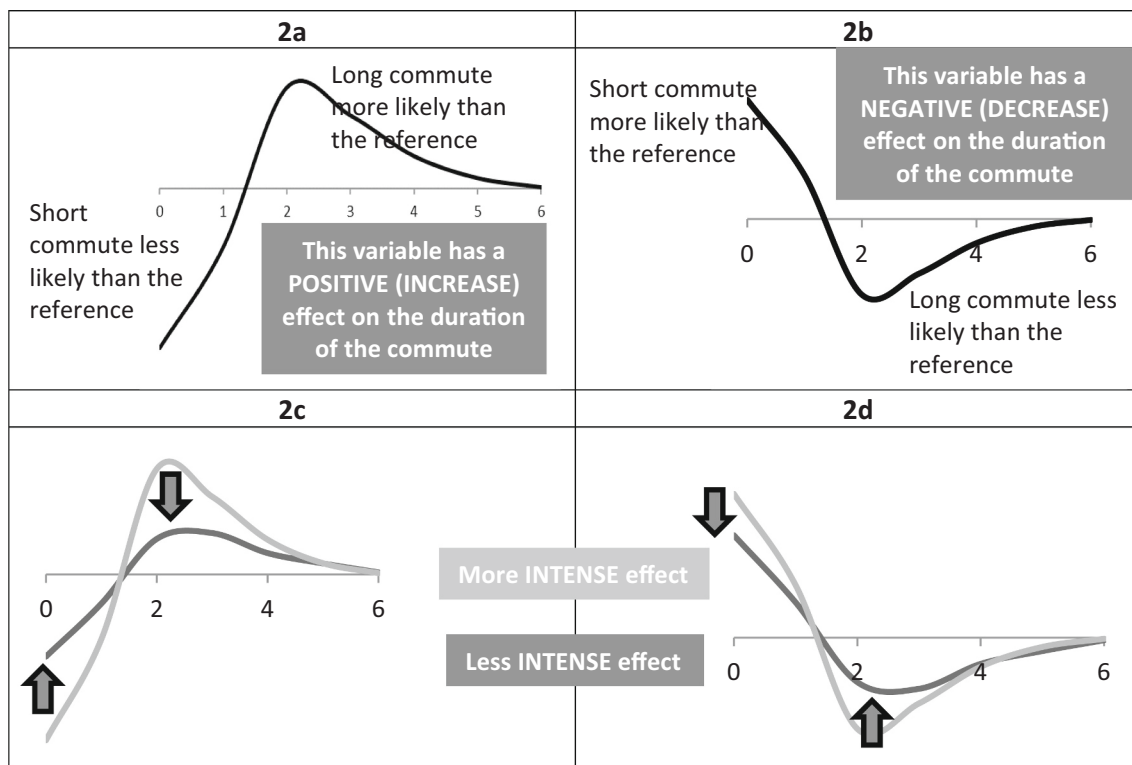


Fig. 2. Interpretation of figures on marginal probabilities at the different values of a characteristic.

municipality, workers in medium-sized municipalities have shorter commute times than workers in small ones, whilst workers in large municipalities show longer commute times. In both cases, the differences decrease over time with respect to workers in small municipalities. When the municipalities of work and residence are different, the effect in both cases is the same. Commute times increase with size, as predicted by the model, although there seems to be a certain decline in this difference over time.

The unemployment rate has a different effect depending on the municipality in which it occurs. It has a positive effect on commute times when it corresponds to the worker's municipality of residence, creating longer commutes for its inhabitants. Conversely, the unemployment rate of the municipality where the firm is located has a negative effect on commute times and thus discourages the search for workers across large areas. There is, nonetheless, an interesting change in the intensity between the two years analysed. Thus, in 2001, the positive effect observed for the unemployment rate of the worker's municipality of residence was of greater intensity than the negative effect of the unemployment rate of the municipality where the firm was located. As such, when both municipalities coincided, the net effect was positive. On the contrary, in 2011, the unemployment rate of the municipality of residence still showed a statistically significant positive effect, but much smaller than in 2001. The negative effect that the unemployment rate of the municipality of firm location has on commute times decreases, too. Therefore, when both municipalities coincide, a negative net effect is observed.

6. Discussion

The results of the estimations presented in the previous section are in general consistent with the theoretical model developed in this paper and also with part of the previous literature. Nonetheless, the introduction of some additional variables, omitted in previous research, may modify some of them. Furthermore, the changes observed between the two years of study are a reflection of the intense social and economic changes that occurred in that period.

First of all, there is evidence that the geographical distribution of both productive activities and residential areas, along with their changes, have an impact on the duration of commutes and explain part of the results. As [Hu et al. \(2018\)](#) and [Schwanen et al. \(2004\)](#) point out, the changes in the urban spatial structure are reflected in commuting patterns. The gentrification and touristification of city centres have moved families out to the periphery ([Gil-Alonso et al., 2013](#); [Blanco-Romero et al., 2018](#)). This has increased both voluntary suburbanisation—towards new ways of life, with single-family homes and large spaces—and compulsory suburbanisation—families that can only afford housing alternatives far from the centre. The first may explain the increase in the duration of commutes with age ([Duranton and Puga, 2015](#)), a result that contrasts with the usual negative sign associated with this variable ([Schwanen et al., 2004](#); [Manaugh et al., 2010](#); [Rapino and Cooke, 2011](#); and [Axisa et al., 2012](#)). The involuntary choice is reflected in the longer commutes of those who have moved—mainly those that leave their parents' home—and recently arrived foreign workers. This coincides with the spatial mismatch hypothesis ([Wang, 2001](#)) and with the results found by [Axisa et al. \(2012\)](#) and [Wang \(2001\)](#) for the United States.

This intense change in the structure of large metropolitan areas has led to significant improvements in urban and interurban transport infrastructures in Spain ([García-López et al., 2015](#)). These improvements have been more pronounced in medium-sized cities, some of which are part of the suburbs of the largest Spanish cities. Thus, there is a certain duality in the relationship between commuting and the size of cities. The times for urban commuting get shorter in medium municipalities. On the contrary, large municipalities show longer commute times because of traffic congestion, as also found by [Gimenez-Nadal et al. \(2018\)](#) for the case of the U.S. The duration of interurban commutes, which are longer, is directly related to the size of the cities. This result was also obtained by [Manaugh et al. \(2010\)](#) for Montreal. The positive relationship between the size of cities and the duration of commutes must be associated with the dominance of monocentric cities in Spain, as found by [He et al. \(2016\)](#) for China. However, this relationship loses intensity over time because of infrastructure development and efficiency improvements

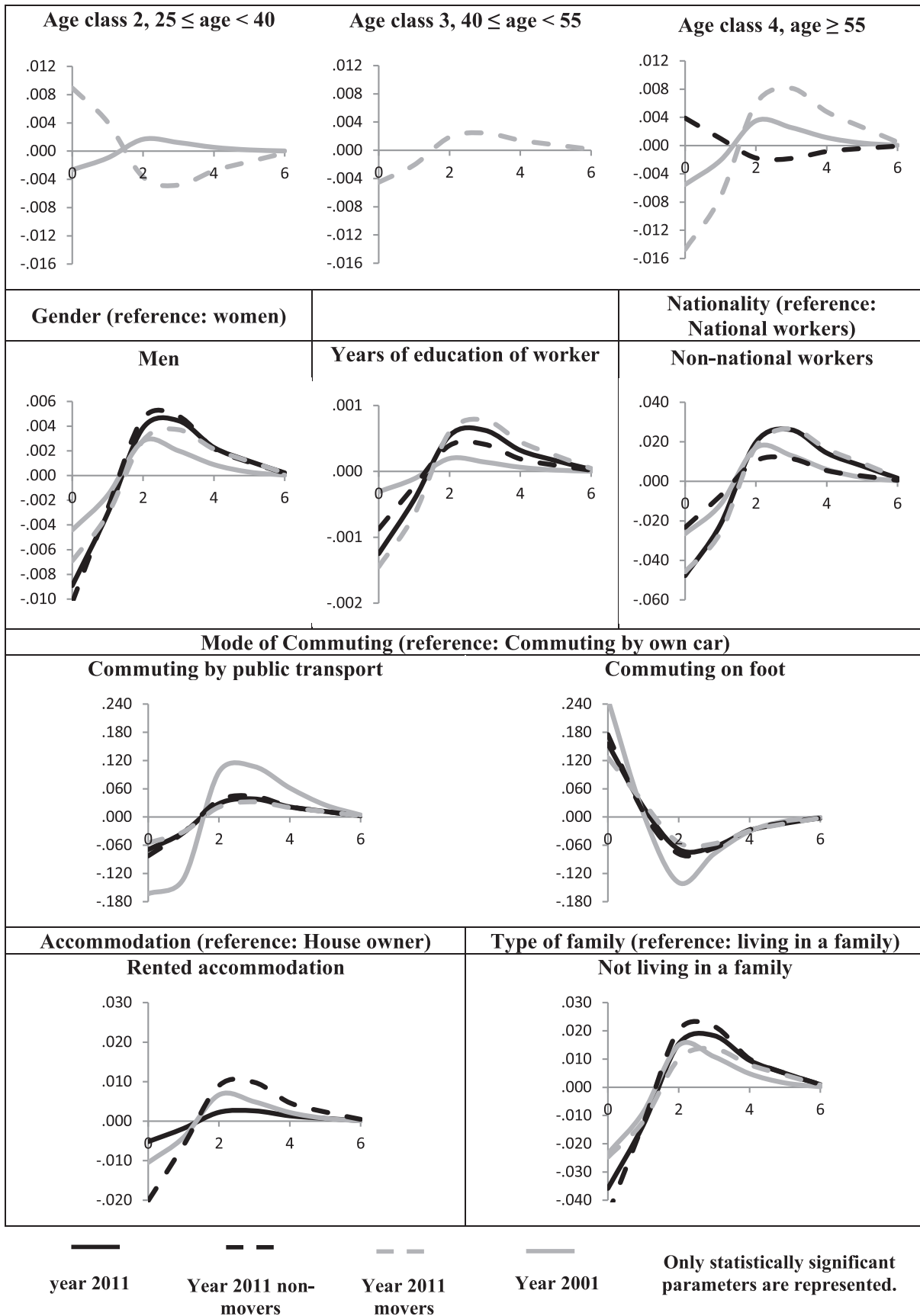


Fig. 3. Effects of the characteristics of workers on the length of the commute Age (reference: class 1, $16 \leq \text{age} < 25$).

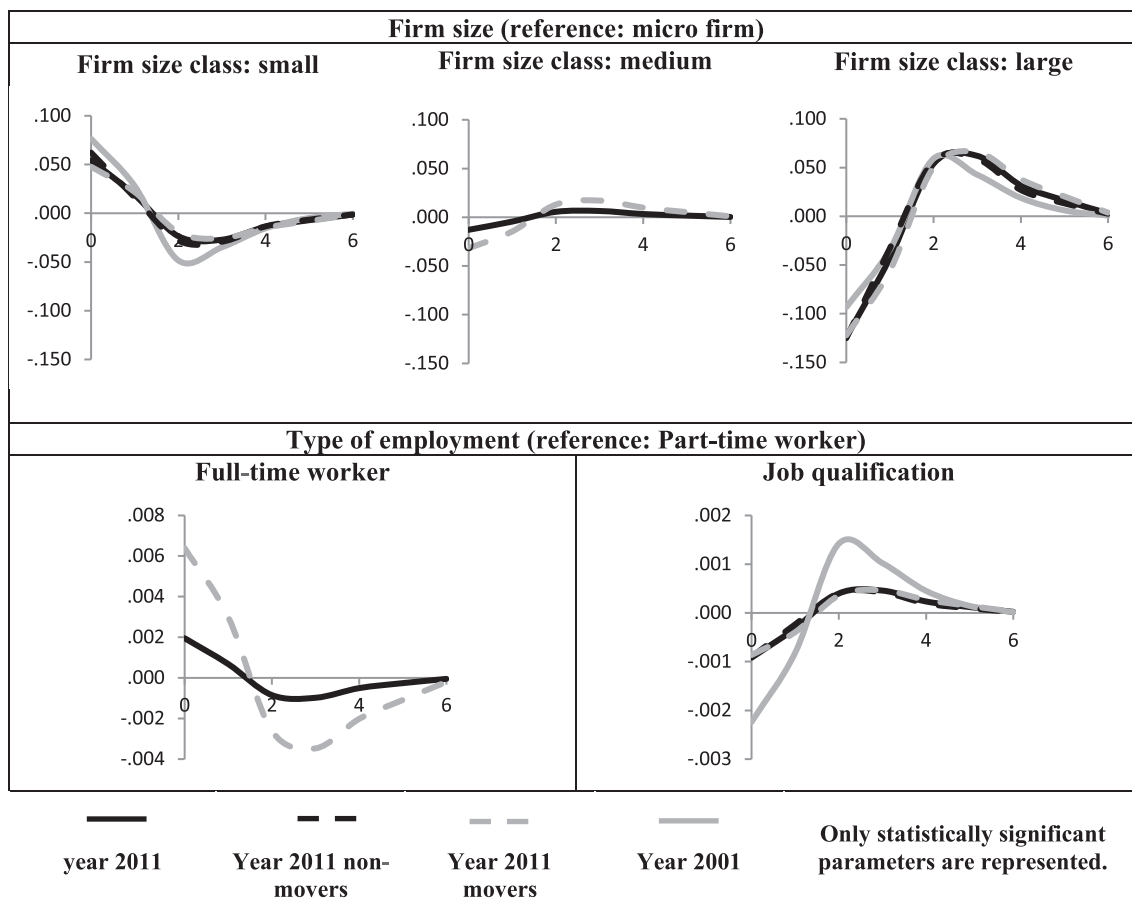


Fig. 4. Effects of job characteristics on the length of the commute.

across the transport network connecting neighbouring municipalities. Also, a phenomenon of monocentricity attenuation occurs because of the decentralisation of jobs to the new commercial suburban areas around new suburban workers' residences as Crane and Chatman (2003) find out in the case of the US. In any case, the improvements have been greater in infrastructures than in public transport services, which implies a disadvantage for the use of these means in favour of private transport, even though this particular pattern may be gradually declining.

A second determinant of the duration of commutes is the family structure and roles. Commutes are shorter in the case of workers who live with their families and women who assume greater family responsibilities or who maintain a work activity subordinate to that of their partner. This gender gap often appears in the literature in different contexts (Lee and McDonald, 2003, for South Korea; Crane, 2007, for Canada; Rapino and Cooke, 2011, for the US; Neto et al., 2015, for Brazil; Chidambaran and Scheiner, 2020, for Germany). Fan (2017), who also analyses the North American case, points out that this difference is independent of the family structure and the main role played by men or women within the couple.

The third determinant corresponds to working conditions. Workers with better working conditions also seem to have shorter commutes. This result contrasts in part with the results found by Axisa et al. (2012). They observe that workers who have full-time positions show longer commutes. In terms of better qualified workers or those in higher-qualified jobs, we find longer commutes, as is usually observed in the literature (Lee and McDonald, 2003; Schwanen et al., 2004, and Gimenez-Nadal et al., 2018), because of more complex matching processes in this kind of position.

As in Hazans (2004) and Romaní et al. (2003), the unemployment rate of the municipality of the worker's residence has a positive effect on

commute times. This effect is reversed when the unemployment rate corresponds to the municipality where the firm is located. In this case, high unemployment in the neighbourhood discourages firms from searching for workers across larger areas. However, both effects are noticeably weakened in 2011. This change is particularly interesting, especially in the case of the municipality of residence, which leaves almost no effect of the rate of unemployment on commute times. This result, which provides evidence of the change in the sensitivity of commuting to changes in the labour market situation, might be explained in terms of the significant and systematic increase of unemployment in Spain between 2001 and 2011. The important geographical and functional rigidities of the labour market and the degradation of working conditions throughout the country may have impeded further adjustments that could have occurred by moving to neighbouring areas. In this sense, this is the most important alteration observed in the sensitivity of commuting. It should be noted that this result is obtained despite the fact that during the study period the successive reforms that took place in the labour market hardened the conditions to receive the unemployment benefits, expanded the objective causes of dismissal and, substantially reduced the compensation that employers had to pay to fired employees.

The results obtained from the groups of movers and non-movers indicate that, on average, a change of address has not reduced the commute time, probably since in most cases the change of residence has been provoked by the housing market bubble. This result is also observed by Axisa et al. (2012) and Maoh and Tang (2012). In fact, Rouwendal and Rietveld (1994) verify that Dutch workers who changed their address did not reduce their commute times.

Comparison of commute times between 2001 and 2011 in Spain shows the stickiness of this variable to adapt to changes in the labour market situation. These commute times have not increased despite the

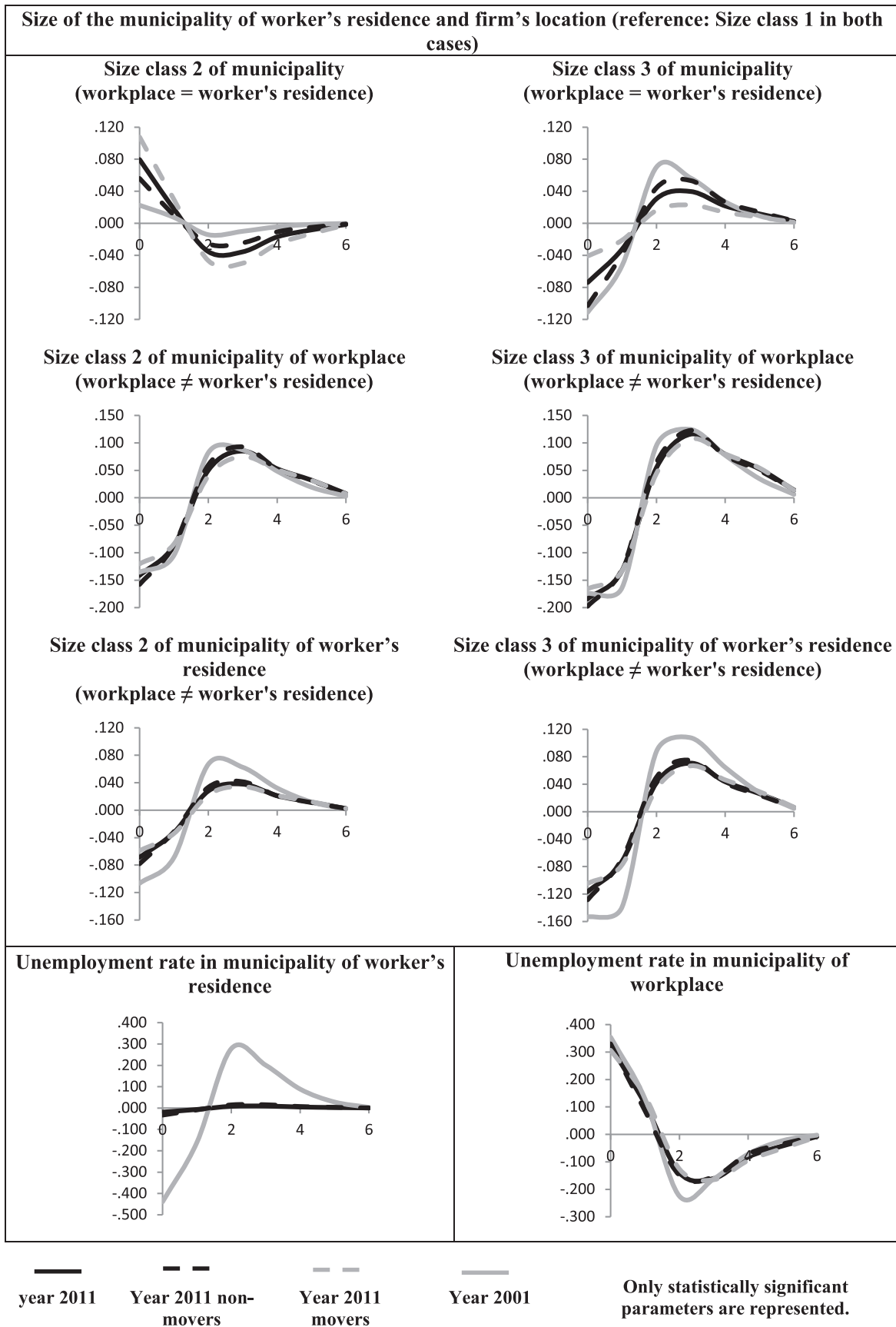


Fig. 5. Effects of the environment characteristics on the length of the commute.

drastically different conditions in the Spanish labour market over this period. Consequently, one can find relatively close geographic areas with contrasting unemployment levels. In this regard, it is worth asking why firms and workers have not reacted to the Global Financial Crisis shock. The answer probably relates to a lack of flexibility in the labour market regulation affecting both parties. In addition, institutional changes in the labour market require longer time horizons, thus possible institutional changes induced by the Global Financial Crisis cannot be jet captured along the considered period of analysis. However, making longer commutes is even more difficult under the current context of degraded working conditions, as there is no adequate compensation for the time and cost involved. Also, the longer duration of commutes hinders conciliation of family life and work. In a context of low fertility such as in Spain, it can have unwanted consequences on other aspects of social and economic life, affecting productivity in particular and thus the sustainability of the welfare state. Likewise, the increase in commute times could have a negative influence on pollution levels, especially in large urban agglomerations.

7. Conclusions

This paper analyses the determinants of the duration of workers' commutes to their workplaces in Spain for the years 2001 and 2011. Thus, the analysis is carried out in two periods under different labour market situations, serving to evaluate the extent to which commuting functions are stable over time or, alternatively, that these functions should only capture cross-section variability without time persistence.

To achieve these objectives, we develop and simulate a theoretical model for commuting decisions based on the different characteristics of workers, jobs, and their corresponding environments. The empirical results we obtained corroborate most of the hypotheses derived from the numerical simulation of the model. The results show lasting positive effects on commute times for the following factors: being men, being single, having a high educational level, working in a highly qualified job, being a foreign worker, living in a rented home, using public transport, the size of the firm, the size of the municipalities of residence and the workplace, and the unemployment rate of the municipality of residence. On the contrary, we find negative effects on commute times with the level of unemployment in the municipality of the workplace. We do not find a conclusive sign in terms of worker age and working time.

The estimation of commuting functions in two different years for Spain allows us to check the temporal stability in their parameters. In this sense, there is also mixed evidence, at least for the Spanish case study, on the time consistency of estimated commuting functions. Although many of the parameters keep their original sign, the times of commutes are not drastically modified, because the changes in the labour market conditions have been partially compensated by variations in the values of estimated parameters, particularly in relation to the unemployment situation in the municipality of residence. The results suggest that the evolution in commute times has also been conditioned by the configuration of the productive activities within the territory and especially in cities as a consequence of changes in lifestyles and the real estate bubble. This research contributes to the literature on commuting by providing evidence on the precautions that must be taken when extrapolating results derived from the estimation of commuting functions. This turns out to be particularly important when there have been significant changes in the independent variables, especially those related to the situation in the labour market.

Furthermore, detecting the effects of labour market imbalances on commuting can be difficult due to the fact that workers do not react immediately to changes in labour market conditions. Added to this asynchrony, is the complexity of determining the correct geographical scope (local, regional or national) of workers' and firms' reference labour markets. In particular, this paper shows the need to continue investigating the reasons behind this adaptation, especially in a context

of strong geographical imbalances in the labour market and high rigidity levels in the geographical mobility of workers.

Finally, it is remarkable that despite having access to a good database, the definition and technical characteristics of the census have prevented the analysis of some relevant aspects. Specifically, the fact that the two cross-sections are independent prevents us identifying all the characteristics linked to changes of place of residence, and in particular, determining whether or not those changes coincide with a change in workplace. In this sense, knowing the main reasons behind the change of address would help in more precisely evaluating the relationship between the choice of work location and place of residence, information that could be complemented with previous wages. Furthermore, ignoring the specific address and location of workplaces does not allow the incorporation of public transport endowments, so it is not possible to analyse the extent to which the choice of the main means of transport is either mandatory or voluntary. Furthermore, despite having used the appropriate econometric methodology for the available data, it would have been more accurate to use continuous measures of commute times.

The results concerning the stability of commute times suggest for future research that it is necessary to further explore the quantification of the benefits in terms of productivity gains and the costs of commuting time. This will provide evidence about the underlying criteria that determine commute times, establishing whether resulting commute times are those which provide the greatest social welfare levels or whether they are simply a consequence of the particular rigidities of the Spanish labour market. In this sense, the introduction of new forms of labour configuration, such as teleworking, could reduce the costs associated with commuting and improve this geographical mismatch.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jtrangeo.2022.103352>.

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