UNIVERSITAT DE BARCELONA

Essays on Public Policies and Socioeconomic Disparities

María Cecilia Olivieri Agazzi

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A mis padres, Beatriz y Carlos

A mis hermanas, Fernanda y Florencia

A mi persona favorita, Manuel

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Chapter 1

Introduction

Economic inequality is receiving more attention nowadays than in the recent past, to the point of being at the center of the political debate (Atkinson, 2016). The traditional neoclassical economic theory argues for the complete separation of ethics and economics, restricting the scope of economics to problems of efficiency (Robbins, 1932). According to efficiency considerations, there is an increase in social welfare when there is a change that does not worsen the well-being of any individual and at least one individual is better off. From this point of view, economics has nothing to say about redistribution.

On the other hand, the proponents of welfare economics state that the discipline should be thought of as a moral science (Atkinson, 2009). They suggest that many of the discrepancies stem, not from differences in how they think the economy works, but in the criteria to be applied when making decisions. Redistributive considerations lead to a zero-sum game where there is compensation between the welfare of the individuals that make up society. This entails social conflicts that may be solved by appealing to normative arguments. In fact, economic equity means the application of normative arguments over issues of redistribution (Trannoy, 2011). Given the important attributes of the improvement of well-being, a specific equalizing policy may be a good implementation, not only for people who will benefit from it, but also from a broader social perspective (Tobin, 1970).

According to the latest theoretical developments, scientific knowledge of the processes of production and distribution of resources, or other determinants of well-being, must be a matter of public debate in order to make more informed policy decisions that ensure the achievement of efficiency and equity. Therefore, considerations of efficiency in economic policies may be complemented with issues of equity.

In this context, the main goal of the research reported in this doctoral thesis is to analyze the relationship between inequality and development. It also studies the role of public policies in fostering economic growth and reducing disparities. An additional purpose is to contribute to the literature by providing empirical evidence of specific economies, with different levels of development, where assessing the results is academically relevant. As will be detailed below, the analysis is carried out using a variety of econometric techniques, based on regional macro data and household surveys.

Specifically, the dissertation encompasses three main topics: 1) the contribution of transport infrastructure to the regional convergence in Spain, 2) the analysis of gendered differences in the personal income tax in Uruguay, and 3) the examination of gendered differences in urban mobility patterns in the Metropolitan Area of Montevideo. The three topics focus on inequality from different points of view, and provide an analysis to assess the magnitude of the problem and the role that public policy can play in reducing these inequalities.

The studies and major findings of the dissertation are presented in three different chapters. Chapter 2, titled *"Transport Infrastructure and Regional Convergence: A Spatial Panel Data Approach"*, addresses the first topic. Spain is a high-income country with wide disparities among its provinces. Since the 1980s, pursuing regional convergence, Spain's national government and the European Union[1] have made great investments in infrastructure. This huge allocation of resources has allowed Spain to substantially expand its transport infrastructure, making it, at present, the European country with the most extensive motorway and high-speed railway networks (Albalate et al., 2015). Against this background, the study of the impact of transport infrastructure on Spain's process of convergence would seem to be a relevant research question.

Given the contents described above, Chapter 2 adds to the previous literature by providing new evidence about the β-convergence-type processes in Spain; both, the absolute and conditional type. As well, it

[1] A particular experience of redistributive policy through public infrastructure investment is the Regional and Cohesion Fund Policy. The program was carried out by the Government of the European Union since the late 1970s, although it has been reinforced in recent years. The main instrument of this policy has been monetary assistance, given to eligible regions as established in "Objective 1". The so-called cohesion countries (Greece, Ireland, Portugal and Spain) have been major beneficiaries of these funds.

analyzes the process of policy-decision making behind the regional allocation of transport infrastructure investment in this country. In particular, it examines whether investments have been incentivated by efficiency, redistribution and/or equity concerns. This result may provide an explanation for the contribution of transport infrastructure to regional convergence. This contribution can be expected to be modest in cases where redistribution or equity concerns are not the ones guiding the regional allocation of investment by the central government. A novelty regarding previous studies is that the analysis includes the impact of transport infrastructure disaggregated into roads, railways, ports and airports. In general, other works include the infrastructure in an aggregated manner, or just consider the roads in isolation.

Regarding the methodology employed, by using a spatial model which incorporates spatial interactions, the analysis captures and corrects for possible dependence or spatial heterogeneity. In particular, it exploits spatial econometric techniques and applies a spatial Durbin model (SDM) to measure the effects on the region where the investment is made, as well as the spillover effects in neighboring regions. For this purpose, a panel of Spanish regions was constructed, containing annual data for the period 1980–2008.

Chapter 3, titled *"Gendered Effects of the Personal Income Tax: Evidence from a Schedular System with Individual Filing in Uruguay"*, addresses the second topic. Uruguay is a medium-income country that belongs to the group with lower levels of inequality within Latin America. This region has historically been pointed out as the most unequal region in the world.

From the perspective of income redistribution, Goñi et al. (2008) state that, contrary to high-income economies, in most Latin American countries the fiscal system does not manage to significantly reduce inequality, mainly due to the limited effect of transfers (which are the bulk of redistribution in European countries) and the region's low levels of tax collection. In order to reverse this trend, the fiscal systems may have a role to play in terms of improving equality. As well the potential impact of the tax system on income distribution in Latin American countries is central for policy makers (Amarante et al., 2012). On a theoretical ground, properties derived from the theory of optimal taxation indicate that direct income taxation should be preferred over indirect taxes as instruments to achieve redistribution. Focusing on direct taxes, there has been a trend in recent decades in developed countries to reform their Personal Income Tax (PIT) systems to dual regimes (capital and labor taxed separately) with individual filing (Genser & Reutter, 2007). It is expected that these reforms will diminish gender bias, therefore earning the support of feminist economics for this type of schedule.

Within this context, Uruguay presents some interesting peculiarities to analyze. In 2007, the government passed a Tax Reform that increased the weight of progressive direct taxes at the expense of indirect taxes. This reform created a personal income tax with a design that reflects the general spirit of the latest reforms in high-income countries that help to mitigate gender biases. The debate about tax reform, however, did not raise issues related to gender equity, leading to there not being any previous studies addressing it.

Therefore, the main contribution of Chapter 3 is to provide the first evidence about the gender differences in direct taxation in Uruguay. Also, it adds to the literature on gender and taxation in the use of survey microdata and in the application of an econometric strategy, in contrast to earlier studies conducted by Grown & Valodia (2010) and Grown & Komatsu (2015). The analysis exploits the national Household Survey "*Encuesta Continua de Hogares*" carried out in 2013 and estimates the average tax rate of the household as PIT-to-gross income ratio. The households are classified according to a combination of dimensions: whether or not the head of household has a partner, employment status of the head and partner (if any), and whether or not it is an extended household. This research is particularly aimed at comparing the average tax rate in three typical scenarios: a) households supported by a male worker and a housewife who is not engaged in paid employment, b) households in which both members of the couple are in the labor market, and c) households in which a single woman is in the labor market. The effect of household type on the average tax rate is assessed by estimating a zero-one inflated beta model (ZOIB). This model properly addresses the fact that the average tax rate is a proportion variable with a high presence of zeros.

The third topic is addressed in Chapter 4, titled *"Determinants of urban mobility with a focus on gender: a multilevel analysis in the Metropolitan Area of Montevideo, Uruguay"*. The study in this case is delimited to the Metropolitan Area of Montevideo (MAM) which comprises the entire department of Montevideo (capital city of Uruguay) and parts of the border departments of San José and Canelones.

Given the amount of immigration at the beginning of the 20th century, the socio-demographic structure of Montevideo is quite similar to that in European cities. This is reflected in the level of education of women and their participation in the labor force, which are higher than the region's standards. As well, the greater economic autonomy of women has led to substantial changes in the family organization: the share of traditional male breadwinner households has fallen, giving rise to dual earner households and even households of women living without a spouse/partner.

Despite this, the high economic volatility, typical of the Latin American region has prevented the economy from achieving the state of development of modern growth-promoting infrastructures. Indeed, their quality of transport infrastructure and characteristics of the built environment are according to those of the developing world. In many of the least developed economies, urban transport systems still have a long way to go to generate accessible and affordable public transport services and quality infrastructure for non-motorized transport. Likewise, the private vehicle predominates and is in continuous growth. As a result, the transport sector is responsible for significant negative externalities. In 2010 an urban mobility plan was implemented by the Government of Montevideo with the main objective of restructuring and modernizing public transport (Abreu & Vespa, 2010; Massobrio, 2018). Under this plan, public transport was unified and integrated along the MAM, with the introduction of buses equipped with on-board GPS units and ticket selling machines operated with smart cards.

Within this peculiar framework, the main contribution of Chapter 4 relies on the analysis of updated urban data to characterize the mobility patterns of residents in the MAM, with a special focus on gender differences. Furthermore, it addresses the household responsibility hypothesis accounting for the interactions between individuals and zone of residence, which remains unexplored. In particular, the study exploits the most comprehensive Mobility Survey for the MAM, "*Encuesta de Movilidad del Área Metropolitana de Montevideo"*, carried out in 2016 and publicly available a few months ago. In this regard, when analyzing the related literature, no previous works aimed at understanding gender differences in mobility patterns and improving urban mobility in the MAM were found. Also, the research reported in this chapter contributes with a new methodology to assess the transportation system and understand gender differences in mobility patterns. This methodology allows contributing to previous literature by providing a link between the research on gender commuting differentials and the research on the impacts of neighborhood environment in travel behavior. The multilevel regression models provide more accurate estimates regarding individual and contextual effects on travel behavior because they take into account the hierarchical structure of the data, as a way to model space heterogeneity.

Overall, this dissertation uses different econometric methodologies, including techniques for handling with spatial data, microsimulations, and hierarchically structured data. These methods are applied to panel regional macro data and survey microdata, to contribute to the evaluation of policies in force and identify possible effects of alternative public interventions.

Following from this Introduction, in Chapters 2 to 4 the quoted studies are presented. The dissertation ends with Conclusions and policy implications in Chapter 5.

Chapter 2

Transport Infrastructure and Regional Convergence: A Spatial Panel Data Approach[2]

2.1 Introduction

Economic growth and changes in regional disparities over time have been traditional concerns of scholars in the field of economics. As a result, several empirical and theoretical approaches have been developed to examine the regional convergence process (see, among others, Baumol, 1986, Barro and Sala-i-Martin, 1992 and Canaleta et al., 2004). Likewise, international organizations have given their backing to public infrastructure investment as a key mechanism to reduce gaps between lagging and leading regions. Indeed, according to the World Bank Report (2009), the greater mobility of the factors of production promoted by these policies makes infrastructure investment a necessary element in any development strategy.

Spain is a paradigmatic example of a country with wide regional disparities. In pursuing regional convergence, the massive allocation of resources has seen the country expand its infrastructure capacity, making it at present the European country with the most extensive motorway and high-speed railway networks (Albalate et al., 2015). Against this backdrop, the positive impact of transport infrastructure on Spain's process of convergence would seem to be a relevant hypothesis to test.

To this point, several studies have examined the role of transport infrastructures in regional convergence. It is generally accepted that

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[2] The article in this chapter was jointly written with Xavier Fageda. Comments from Paul Elhorst, Donald Lacombe and Omar Licandro really contributed to improve this paper. I thank PhD Workshop committee and participants to the 2016 PhD in Economics Workshop and seminar audience at the XIV Arnoldshain Congress, for helpful comments. Article published at Papers in Regional Science. Reference: Fageda, X., Olivieri, C. (2019) "Transport Infrastructure and Regional Convergence: A Spatial Panel Data Approach", *Papers in Regional Science*, https://doi.org/10.1111/pirs.12433.

transportation contributes to economic growth, but its influence on reducing regional economic inequalities is less clear.

Studies that use samples of several countries generally find a positive effect of surface transportation on regional convergence. Calderón and Chong (2004) use country-level data to show that the endowment of roads and railways (in terms of both quantity and quality) are negatively linked with income inequality. Del Bo and Florio (2012) find a positive effect of motorways on regional convergence using data of regions within the European Union. Lesssmand and Seidel (2017) use luminosity data to examine the determinants of regional inequality for a sample of countries from all over the world. They use gasoline prices and country size as proxies for transportation costs and find that increasing transport costs increases regional inequality in large countries.

However, studies that use regional data within a country generally do not find evidence about a positive influence of transport infrastructure on regional convergence. Some works do not explicitly test for regional convergence, but their analyses have implications on the role of transportation in reducing regional disparities. Costa-Font and Rodríguez-Oreggia (2005) investigate the contribution of public investments in infrastructure to the reduction of regional inequalities in México. By means of a quantile regression, they find that public investments have only been able to reduce regional inequalities among the richest regions. In a similar vein, Pereira and Andratz (2006) estimate vector autoregressive (VAR) models for each region of Portugal and find that public investments in transportation have contributed to a concentration of the activity in Lisbon. Finally, Baum-Snow et al. (forthcoming) analyses the effects of the recently constructed Chinese national highway system on regional outcomes. They find that highways that improve access to local markets lead to an economic output and population increase in regional primates at the expense of hinterland prefectures. On the other hand, highways that improve access to international ports promote growth of hinterland prefectures.

Some other works analyze the regional convergence process within a country and the role of transportation in said process. Checherita (2009) shows that the regional convergence process in United States is not explained by the public capital stock in each state. Rodríguez-Pose et al.

(2012) develop a spatial econometric model to show that public investments in transport infrastructure have not contributed to the regional convergence in Greece. Cosci and Mirra (2018) analyze the role of highways on the regional convergence in Italy using a spatial econometric model. Their results suggest that motorways may have contributed to the reduction of regional disparities in some periods. However, the opening of the Autostrada del Sole has just contributed to the economic growth of the richer regions located in the centre-north.

In this paper, it is added to this literature by examining the role of different types of transport infrastructure on regional convergence in Spain. Evidence is provided for the conditional and unconditional convergence processes undergone by the Spanish provinces between 1980 and 2008.

As seen in the studies of Rodríguez-Pose et al. (2012) and Cosci and Mirra (2018), this paper exploits spatial econometric techniques and applies a spatial Durbin model (SDM) to measure the effects on the region where the investment is made, as well as the spillover effects in neighboring regions. In this regard, the direct, indirect and total impact of roads, railways, ports and airports are examined. This disaggregation in different types of transport infrastructure is a novelty with respect to previous studies on the contribution of transport infrastructure to regional convergence. Indeed, these studies usually use an aggregate indicator of the investment or the stock of transport infrastructure and only, in some cases, focus on the role of roads.

Furthermore, the main drivers of the regional distribution of investments in transportation during the considered period are analyzed. In particular, it is examined whether investments have been guided by efficiency, redistribution and/or equity concerns. This policy equation may provide an explanation for the contribution of transport infrastructures to regional convergence. The contribution of transport infrastructure to regional convergence could be expected to be modest in cases where redistribution or equity concerns are not the ones guiding the regional allocation of investments by the central government.

In this regard, a number of studies have analyzed the determinants of the regional allocation of investment in transportation, focusing on the equity-efficiency trade-off and the role played by political factors (Yamano and

Ohkawara, 2000; Castells and Solé-Ollé, 2005; Cadot et al., 2006; Golden and Picci, 2008; Kemmerling and Stephan, 2002, 2008; Albalate et al., 2012; Monastiriotis and Psycharis, 2014). Hence, a bridge is provided between the literature that examines the role of transportation on regional convergence process and the literature that studies the factors that account for the regional allocation of investment in transportation.

It is found that the Spanish provinces converge in a common steady-state level that could be indicative of an automatic tendency towards the equalization of income. Furthermore, the endowment of transport infrastructure does not appear to play a substantial role in the regional convergence process. However, the positive direct effect of roads on economic growth may have contributed to an intensification of the regional convergence in Spain. Results of the policy equation suggest that investment has been guided by an equity concern in the sense of equalizing the transport infrastructure endowment between the Spanish provinces. This could explain the positive effect of roads on regional convergence, although it is also found that regions with a higher level of income per capita have received more investment.

The remainder of this study proceeds as follows. Section 2.2 provides a detailed description of the literature. Section 2.3 reports Spanish transport investment data. Section 2.4 describes the variables included in the analysis and their data sources. Section 2.5 presents the empirical specification of the models and the econometric approach. Section 2.6 reports the results and section 2.7 presents the conclusions and discusses the policy implications of the results.

2.2 Literature review

The economic impact of transport infrastructure has been extensively studied, with analyses falling into three main streams: the impact of transportation on economic growth, the factors that determine investment across regions and the identification of a relationship between infrastructure and regional convergence. The analysis undertaken in this paper seeks to address these last two questions. Nevertheless, in discussing our findings the close interrelation between all three questions become evident.

Regarding the first issue, many empirical studies seek to estimate production functions to determine the impact of aggregate amounts of public capital on economic growth. They include Aschauer (1989), Munnell (1990), Garcia-Milà and McGuire (1992) and Holtz-Eakin and Schwartz (1995). Other studies undertake their analyses using cost functions (Nadiri and Mamuneas, 1994; Morrison and Schwartz, 1996). Some recent contributions to this question have employed different theoretical frameworks to capture the spatial externalities of transport infrastructure (Cohen, 2010; Del Bo and Florio, 2012; Crescenzi and Rodríguez-Pose, 2012; Yu et al., 2013; Chen and Haynes, 2015; Lo Cascio et al., forthcoming). In general, their results point (albeit not unanimously) to a direct and positive impact. However, these new econometric techniques suggest that the magnitude of the effect is not as great as that reported in the pioneering work of Aschauer, although this is still under debate.

For the specific case of Spain, several studies have analyzed the impact of transport infrastructure considering the possible existence of spatial spillovers. Álvarez et al. (2006) report positive direct effects of the stock of public capital while evidence of indirect effects is inconclusive. Baños et al. (2013) obtain the same results when studying the impact of better road accessibility on the private sector. Gomez-Antonio and Fingleton (2012) evidence positive direct effects but negative spillovers from the change in capital stock over neighboring provinces. Likewise, Delgado and Álvarez (2007), in a specific study of high capacity road endowments, and Moreno and López-Bazo (2007) demonstrate that transport infrastructure has a positive direct effect but a negative spillover effect for other provinces. The latter authors also find that returns to local public capital are higher than those to transport infrastructure, in line with Gómez-Antonio and Garijo (2012). As well, Arbués et al. (2015) find positive direct and indirect effects of roads and negative direct effects of ports.

With only a few exceptions (Arbués et al., 2015; Chen and Haynes, 2015; Lo Cascio et al., forthcoming), the analysis is made without any prior disaggregation by type of infrastructure. In this regard, different studies have found a positive impact from a specific transportation mode on some measure of the regional or urban economic performance. Relevant examples of this literature include Agrawal et al. (2017), Blonigen and Cristea (2015), Bottasso et al. (2013), Donaldson (2018), Duranton (2016), Duranton and Turner (2012), Möller and Zierer (2018), Percoco (2016) and Xu and Nakajima (2017). None of these studies aimed at examining the contribution of transport infrastructure to regional convergence, which is the main goal of our analysis.

The second stream analyses the political decision-making process behind regional transportation investment. Most studies on this subject focus on the three normative principles of infrastructure investment allocation across regions: that is, efficiency, redistribution and equity. The so-called "trade-off between efficiency and equity" implies that, in general, one of these objectives is in conflict with the others. According to this research (Yamano and Ohkawara, 2000; Kemmerling and Stephan, 2002, 2008; Monastiriotis and Psycharis, 2014), the efficiency criterion means spending in regions where the marginal productivity of infrastructure is highest; redistribution means promoting the development of poorer regions by means of infrastructure investment; and equity seeks to target investment in regions with the lowest infrastructure endowment.

Among their empirical studies, Yamano and Ohkawara (2000) examine the effects of public infrastructure investment on Japan's regional production structure and conclude that if the government had adopted a policy guided by goals of efficiency, the level of production would have been greater than the one experienced by pursuing equity. In the same line, De la Fuente (2004) argues against the regional policy applied by the EU, in which resources were allocated directly to public investment in infrastructure to improve the productive capacity of the less developed regions. Among EU countries, in a study of transportation infrastructure in Spain, Castells and Solé-Ollé (2005) conclude that regional governments seem to be more inclined towards efficiency than central governments are; whereas, in an analysis of the functional and spatial allocation of the highly centralized public investment in Greece, Monastiriotis and Psycharis (2014) conclude that the allocation has not been efficient. Kemmerling and Stephan (2008) find that both, efficiency and redistribution, matter in an analysis for France, Germany, Italy and Spain.

Furthermore, Kemmerling and Stephan (2002) for Germany, Castells and Solé-Ollé (2005) for Spain, Golden and Picci (2008) for Italy and Cadot et al. (2006) for France find that political factors such as electoral competition or electoral rents influence the allocation of public infrastructure investment. Also, Albalate et al. (2012) and Bel (2011) show that the infrastructure policy in Spain responds to the objective of transport centralization around the capital.

This paper's contribution to the literature on the determinants of the investments in transport infrastructures is the linking of the results of this equation to those obtained in the equation of regional convergence. It could be expected that the contribution of transport infrastructure to regional convergence is modest in cases where redistribution or equity concerns are not guiding the regional allocation of investments by the central government.

Finally, the third stream focuses on the somewhat controversial issue of the regional convergence process. As mentioned above, empirical studies on the role of public infrastructure on convergence provide conflicting results. Cross-country analyses show a positive impact of transport infrastructures on regional convergence (Calderón and Chong, 2004; Del Bo and Florio, 2012; Lesssmand and Seidel, 2017). In contrast, regional analysis within a country usually do not find evidence of a relevant contribution of transportation on such regional convergence (Costa-Font and Rodríguez-Oreggia, 2005; Pereira and Andratz, 2006; Checherita, 2009; Rodríguez-Pose et al., 2012; Cosci and Mirra, 2018, Baum-snow et al., forthcoming).

This paper's contribution to this previous literature on transport infrastructure and regional convergence is the disaggregation of the analysis for different types of transport infrastructures (roads, railways, airports, ports).[3] Furthermore, an equation for the determinants of public investments in transport infrastructures is estimated to provide an explanation of the results for the contribution of transportation to regional convergence. A spatial econometric model is also estimated as it has been done in just two previous studies (Rodríguez-Pose et al., 2012; Cosci and Mirra, 2018).

Finally, there is growing literature that is loosely connected to the role of infrastructure in reducing economic inequality between territories. Indeed, several studies show the role of roads in promoting processes of suburbanization or decentralization of population and economic activity

[3] Unfortunately, data obtained does not allow disaggregating between different types of roads.

within an urban area (Baum-Snow, 2007; Baum-Snow et al., 2017; Garcia-López et al., 2015). However, note that the focus of this paper is on economic inequality between regions, while these studies focus on inequalities within an urban area.

2.3 Investment in transport infrastructure in Spain

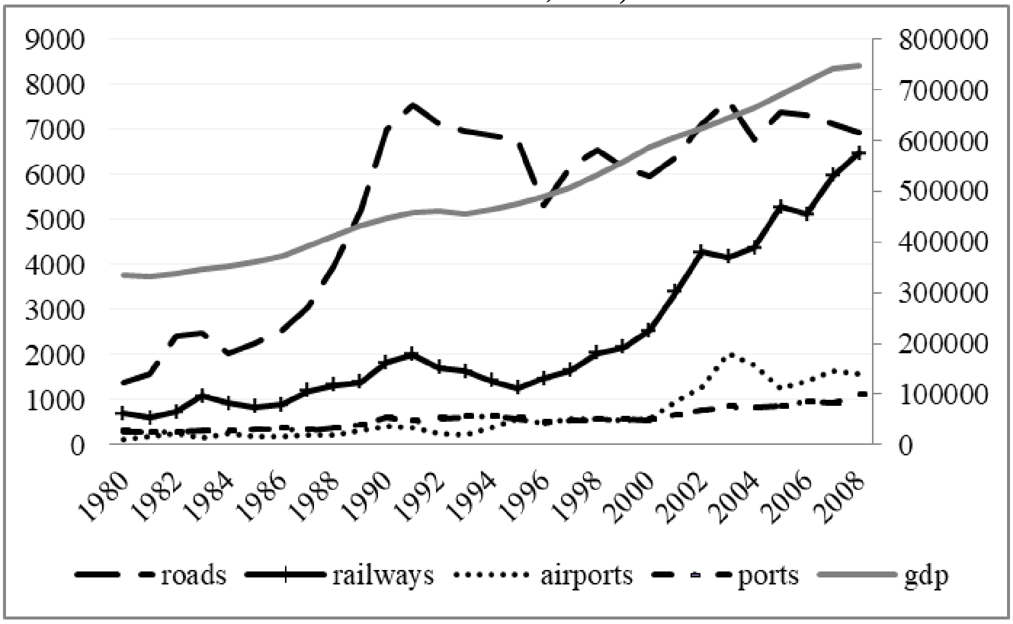
Spain has substantially expanded its transport infrastructure over the period studied in this paper. Figure 2.1 shows the evolution of transport investment at a national level, disaggregated into roads, railways, airports and ports. It also shows the evolution of the gross domestic product (GDP) on the right axis. As can be seen, at the beginning of the 1980s, the Government's transport investment policy was targeted at increasing the capacity of roads, in order to endow the country with high-capacity motorways. From that date until the end of the 1990s, the investment policy stressed on the strengthening of the political centre, by constructing a 200-kilometre belt around Madrid and increasing the connections of the centre with the periphery (Albalate et al., 2012).

In recent decades, Spain's transport investment policy has shifted its attention from roads to high-speed railways, responding to the expansion of the number of destinations, and is targeted almost exclusively at passenger transport.

The financing schemes for transport infrastructure have not experienced the same shift. Thus, high capacity network modes (roads, railways) receive the largest share of Spanish transport infrastructure investment, while single transport facilities (ports, airports) receive a smaller allocation of resources (see Figure 1). Having said that, airport investment in Spain has been much higher than that of other European Union (EU) air markets.

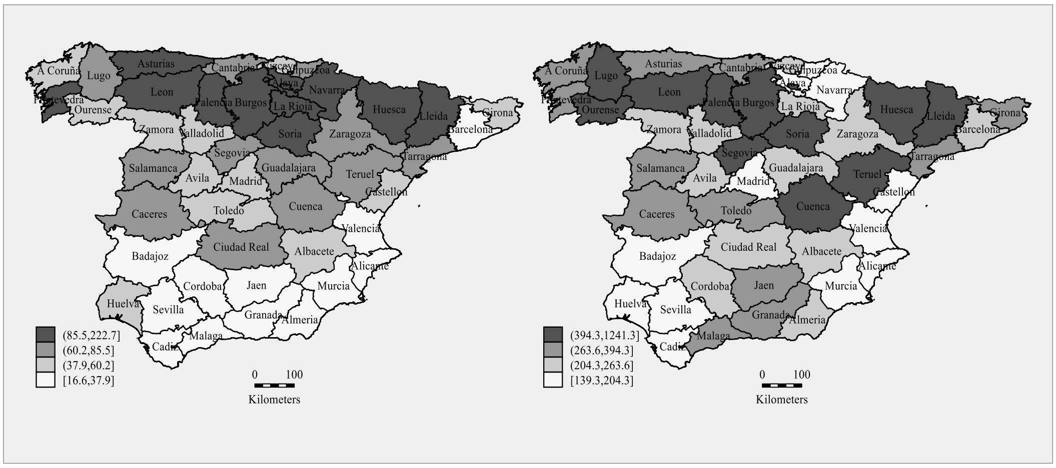
The regional allocation of investment in network (roads, railways) and single facilities (ports, airports) at the beginning and at the end of the period is shown in Figures 2.2 and 2.3. The figures show that investment in network modes has been allocated mainly to the north of the country, although it has increased throughout the rest of the territory as well. At the same time, investment in single facilities predominates along the Atlantic and Mediterranean coasts. Nevertheless, at the end of the period, an increase in investment is recorded in other regions inside the country.

FIGURE 2.1 Evolution of transport investment in Spain, 1980-2008 (thousands of constant euros, 2000).



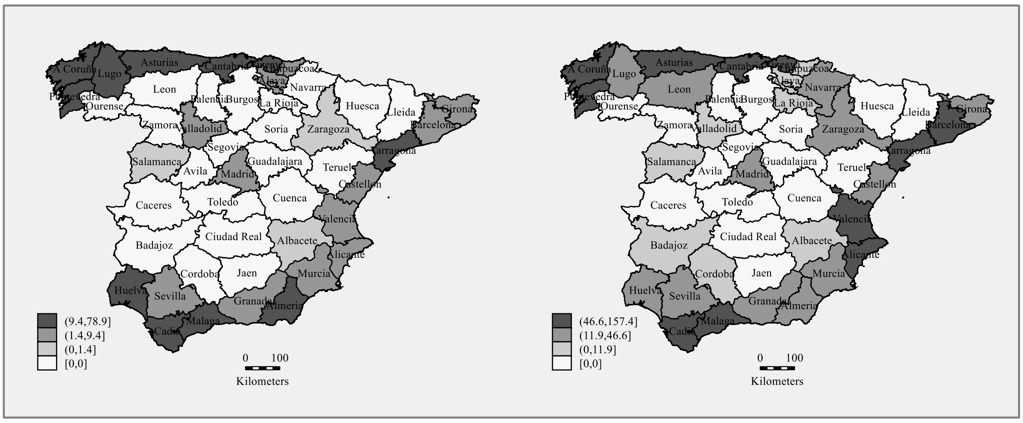
Source: Own elaboration based on data on *Instituto Valenciano de Investigaciones Económicas* and *Instituto Nacional de Estadística*

FIGURE 2.2 Distribution of network investment in 1980 (left) and 2008 (right) at NUTS-3.



Source: Own elaboration based on *Instituto Valenciano de Investigaciones Económicas*

FIGURE 2.3 Distribution of single investment in 1980 (left) and 2008 (right) at NUTS-3.



Source: Own elaboration based on *Instituto Valenciano de Investigaciones Económicas*

The policies implemented have enabled Spain to become the EU country with the most extensive motorway network and to develop the most extensive high-speed railway network in Europe (Albalate et al., 2015). Moreover, according to data provided by the International Transport Forum (cited in Albalate et al., 2015), over the period 2000–2009, airport investment in Spain was also high: 1.5 times greater than that in Germany, 1.9 times higher than that in France and 4.8 times greater than the corresponding investment in Italy. The figures for investment in ports tell a similar story. Data indicates that between 2000 and 2009, investment in Spanish ports doubled that of Italy, and was three times higher than the German budget and six times higher than the French budget.

2.4 Data and variables

For the purpose of this study, a panel of Spanish regions was constructed using annual data for the period 1980–2008. All of Spain’s provinces are considered, with the exception of the islands and the autonomous cities of Ceuta and Melilla, due to differences in the endowment of their transport infrastructure and the difficulties to capture their indirect effects.

TABLE 2.1 Annual growth rate, descriptive statistics

Province	mean	min	max	range	p25	p75	sd	cv
A Coruña	2.05	-1.98	7.82	9.80	0.78	3.20	2.16	1.05
Alacant	1.11	-2.98	6.42	9.41	-0.76	3.30	2.48	2.24
Albacete	2.17	-7.36	7.25	14.60	0.86	3.24	3.44	1.59
Almería	2.10	-3.27	10.34	13.61	-0.76	4.35	3.60	1.71
Alaba	1.38	-8.08	4.96	13.04	0.40	3.39	2.82	2.04
Asturias	2.46	-2.76	5.80	8.55	1.31	3.92	1.85	0.75
Ávila	2.71	-8.09	8.64	16.73	1.70	4.83	3.74	1.38
Badajoz	2.82	-2.99	9.20	12.19	0.86	3.96	2.82	1.00
Barcelona	2.19	-2.48	6.50	8.98	0.56	3.59	2.50	1.14
Bizkaia	2.22	-1.49	7.01	8.50	0.11	3.46	2.21	1.00
Burgos	2.58	-4.07	9.51	13.58	1.60	3.77	2.83	1.10
Cádiz	3.90	-2.45	20.83	23.28	1.71	4.63	4.41	1.13
Cantabria	1.92	-3.78	7.36	11.14	0.22	3.47	2.73	1.42
Castelló	2.04	-4.84	10.26	15.10	0.51	3.07	2.86	1.40
Ciudad Real	1.78	-2.75	8.31	11.07	0.05	4.07	2.68	1.51
Cuenca	2.42	-3.94	9.16	13.10	1.14	3.66	2.59	1.07
Cáceres	2.67	-4.11	10.90	15.01	0.62	4.05	3.32	1.24
Córdoba	2.51	-8.19	8.58	16.77	1.98	4.07	3.77	1.50
Gipuzkoa	2.25	-5.13	6.82	11.95	0.36	4.43	2.75	1.22
Girona	1.55	-3.45	9.86	13.31	-0.96	3.46	2.87	1.85
Granada	2.60	-5.87	8.43	14.30	1.41	3.92	2.56	0.98
Guadalajara	1.61	-5.07	17.94	23.01	-1.29	2.02	5.17	3.21
Huelva	1.89	-6.16	10.26	16.42	-0.65	3.92	3.70	1.96
Huesca	2.49	-9.91	12.66	22.57	1.41	4.11	4.32	1.74
Jaén	2.80	-8.87	11.80	20.67	0.49	4.43	4.55	1.62
La Rioja	2.75	-6.15	15.94	22.09	1.29	3.80	3.55	1.29
León	2.88	-1.28	9.02	10.30	1.55	4.38	2.49	0.86
Lleida	1.94	-2.80	6.17	8.97	0.70	3.42	2.25	1.16
Lugo	2.26	-8.65	9.67	18.32	1.30	3.80	3.49	1.55
Madrid	2.31	-2.05	8.14	10.19	0.90	3.72	2.32	1.00
Murcia	1.74	-2.79	7.49	10.28	0.61	2.79	2.30	1.32
Málaga	1.59	-3.47	5.96	9.43	0.19	3.14	2.28	1.44
Navarra	2.13	-2.20	9.16	11.37	1.32	2.72	2.62	1.23
Orense	3.19	-4.77	10.66	15.43	1.87	4.22	2.88	0.90
Palencia	2.41	-9.58	13.87	23.45	-0.07	4.26	4.80	1.99
Pontevedra	1.93	-2.57	5.95	8.52	0.69	3.40	2.14	1.11
Salamanca	3.39	-6.31	8.08	14.39	1.63	5.54	3.14	0.93
Segovia	2.60	-5.33	11.75	17.08	0.66	4.50	3.61	1.39
Sevilla	2.42	-6.50	7.68	14.18	1.09	3.91	3.06	1.26
Soria	3.03	-6.88	10.75	17.63	0.84	5.03	3.75	1.24
Tarragona	1.48	-3.90	9.83	13.73	-0.92	3.62	3.08	2.08

TABLE 2.1 (cont) Annual growth rate, descriptive statistics

Province	mean	min	max	range	p25	p75	sd	cv
Teruel	2.37	-19.37	14.10	33.46	0.10	5.03	5.88	2.48
Toledo	1.72	-9.13	12.18	21.31	0.24	2.83	3.97	2.31
València	2.27	-3.61	6.25	9.87	1.13	4.06	2.25	0.99
Valladolid	2.46	-6.79	6.66	13.45	1.43	4.62	2.76	1.12
Zamora	3.20	-10.49	13.21	23.70	2.17	5.02	4.18	1.31
Zaragoza	2.61	-2.58	7.74	10.32	1.74	3.83	2.39	0.92
Total	2.32	-19.37	20.83	40.20	0.71	3.91	3.25	1.40

Source: Own calculations based on *Instituto Nacional de Estadísticas*

The data employed was provided by the *Instituto Valenciano de Investigaciones Económicas* (Valencian Institute of Economic Research, IVIE) and Spain's *Instituto Nacional de Estadísticas* (National Institute of Statistics, INE). The first one provided data on investment, net capital stock and employment, while the second one supplied information on GDP, population and surface area. The spatial unit of analysis is the EU regional level classification NUTS3 (*Nomenclature des Unités Territoriales Statistiques*), which in the case of Spain corresponds to the provinces.

The dependent variable in the analysis of the regional convergence process is the regional growth rate of GDP *per capita* ($\Delta GDP_{i,t0+T}$), computed as the difference between the logarithm of the GDP *per capita* of province *i* in period t_{0+T} and the logarithm of the GDP *per capita* of province *i* in period *t0*. The main descriptive statistics of this variable, for each province and the entire period, are given in Table 2.1. Note that in the analysis of the role played by transport infrastructure in regional convergence the regional income *per capita* is considered, as well as the interregional public stock *per capita* of infrastructures, disaggregated into roads, railways, ports and airports. According to the data source, the estimation procedure of the net capital stock is the perpetual inventory method (see Table 2.2 for the descriptive statistics). In the analysis of the determinants of investment in transportation, the dependent variable is the regional growth rate of the total stock of transport infrastructure ($\Delta Transport_{i,t0+T}$), computed as the difference between the transport stock in province *i* in period t_{0+T} and the transport stock in province *i* in period t_0.

TABLE 2.2 Disaggregation of capital stock, mean values (thousands of constant euros, 2000)

Province	Roads	Railways	Airports	Ports
A Coruña	1,172	114	106	172
Alacant	876	52	47	57
Albacete	1,959	183	3	0
Almería	1,790	50	41	126
Alaba	2,246	35	84	0
Asturias	2,094	176	14	87
Avila	2,744	108	0	0
Badajoz	1,678	70	6	0
Barcelona	741	276	46	18
Bizkaia	1,547	118	63	76
Burgos	2,371	94	0	0
Cadiz	2,282	88	0	0
Cantabria	885	64	10	90
Castelló	2,326	112	50	97
Ciudad Real	1,480	381	0	94
Cuenca	1,714	424	0	0
Cáceres	1,289	540	3	0
Córdoba	4,044	69	0	0
Gipuzkoa	2,022	138	14	125
Girona	1,621	126	77	80
Granada	1,581	34	11	37
Guadalajara	3,732	57	0	0
Huelva	1,643	83	0	103
Huesca	3,660	166	0	0
Jaen	1,733	48	0	0
La Rioja	1,500	48	0	0
Leon	2,456	88	0	0
Lleida	2,942	133	0	0
Lugo	3,240	57	0	131
Madrid	637	360	98	0
Murcia	1,215	92	112	74
Malaga	992	42	2	42
Navarra	2,297	76	15	0
Ourense	2,413	41	0	0
Palencia	2,841	216	0	0
Pontevedra	1,266	91	29	79
Salamanca	1,913	66	16	0
Segovia	2,819	96	0	0

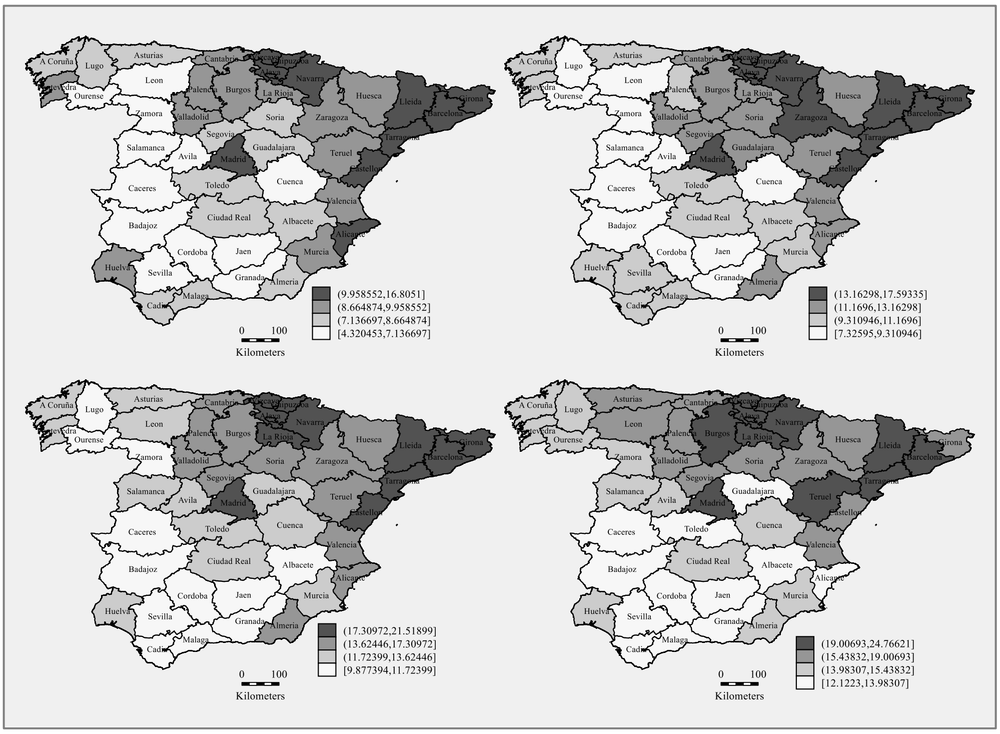
TABLE 2.2 (cont) Disaggregation of capital stock, mean values (thousands of constant euros, 2000)

Province	Roads	Railways	Airports	Ports
Sevilla	1,091	178	69	17
Soria	4,978	243	0	0
Tarragona	1,549	312	15	103
Teruel	4,109	140	0	0
Toledo	1,953	246	0	0
València	1,035	295	23	22
Valladolid	1,541	46	20	0
Zamora	3,451	67	0	0
Zaragoza	1,225	189	20	0
Total	2,057	143	21	35

Source: Own calculations based on IVIE

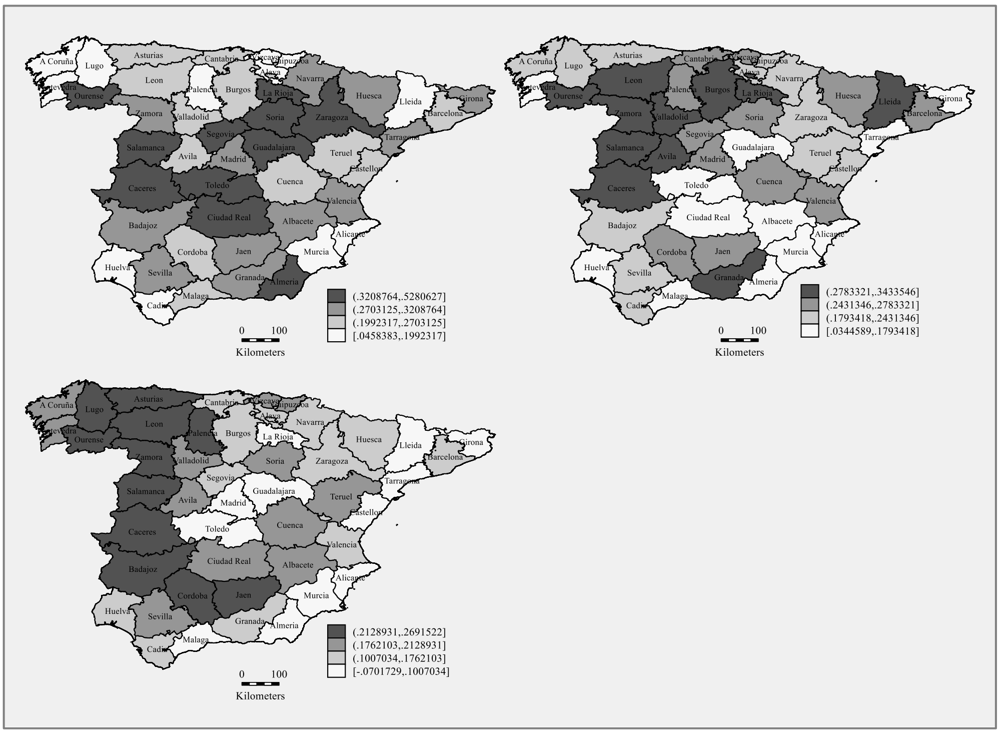
The data shows geographical inequalities in the distribution of GDP *per capita* across the Spanish provinces. Figure 2.4 shows how it evolved, focusing on four specific years during the period studied: 1980, 1990, 2000, and 2008. As can be seen, the richer provinces are located in the northeast of the country, whereas the poorer provinces are in the southwest. This distribution pattern is largely maintained throughout the period. Figure 2.5 shows the distribution of GDP *per capita* growth between 1980–1990, 1990–2000 and 2000–2009. In this case the distribution pattern is less clear, although the fastest growing areas are those with the lowest GDP *per capita*.

FIGURE 2.4 Distribution of GDP per capita among regions, years: 1980-1990-2000-2008.



Source: Own elaboration based on *Instituto Nacional de Estadísticas*

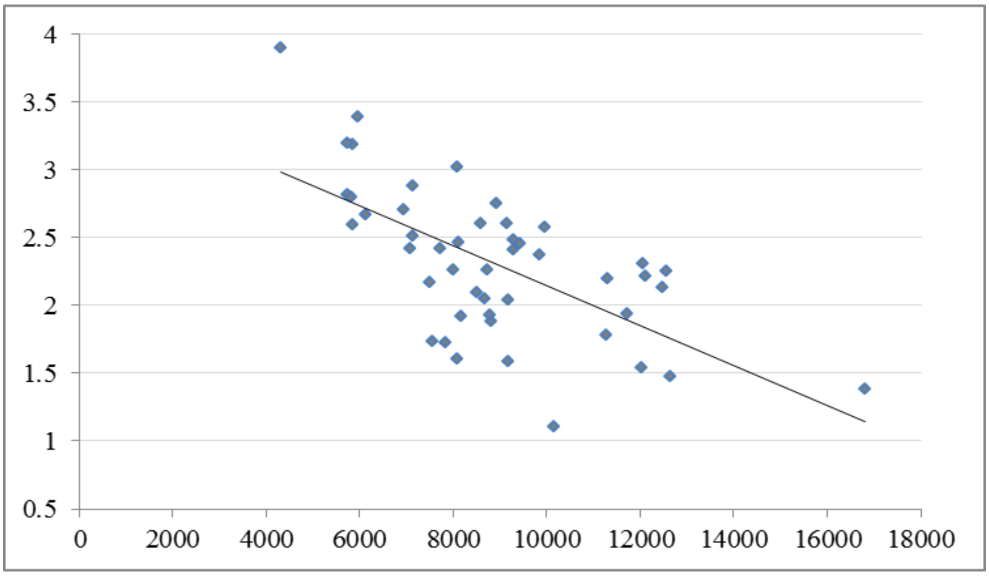
FIGURE 2.5 Distribution of GDP per capita growth among regions, periods (90-80) (00-90) (09-99)



Source: Own elaboration based on *Instituto Nacional de Estadísticas*

Figure 2.6 depicts a scatter chart for the whole sample. The annual growth rate of GDP *per capita* is on the y-axis and the initial level of output on the x-axis. A negative relationship can be seen between the two variables, which is indicative of the validity of the convergence hypothesis.

FIGURE 2.6 Relationship between the average annual growth rate of GDP *per capita* and the initial level of output



Source: Own elaboration based on *Instituto Nacional de Estadísticas*

2.5 The empirical strategy

2.5.1 Regional convergence and transport infrastructure

In this study, it is sought to validate the hypothesis that there has been a process of economic convergence between Spain's provinces in the period 1980–2008. Complementary to this, it is also sought to verify the hypothesis that transport infrastructure plays a significant role in accounting for regional convergence.

Economic convergence at national or regional level refers to an inverse relationship between the growth rate of income *per capita* and the starting level of income *per capita*. Specifically, it is a situation where the gap in output *per capita* between regions tends to decrease over time.

Empirically, the most frequently employed model of convergence is the "β-convergence model" developed by Barro and Sala-i-Martin (1992) and Sala-i-Martin (1996). Within this framework, the process by which poorer regions grow faster than their richer counterparts in the transition to the steady-state is measured by the β coefficient of the estimated regression. There is evidence of convergence if β is negative and statistically significant.

Overall, a panel data analysis is conducted to consider both, the cross-sectional and time series dimensions of the processes. Additionally, the analysis includes a spatial panel data specification in order to capture potential externalities. The Moran's I test is applied as an indicator of spatial autocorrelation. The index indicated the presence of significant spatial autocorrelation in the models, supporting the inclusion of spatial factors.

Three main models have been proposed in the spatial econometric literature. The spatial Durbin model (SDM) controls for endogenous spillovers, including the spatially lagged dependent variable, and for exogenous spillovers, using spatial lags in the regressors. In contrast, the spatial autoregressive model (SAR) only includes a spatially lagged dependent variable, while the spatial error model (SEM) contains a spatially correlated error component.

The decision as to which spatial model to select is governed by the specific research goals and the context in which the model is to be applied (Lesage and Fisher, 2008; Lesage and Pace, 2009). In this case, eventual selection of the model specifications was driven by Wald and likelihood ratio test results; the first one indicated the greater suitability of the SDM compared to that of the SAR, while the second one rejected the SEM as unsuitable. Furthermore, the SDM contains the other two models and has the attribute of giving unbiased estimates, even if the true economic process is SAR or SEM (Elhorst, 2010).

In the specific context of this study, the implication is that the economic performance of a particular region is dependent, to some degree, on the value that the variable assumes in neighboring areas. It is this dependence that justifies the inclusion of a spatially lagged dependent variable.

Moreover, a change in an independent variable for a particular province can potentially affect the economic activity in all the other provinces.

Indeed, the literature presents evidence of the fact that better transport infrastructure in a region may have an impact on neighboring regions, thus permitting the inclusion of spatially lagged explanatory variables. A positive effect means that a particular region benefits from the better endowment of its neighbors, while a negative effect indicates that the region is left worse off.

In the first stage of the empirical strategy, the unconditional β-convergence hypothesis is tested. To do so, an unconditional convergence estimation is performed using the whole sample of 47 provinces, with the annual growth rate of GDP *per capita* as the endogenous variable and the initial level of GDP *per capita* (in logs) as the explanatory variable.

The specification of the SDM model, for the corresponding province *i* in year *t*, is as follows:

$$\Delta GDP_{it+1,t} = \rho W\left(\Delta GDP_{it+1,t}\right) + \beta \ln(GDP_{it}) + \gamma W \ln(GDP_{it}) + \mu_i + \epsilon_{it} \qquad (2.1)$$

In the second stage, the role played by transport infrastructure in regional growth is examined. A similar procedure to that of absolute convergence is applied, but in this case the disaggregation by type of transport infrastructure is included:

$$\begin{aligned}\Delta GDP_{it+1,t} = {} & \rho W\left(\Delta GDP_{it+1,t}\right) + \beta \ln(GDP_{it}) + \gamma_1 ln(Roads_{it}) \\ & + \gamma_2 \ln(Railways_{it}) + \gamma_3 \ln(Airports_{it}) + \gamma_4 \ln(Ports_{it}) \\ & + \gamma_5 W\ln(GDP_{it}) + \gamma_6 W ln(Roads_{it}) + \gamma_7 W \ln(Railways_{it}) \\ & + \gamma_8 W \ln(Airports_{it}) + \gamma_9 W \ln(Ports_{it}) + \mu_i \\ & + \epsilon_{it} \qquad (2.2)\end{aligned}$$

In equation 2.2, the net stock of roads, railways, airports and ports (in logs) are added as explanatory variables. Note that in equations 2.1 and 2.2 the spatially lagged dependent variable and the spatially lagged explanatory variables are included.

In equations 2.1 and 2.2, μ_i are individual fixed effects and W (N×N) are the spatial weights matrices which summarize the arrangements of the N spatial units in the sample. In general, the literature does not recommend using the random effects model for estimates of this type (Elhorst, 2014). In addition, the fixed effects model allows us to control for omitted variables that correlate with the dependent variables and which are invariant over time. In this respect, the fixed effects model only captures the variation within the data.

Each element of W is referred to as the spatial weight, w_{ij}. The spatial weights capture the neighborhood effect and differ from zero when regions i and j are neighbors. By convention, no region can be its own neighbor, so all the elements in the main diagonal of W are equal to zero ($w_{ii} = 0$).

The spatial weights matrix occupies a central position in spatial econometrics as it defines the set of neighbors for each location. However, one weakness that has been attributed to spatial econometric models is that the choice of the weight matrix influences the rest of the analysis (Elhorst, 2010). In practice, the weight matrix is constructed using different criteria. These criteria range from the use of geographical locations to the use of flows that capture social interactions and other sources of socio-economic information. The geographical criterion has the advantage of being exogenous to the model, since the choice of neighbors, as Anselin (1988, 2001) points out, does not respond to the variables considered in the analysis.

Once the spatial weights have been selected, it is usual to work with a transformation to improve the statistical properties of the estimators and contrasts. The row-standardization, which is the most commonly employed, was applied.

An SDM was estimated with three different specifications of the spatial weight matrix: a standardized contiguity matrix, a standardized inverse matrix of the squared distance and the five-nearest-neighbors matrix. First, a row-standardized contiguity matrix (W_contiguity) was considered with elements $w_{ij} \neq 0$ when two provinces share a common border and $w_{ij} = 0$ when otherwise. This matrix assumes that interregional effects are present only between bordering provinces. Second, a row-standardized inverse matrix of the squared distance (W_distance) was computed, based on the geographical location of the provincial capitals. The assumption behind this specification is that all regions contribute to spatial spillovers according to their respective distances between each other, the greater distances being penalized more heavily. Additionally, in order to check the robustness of the results, a row-standardized five-nearest-neighbors matrix (W_nearestn) was constructed, in which the elements $w_{ij} \neq 0$ are the five nearest provinces. In this case, the assumptions made with regards to the first matrix are relaxed, and more elements in the interactional space are included.

The spatial lags included in the regression model introduce difficulties in the interpretation of the estimates. In order to measure and accurately interpret this spatial connectivity, a methodology has been proposed (for a deeper and more exhaustive discussion see LeSage and Fisher, 2008). When analyzing the results, the total effect of any change in an explanatory variable of a region can be decomposed into a 'direct effect' and an 'indirect effect'. The direct effect captures the impact on the region itself, accounting for the feedback influences that arise as a result of the regional interconnection. The indirect effect is that associated with the impact on other regions, the spatial spillovers and the feedback influences. The sum of the direct effect and the indirect effect equals the 'total effect'.

Overall, the expected signs of the spatially lagged variables are unclear. In spatial growth models, the spatial dependence parameter (ρ) is expected to be positive and less than unity, indicating that regional growth rates are positively related to those from neighboring regions (LeSage and Fisher, 2008). In the case of network infrastructures (roads, railways) a positive effect may be found reflecting the better connectivity provided by improved road and railway links beyond the specific region in which the investment was made. However, the effect could also be negative due to the fact that better infrastructure may attract the factors of production from other regions. In the case of single infrastructures (ports, airports), the provinces situated closest to well-endowed regions may benefit from easier access to a wider range of goods from distant markets, while provinces with large ports and/or airports may also attract productive factors from neighboring regions which lack said infrastructure.

Moreover, it is worth mentioning that in all the specifications the null hypothesis that the SDM could be simplified to the spatial lag model or to the SEM was rejected. Indeed, the spatial autocorrelation coefficient ($W(\Delta GDP_{it+1,t})$) is significant in all specifications, which provides evidence of the fact that Spanish provinces are spatially interconnected. Additionally, the Hausman test was computed for all specifications to select between fixed and random effects. In all cases, the fixed effects model was shown to be more suitable for the spatial panel models.

2.5.2 Determinants of investment in transport infrastructure

The determinants of transport infrastructure investment were also analyzed. To do so, a policy equation which includes similar explanatory variables as in previous studies was used. The interest in this equation arises from its capability to provide an explanation of the results for the regional convergence equation. In particular, it is of interest to examine whether efficiency, redistribution and/or equity have been major drivers in the regional allocation of investments in transport infrastructure.

In line with Yamano and Ohkawara (2000), Kemmerling and Stephan (2002, 2008) and Monastiriotis and Psycharis (2014), efficiency implies investment in regions where the marginal productivity of the capital stock is higher. Redistribution implies a positive discrimination towards lagging regions, due to which a negative relationship between investments and income should be expected. Equity implies reducing inequalities between regions in terms of infrastructure endowment. Thus, regions with a lesser endowment of transport infrastructure would receive more investment. Note that a modest contribution of transport infrastructure to regional convergence should be expected if redistribution and/or equity have not driven the central government's regional investment in transport infrastructure.

Previous studies also include political variables related to electoral competition or electoral rents. For consistency with these previous studies, two control variables related to electoral competition are included, although they are not essential for this analysis.

The policy investment equation to estimate is as follows:

$$\Delta Transport_{it+1,t} = \alpha + \rho \Delta Transport_{it,t-1} + \beta_1 \, ln(Efficiency_{it}) + \beta_2 ln(Redistribution_{it}) + \beta_3 \, ln(Equity_{it}) + \beta_4 (Partisan\ strongholds)_{it} + \beta_5 (Political\ congruence)_{it} + \mu_t + \epsilon_{it} \quad (2.3)$$

In the above equation, μ_t are year dummy variables. The other variables included are the following:

- *Efficiency.* This principle implies that investment should be made in provinces where it can be expected to have a high impact on growth: the higher the productivity, the greater the efficiency in any given region. Efficiency is measured as the ratio between regional GDP and total stock of transport infrastructure in a region. Thus, the estimated coefficient of this variable is expected to be positive if efficiency is a goal in the regional allocation of investment in transport infrastructure. This variable has also been considered in the studies of Yamano and Ohkawara (2000), Kemmerling and Stephan (2002, 2008), Cadot et al. (2008) and Monastiriotis and Psycharis (2014).
- *Redistribution.* This principle of regional policy is based on the use of transport infrastructure to promote the development of poorer regions. It is defined as GDP divided by the employed population in the respective province. The estimated coefficient of this variable is expected to be negative if redistribution is a goal in the regional allocation of investment in transport infrastructure. This variable has also been considered in the studies of Yamano and Ohkawara (2000), Kemmerling and Stephan (2002, 2008), Golden and Picci (2008), Albalate et al. (2012) and Monastiriotis and Psycharis (2014)
- *Equity.* This principle holds on to the idea of equalizing the infrastructure endowment between regions. It is measured as the total transport infrastructure stock over the size of the province in square kilometers. The estimated coefficient of this variable is expected to be negative if equity is a goal in the regional allocation of investment in transport infrastructure. This variable has also been considered in the studies of Yamano and Ohkawara (2000), Kemmerling and Stephan

(2002, 2008), Albalate et al. (2012) and Monastiriotis and Psycharis (2014).

- *Partisan strongholds* and *Political congruence.* From a political point of view, this theory holds that investment is likely to be higher in provinces where the central government party has greater support among the population or in provinces where the regional and national governments have greater affinity. The percentage of votes obtained in each province by the central government party at the general elections is used as a proxy for this first variable. Likewise, political congruence is measured with a dummy variable that takes a value of one when the regional party is the same as that in central government. The estimated coefficients are expected to have a positive sign.

In this context, the main motivations of the estimation strategy are the control of endogeneity and efficiency. The panel data methodology first considered best suited for growth rate empirical models was the first-difference generalized method of moments (GMM) developed by Holtz-Eakin et al. (1988) and Arellano and Bond (1991). It involves the assumption of no serial correlation of time-invariant disturbances in the original equation in levels (Caselli et al., 1996; Forbes, 2000; Levine et al., 2000). Bond et al. (2001) identified some problems in the effectiveness of this method in empirical growth models using small samples, especially when the variables show persistence over time. By way of solution, they proposed the GMM system estimator (Arellano and Bover, 1995; Blundell and Bond, 1998).

In this paper's sample, however, persistence does not seem to be a major problem and so it was opted to apply the first-difference GMM estimator. Given this assumption, the GMM estimator should be consistent even in the presence of measurement errors and endogenous explanatory variables (Di Giacinto and Espósito, 2012). Moreover, the validity of the instruments can be tested using the Hansen test of overidentifying restrictions.

However, it is worth noting that while the GMM estimator has the advantage of eliminating any problems of endogeneity, it has the disadvantage of not allowing the heterogeneity between regions to be incorporated when it is not captured by the explanatory variables, whereas the other estimators do.

As explained previously and following the state of the art on this specific issue, the first-difference GMM technique was performed, considering as endogenous variables the lag of investments and regional GDP.

2.6 Results

The empirical analysis is presented in three sub-sections. Sub-section 2.6.1 presents the empirical results for the absolute β-convergence process in terms of annual growth rates. In sub-section 2.6.2, it is allowed for the possibility of multiple steady states and it is sought to verify the conditional β-convergence hypothesis, considering different components of public stock of transport infrastructure. The main concern in this section is to determine the contribution of regional public transport endowment to the Spanish provinces' growth rates and to test the extent to which transport infrastructure is influencing the convergence process. Lastly, sub-section 2.6.3 assesses the drivers of investment in transport infrastructure across regions to provide an explanation of their contribution to regional convergence.

2.6.1 Absolute β-convergence

Table 2.3 reports the results of the absolute convergence estimation of the bias-corrected SDM model[4] using the contiguity, distance and nearest neighbor weights matrices, respectively. It is found that the signs and significance levels are consistent across the three specifications, although the coefficients differ. Focusing on our variable of interest, the empirical evidence suggests the presence of an absolute convergence process between the Spanish provinces throughout the period. The β-coefficient, that is, the estimated parameter of the initial level of GDP *per capita* is negative and statistically significant for all specifications. Due to similar levels of technology, factor mobility and regulations, this process is more likely among homogeneous regions, mostly in the case of provinces within the same country. Having said this, results are in line with Checherita (2009)

[4] The maximum likelihood (ML) estimator was applied to fit the spatial panel data models, as suggested by Anselin (1988). The ML estimation is based on the assumption of normal error terms and is implemented in the *xsmle* stata command.

for US states, Del Bo et al. (2010), Del Bo and Florio (2012) for European regions, and Lessman and Seidel (2017) for worldwide regions. In contrast, Rodríguez-Pose et al. (2012) does not find evidence of absolute convergence for Greek regions.

In order to obtain a preliminary idea of the spatial interactions, Table 2.3 also notes that, as with the spatially lagged independent variable, the annual growth rate of GDP *per capita* in a province is positively correlated to the initial level of GDP *per capita* in the neighboring areas. The magnitude of the spatial spillover effects are provided in Table 2.4.

The total effect of the initial level of GDP *per capita* is not significant, unlike its direct and indirect effects (see Table 2.4). The indirect effect is positive and statistically significant, which means that the independent variable not only contributes to the dependent variable directly, but also indirectly through spatial spillovers. Indeed, the contribution of a particular region to the growth rate of the neighboring areas is positive, whereas the impact on its own GDP *per capita* growth rate is negative. Likewise, the findings are in line with the β-convergence hypothesis.

TABLE 2.3 Estimation results of Absolute Convergence (bias-corrected fixed effects). Dependent variable is growth of GDP per capita

VARIABLES	W_contiguity	W_distance	W_nearestn
Gdp	-8.339	-8.903	-8.778
	(1.286)***	(1.310)***	(1.271)***
W*Gdp	8.120	8.663	8.631
	(1.331)***	(1.355)***	(1.313)***
W*$\Delta GDP_{it+1,t}$	0.411	0.450	0.596
	(0.030)***	(0.031)***	(0.030)***
σ_{ϵ}^2	8.723	8.714	8.175
	(0.351)***	(0.350)***	(0.328)***
Spatial specific effects	YES	YES	YES
Observations	1,269	1,269	1,269
R-squared	0.016	0.017	0.018
Log-likelihood	-3,202.55	-3,198.97	-3,161.12

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 2.4 Absolute Convergence, the direct and indirect effects of the explanatory variable. Dependent variable is annual growth of GDP per capita

VARIABLES		W_contiguity	W_distance	W_nearestn
Gdp	Direct effect	-7.828	-8.459	-8.501
		(1.015)***	(1.048)***	(1.038)***
	Indirect effect	7.502	8.079	8.212
		(1.272)***	(1.329)***	(1.501)***
	Total effect	-0.326	-0.381	-0.288
		(0.740)	(0.781)	(1.039)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

2.6.2. Conditional β-convergence

Tables 2.5 and 2.6 display the estimation results of the conditional convergence (equation 2.2), which includes the variables of transport infrastructure.

The evidence still points to the presence of a β-convergence process, even after introducing infrastructure variables in the model. In fact, the direct negative coefficient of the income per capita variable is now higher. Thus, the introduction of the infrastructure variables seems to accelerate the regional convergence process. This is contrary to the general result obtained in previous studies. Indeed, regional analysis within a country usually do not find evidence of a relevant contribution of transportation on such regional convergence (Costa-Font and Rodríguez-Oreggia, 2005; Pereira and Andratz, 2006; Checherita, 2009; Rodríguez-Pose et al., 2012; Cosci and Mirra, 2018).

It should be emphasized that, unlike previous studies, the analysis is disaggregated for four different types of transport infrastructures: roads, railways, ports and airports. In addition, the Spanish case is particular in the sense that investment in transport infrastructure has been much higher than in other countries (Albalate et al, 2012).

Looking at the effects of the stock of infrastructure on the annual growth rate of GDP *per capita*, only a positive and statistically significant direct effect of roads is found. Such positive effect of roads is in line with that obtained by Delgado and Álvarez (2007), Baños et al. (2013) and Arbués et al. (2015) for Spanish regions. However, their indirect and total effects are not statistically significant.

Furthermore, the direct, indirect and total effects of railways and airports are not statistically significant. Indeed, a negative direct effect of ports and a modest positive indirect effect were found. The total effect of ports is not statistically significant.

Hence, the direct positive effect of roads seems to have contributed to the process of regional convergence in Spain. In contrast, the rest of the transport infrastructures have not played an important role in this process.

The lack of statistical significance of the railway variable may be explained by the great expansion undergone by Spain's high-speed railways during this period, a network that was designed almost exclusively for passenger transport with little support for freight. Indeed, the limited increase in freight rail transport seems to have weakened the capacity of railways to promote regional equality (Albalate et al., 2015).

The direct negative effect of ports, together with the indirect positive effect, is in line with Bottasso et al. (2013) and Arbués et al. (2015). Negative externalities associated to this infrastructure, such as congestion on the roads, are concentrated in the region where the port is located. However, the positive effects go beyond the region where the port is located.

In addition, the lack of statistical significance of the airport variable may be explained by the centralized management system, in which investments in each airport are not necessarily related to the amount of traffic that such airport is able to generate (Bel and Fageda, 2009).

TABLE 2.5 Estimation results of Conditional Convergence including infrastructure stock (bias-corrected fixed effects). Dependent variable is growth of GDP per capita

VARIABLES	W_contiguity	W_distance	W_nearestn
Gdp	-11.7543	-12.1617	-12.0172
	(1.476)***	(1.480)***	(1.452)***
Roads	1.8369	2.0710	2.0143
	(0.635)***	(0.639)***	(0.655)***
Railways	-0.1783	-0.1129	-0.1158
	(0.180)	(0.175)	(0.172)
Airports	-0.0425	-0.0545	-0.0398
	(0.067)	(0.067)	(0.066)
Ports	-0.7322	-0.8827	-0.8164
	(0.289)**	(0.284)***	(0.277)***
W*Gdp	8.4905	8.8920	10.2465
	(1.859)***	(1.884)***	(2.046)***
W*Roads	-0.8899	-0.9513	-2.0047
	(0.880)	(0.891)	(1.120)*
W*Railways	0.1407	0.0676	-0.2185
	(0.398)	(0.438)	(0.594)
W*Airports	-0.0782	0.0236	0.0658
	(0.138)	(0.159)	(0.154)
W*Ports	1.5581	1.3586	2.4765
	(0.667)**	(0.686)**	(1.098)**
W* $\Delta GDP_{it+1,t}$	0.4142	0.4456	0.5893
	(0.030)***	(0.031)***	(0.034)***
σ_{ϵ}^{2}	8.5427	8.5419	8.0254
	(0.344)***	(0.343)***	(0.322)***
Spatial specific effects	YES	YES	YES
Observations	1,269	1,269	1,269
R-squared	0.41	0.40	0.46
Log-likelihood	-3188.50	-3185.81	-3148.74

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 2.6 Conditional Convergence and the direct and indirect effects of the four types of transport infrastructure stock. Dependent variable is annual growth of GDP per capita

VARIABLES		W_contiguity	W_distance	W_nearestn
Gdp	Direct effect	-11.3415	-11.8200	-11.7454
		(1.196)***	(1.207)***	(1.197)***
	Indirect effect	6.1955	6.3821	8.1707
		(2.402)***	(2.578)**	(3.877)**
	Total effect	-5.1460	-5.4379	-3.5747
		(2.386)**	(2.541)**	(3.832)
Roads	Direct effect	1.8511	2.1007	1.9767
		(0.684)***	(0.693)***	(0.713)***
	Indirect effect	-0.4887	-0.3409	-2.4542
		(1.274)	(1.376)	(2.437)
	Total effect	1.3624	1.7598	-0.4775
		(1.335)	(1.428)	(2.463)
Railways	Direct effect	-0.1646	-0.1048	-0.1353
		(0.225)	(0.210)	(0.214)
	Indirect effect	0.0406	-0.0409	-0.8262
		(0.709)	(0.778)	(1.488)
	Total effect	-0.1240	-0.1457	-0.9615
		(0.879)	(0.915)	(1.632)
Airports	Direct effect	-0.0548	-0.0559	-0.0367
		(0.070)	(0.070)	(0.069)
	Indirect effect	-0.1681	-0.0164	0.0901
		(0.207)	(0.255)	(0.352)
	Total effect	-0.2229	-0.0723	0.0534
		(0.248)	(0.294)	(0.392)
Ports	Direct effect	-0.5399	-0.7404	-0.5916
		(0.312)*	(0.291)**	(0.295)**
	Indirect effect	2.1573	1.7830	5.1348
		(1.198)*	(1.302)	(2.933)*
	Total effect	1.6174	1.0426	4.5432
		(1.384)	(1.439)	(3.082)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

2.6.3 Determinants of transport infrastructure investment

This sub-section report the findings concerning the determinants of transport infrastructure investment, including the set of independent variables described earlier (equation 2.3). Results are shown in Table 2.7.

Several tests were conducted to ensure a good model fit. More specifically, the Arellano and Bond test did not reject the null hypothesis of no autocorrelation from the second-order autoregressive residuals, so the estimates include this specification. Moreover, the Hansen J test of overidentifying restrictions accepts the null hypothesis, as did the difference-in-Hansen tests of exogeneity of instrument subsets.

It was found that the main driver of the investment policy in transportation by the central government in Spain has been to equalize the infrastructure endowment between the different Spanish regions. Indeed, the regions with the lowest relative endowment of infrastructure have received a greater volume of investment.

The result for the variable of transport infrastructure endowment is, above all, determined by the provision of roads and railways, given the high weight of these two types of infrastructure in the total stock of transport infrastructures. In this regard, the reduction of inequalities between regions in terms of road provision could explain its positive contribution to the process of regional convergence in Spain.

In contrast, interregional redistribution and efficiency do not appear to have been priorities during the period analyzed in this paper. Contrary to what was expected, the variable of redistribution is positive and the variable of efficiency presents a negative sign. Hence, investments have been higher in richer regions. Furthermore, they have been higher in regions where the marginal productivity of the stock of capital is lower.

The failure to consider efficiency as an objective of the infrastructure investment policy may explain why we no evidence can be found of a significant positive effect of infrastructure on regional economic growth. In a similar vein, the fact that investments have been higher in regions with higher income levels does not help transport infrastructure's contribution to regional convergence. Only in the case of roads, it may seem that the reduction in inequality between regions in terms of endowment may be offsetting the lack of concern for efficiency and redistribution.

TABLE 2.7 Estimation results of the determinants of transport infrastructure investment. Dependent variable is annual growth of stock in transport infrastructure

VARIABLES	Δtransport
Δtransport(-1)	-0.0426
	(0.062)
Efficiency	-0.2547
	(0.105)**
Redistribution	0.3632
	(0.090)***
Equity	-0.4698
	(0.107)***
Partisan strongholds	-0.0009
	(0.005)
Political congruence	-0.0085
	(0.035)
Observations	1,222
Number of regions	47
Time dummy variables	Yes
Number of instruments	108
Hansen Test Overid (p-value)	1
Difference-in-Hansen (p-value)	1
AR(1) (p-value)	0.000
AR(2) (p-value)	0.286

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

2.7 Conclusions

Spatial econometric techniques have been used to analyze both, the absolute and conditional β-convergence-type processes, and the policy decision-making process underpinning the regional allocation of investment in transport infrastructure.

This paper adds to previous literature on the link between transport infrastructure and regional convergence by examining the direct, indirect and total impacts of roads, railways, ports and airports. Furthermore, an analysis on whether transport investments have been guided by efficiency, redistribution and/or equity concerns was conducted to explain the role of transportation on such regional convergence.

Drawing on data from 1980 to 2008, strong evidence of absolute convergence occurring across Spanish provinces has been found. This result also holds when considering conditional convergence, as well as the explicit role of transport infrastructure. However, only roads seem to have contributed to the process of regional convergence in Spain. In contrast, the other types of transport infrastructure have not played an important role in this process. It was also found that the main driver of investment has been to equalize the infrastructure endowment between the different Spanish regions. The reduction in inequality between regions in terms of roads endowment could explain its positive contribution to the regional convergence in Spain.

These findings may contribute to the debate on the distribution of public resources. In Spain, regional policies have been widely promoted by successive governments using investment to equalize the endowment of transport infrastructure. However, massive investment in transport infrastructure does not necessarily contribute to the reduction of regional disparities. The development of an extensive high-speed rail network and the high amount of resources devoted to ports and airports have not been effective in reducing economic inequalities between Spanish regions. Hence, these results suggest that efficiency and redistribution need to be taken into account in order to achieve the best possible allocation of public resources.

A limitation of this study is the use of the stock of capital as the only indicator of the infrastructure endowment that a region has. The use of physical indicators or indicators based on demand could complement the stock of capital to have a more complete measurement of this endowment. Future research may include a more detailed set of infrastructure endowment indicators to further advance the study of the role of transportation in regional convergence.

Chapter 3

Gendered Effects of the Personal Income Tax: Evidence from a Schedular System with Individual Filing in Uruguay[5]

3.1 Introduction

A strand of the literature on gender equity studies the role of public policies in mitigating or reinforcing asymmetrical gender behavior. Stotsky (1996) defined and identified explicit and implicit gender bias in tax policies, which are particularly relevant in the Personal Income Tax (PIT). Explicit bias arises from the tax code when it identifies and treats men and women differently. Implicit forms of gender bias refer to provisions in the tax systems that tend to generate different incentives for men than for women, due to the culture or socioeconomic arrangements.

Many of the empirical studies focus on the presence of implicit bias when the tax is assessed on the combined income of the couple, through joint filing (Andrienko et al., 2015). Under this rule, the second earner (typically women) effectively pays a higher tax (on her income) than if she was taxed individually, because of increasing marginal rates. This pattern is criticized for different reasons. For example, it is at odds with policy recommendations derived from the optimal taxation perspective, in which individuals with higher labor supply elasticity should be less taxed. As married women have a more elastic labor supply than their spouses, tax

[5] The article in this chapter was jointly written with Marisa Bucheli. Comments from Andrea Vigorito, Verónica Amarante and Javier Alejo really contributed to improve this paper. I thank seminar audience at the XIV Arnoldshain Congress, for helpful comments. Article accepted for publication at International Journal of Microsimulation. Reference: Bucheli, X., Olivieri, C. (2019) ” Gendered Effects of the Personal Income Tax: Evidence from a Schedular System with Individual Filing in Uruguay”, *International Journal of Microsimulation*, forthcoming.

rates on labor income should be lower for women than for men (Alesina et al., 2011). Also, from a gender equity perspective, joint taxation discourages the participation of married women in the labor market and men's participation in unpaid domestic work, creating gender biases (Apps & Reese, 2010; Bach et al., 2013; Guner et al., 2011).

Two additional issues enrich the discussion of the PIT from the feminist economic theory perspective. Nelson (1991) claims that ignoring home production for the purpose of taxing personal income, not only discourages female participation in the labor market but has a negative effect on horizontal equity. Indeed, a dual earner couple has to purchase household services in the market or forgo leisure time compared with the traditional male breadwinner couple. Thus, a similar welfare level of a household may lead to a higher burden PIT for a dual than one earner couple. A similar argument holds when comparing male breadwinner and lone parent families. However, not all who advocate gender equity give support to taxes on home production because of distributive concerns, on the understanding that it would increase more the tax burden of low than high income households (Grown & Valodia, 2010).

Another interesting point raised by Nelson (1991) is that usually PIT does not consider dependents (people unable to support themselves) except children. This means an unfair treatment to a single taxpayer that supports a dependent (for example a disabled parent) compared to a one-earner couple that can benefit of the income-splitting allowed under joint taxation.

Besides, under a global income tax, gender bias may arise from the rules governing the allocation of shared capital income and the gender differences in the asset ownership (a review of this literature is presented in Apps & Reese, 2009)

In this context, it is not surprising that feminist economics gives support to individual filing and an income tax regime that taxes every source separately (schedular income tax). However, Stotsky (1997) and Elson (2006) mention different source of gender bias that persist such as the rules governing the allocation of shared capital income, exemptions or other tax preferences. Besides, gender differences in labor market outcomes and assets ownership also produce gender bias in taxation.

In recent decades, there has been a trend in developed countries to reform their PIT systems to dual regimes (capital and labor taxed separately) with individual filing (Genser & Reutter, 2007). It is expected that these reforms would diminish gender bias. However, gender tax burden differences may be observed even under individual filing and a schedular system as reported in several empirical studies (see Grown & Valodia, 2010, for a survey). For example, Rodríguez Enriquez et al. (2010) find a gender gap in Argentina because women are more prone to be employed in occupations that are taxed at lower rates than occupations which tend to intensively employ males.

The purpose of this study is to analyze the gender differences in the PIT-to-income ratio in Uruguay. The PIT was created in 2007 when a left-coalition was running the administration for the first time in the Uruguayan history, and in 2013, it accounted for 10% of public revenue. The PIT was the result of a commitment during the campaign to improve the distributive effect of the tax system. The debate about tax reform did not raise issues related to gender equity and in fact, this is the first analysis that addresses it. However, the PIT design reflects the general spirit of the latest reforms in developed countries that help to mitigate gender biases. Labor income, pensions and capital income are subject to a differentiated schedule tax, with marginal progressive rates for the first and second sources and a flat rate for capital income. Individual filing is the norm but joint taxation is also allowed, and there are no explicit gender biases in the code.

Our study builds on the work on gender and taxation for several countries collected in Grown & Valodia (2010) and the comparative study by Grown & Komatsu (2015). The main difference with the first of these studies is that we use actual data instead of simulations of representative agents. Compared to the second study, which uses survey data as in this paper, our main innovation is to use an econometric strategy for the analysis.

We use the household survey carried out in 2013 by the Statistical Office in Uruguay. The survey reports post-tax income. Therefore, we simulate taxes and contributions using the statutory rates in force in 2013, and we add them to the reported income in order to have a proxy of gross income. We estimate the average tax rate of the household as PIT-to-gross income ratio taking into account paid taxes and income of all household earners. As we work with a database of individuals, we assign the same tax rate to all household members.

We classify the households according to a combination of dimensions: whether or not the household head has a partner, employment status of the head and partner (if any), and whether or not it is an extended household. We are particularly interested in comparing the average tax rate in three typical cases: a) households supported by a male worker and a housewife who is not engaged in paid employment, b) households in which both members of the couple participate in the labor market, and c) households in which a single woman works in the labor market. We also compare households of non-employed individuals, i.e. pensioners. We assess the effect of household type on the average tax rate by estimating a zero-one inflated beta model (ZOIB). This model properly addresses the fact that the average tax rate is a proportion with presence of zeros.

We find that, given per capita household income, the PIT incidence is higher for male breadwinner households than for dual earner households. Following Elson (2006) and Grown (2010), we consider this result to be consistent with gender equality because it is in line with more equal gender time allocation within the family. However, male breadwinner households also bear a higher tax incidence than female breadwinner households with a dependent spouse. This gender difference mainly comes from their different structure of income sources. The households headed by a single female worker exhibit a lower PIT incidence mainly due to the high share of non-taxed sources in their household income. Finally, we do not find gender differences within pensioners.

These results are based on the assumption that everybody files taxes individually. This assumption is quite realistic because joint filing is rarely used. Joint filing has not been analyzed in Uruguay and probably its non-use is partly due to lack of information. However, joint filing is preferable for households in which one spouse does not participate in the labor market and for a percentage of the households in which both members of the couple do. Thus, as a robustness check for the basic results, we estimate gender gaps under the assumption that households opt for joint filing when it allows them to pay lower taxes than under individual filing. Though gender equity is eroded, we come up with the same conclusions.

The main contributions of this work are a) the implementation of a new strategy to analyze the data in the study of gender and taxation and b) the presentation of evidence about the gendered differences in the PIT burden in a developing country which last decade passed a tax reform that follows the main guidelines of regimes in advanced economies.

The remainder of this study proceeds as follows. In the next section we provide a description of the Uruguayan economy, after that we present the data and methodology and then we report the main results of the analysis. In the final section we conclude.

3.2 Traits of Uruguayan economy

3.2.1 A gendered socio-economic picture

At the beginning of the 20th century, the country had low fertility and high life expectancy compared to Latin American standards. Since then, fertility has decreased and life expectancy has increased, and Uruguay is now in an advanced stage of demographic transition. Around 14% of the population is older than 64 years of age as compared to less than 7% on average in Latin America (see Table 3.1).

Also, the level of education of women, their labor force participation and their marital status have undergone a substantial change since the middle of the 20th century. Uruguay is among Latin American countries in which these processes are in the most advanced stage, in part because of differences in initial conditions. Uruguayan women have on average 10.2 years of schooling and their participation rate is 67% whereas the Latin American averages are respectively 8.7 years and 55% (see Table 3.1). Note that in Uruguay, female level of education is higher than male; this difference is even larger among workers because female labor participation increases with education. The socio-demographic changes have impacted household structures to the extent that they are substantially different from the Latin American average. Since the aging process is more advanced in Uruguay, there is a relatively high incidence of one person households (mostly elderly) and couples without children, as reported in Table 3.1.

Another relevant characteristic is that the share of extended households is relatively low. In this paper we focus on non-extended households (84% of all households). Single-parent households, majoritarily headed by an adult woman, are 12% of total households.

TABLE 3.1 Socio-demographic characteristics

	Uruguay				Latin American average			
	All	Women	Men	W/M	All	Women	Men	W/M
Children per woman [a/]		2.04				2.14		
Life expectancy [a/]	77.0	80.5	73.3	1.1	74.8	78.1	71.5	1.1
Population older than 64 [b/ c/]	14.0	16.5	11.2	1.5	6.7	7.5	5.9	1.3
Years of education [b/ d/]	9.8	10.2	9.5	1.1	8.7	8.7	8.8	1.0
Participation rate [b/ c/ e/]	76.1	66.9	85.7	0.8	68.5	54.8	82.6	0.7
Households structure [b/ f/]								
One person households	21.9				11.0			
Couple without children	17.2				9.0			
Couple with children	33.2				39.9			
Lone-parent family	12.0				11.9			
Extended households	15.7				28.2			

Source: CEPAL (2016) and World Bank (2016)
Notes: a/ 2005-2010; b/ 2010; c/ Percentage of population; d/ Population ages 25-59; e/ Population ages 15-64; f/ Percentage of households

In sum, this brief picture shows that women are very much involved in the economy, and thus they were affected by the creation of the Personal Income Tax. However, the effect of PIT is different for women and men if there are gender differences in factors such as labor market outcomes and evasion.

The average labor income is lower for men than women. Between 2006 and 2013, the gender gap ranged between 47% and 56% of male labor income (Bucheli & Lara, 2018). Part of it is due to gender differences in time spent in labor market: working hours per week were on average 32 for women and more than 40 for men. Other portion is related to gender differences in labor income per hour: in 2006-2013, the average value of (post-tax) per hour labor income gender gap oscillated around 6% of male labor income. Previous studies for Uruguay show that the gender gap subsists after controlling individual observable characteristics and that the discrimination measures have been stable in the last two decades (Amarante

& Espino, 2004; Bucheli & Sanromán, 2005; Espino, 2013; Espino et al., 2014). These works find that the portion of the gender gap that is not explained by observable productive attributes (which is usually interpreted as a measure of discrimination) is on average more than 100% of the wage gap, and that there is evidence of a glass ceiling phenomena for the most educated women.

Part of the wage gap that is not explained by observable attributes is due to occupational segregation. However, a considerable wage gap subsists when job characteristics are controlled. According to Espino et al. (2014), also the level of segregation has been stable in the last decades. In 2006-2013, women were less than 10% of employment in the construction sector, mining and manufacture of machinery and equipment whereas they were more than 90% in garment sector and more than 70% in health care, education and personal services. Besides salary work is higher among women than men (74% and 69% of female and male employment, respectively) whereas self-employment is lower (20% and 24%).

Finally, an important question as regards the PIT burden is to examine gender differences in evasion patterns. We have information about the incidence of non-contribution to social security among workers. As contributions are compulsory for all workers, lack of contribution is a good proxy of PIT evasion. The incidence of non-contribution declined from 35% to 26% of employment between 2006 and 2013. This decline may be explained by the combination of growth and the strengthening of controls of the Administration. During all the period, the incidence of lack of contribution was similar for women and men.

3.2.2 The Personal Income Tax

In 2004, for the first time in Uruguayan history, national elections were won by a left coalition. The new administration that entered into office in 2005 was strongly committed with the reduction of inequality and poverty, and to carry out reforms of the tax and benefits system. One of the main pledges during the political campaign was to increase tax progressivity without changing the average tax burden. In 2007 the government passed a Tax Reform that increased the weight of progressive direct taxes at the expense of indirect taxes. Besides introducing changes in the indirect tax system, the reform created a Personal Income Tax that reflected the spirit of the latest reforms that were proposed and debated in developed countries.

First, it was designed as an individual filing system without explicit gender bias. The possibility to opt for joint taxation was introduced in 2009 and is only allowed for labor income received by married couples or those in a consensual union. Though there is no information about the percentage of couples that choose this option, administrative records make it possible to estimate it. The Tax Office provides information of the number of tax units registered as taxpayers (including exempted and non-exempted ones) of the PIT labor income component. These tax units include workers that choose individual filing (*ind_file=1,277,210* in 2013) and couples that choose joint filing (*joint_file=22,567* in 2013). The number of individuals involved in the records was 1,332,344 *(=ind_file+2*joint_file*) in 2013. According to the Household Survey of 2013, 63% of workers lived with a partner. If we apply this proportion to Tax Office information we may estimate that in 2013 the records involved 416,538 (*=(ind_file+2*joint_file)*0.63/2*) couples. So, we estimate that only 5.4% of couples chose joint filing in 2013.

Second, PIT was conceived as a dual tax under which capital income was taxed at a flat rate whereas labor income and pensions were subjected to progressive rates. Some months after its introduction, litigious issues led to taking out pensions and creating a progressive tax specific to them. In this study we refer to the PIT, including on pensions. The government justified the dual income tax because of the difficulties of tracing non-domestic sources of income, the prevention of lobbying activities and the high risk of evasion (Barreix & Rocca, 2007). At the same time, it facilitates tax administration relating to ownership and splitting treatments (for pros and cons of dual income taxes, see Genser & Reutter, 2007). With regard to the topic of concern in this study, a relevant characteristic of the dual structure is that a flat rate on capital income eliminates the incentive for capital income splitting between the household members, which has potential gender consequences.

Capital gains (derived from sales) and holding income (derived from the possession of assets) are taxed at a flat rate that varies between 3% and 12% depending on the source (interests, profits, etc.). Deductions are allowed for bad debts, real estate taxes, and the cost of renting. In most of the cases, there is a withholding agent. If not, advance payments and annual filings are required.

Pensions are subject to individual progressive taxation and there is no option for joint taxation. There are four marginal rates that range from 0 to 25%. Tenants are allowed to subtract 6% of their rent and no other deductions are allowed. The agencies that administer the Social Security System are the withholding agents responsible for collection and payment of the tax. When receiving pensions from different agencies, the taxpayer must do an annual filing.

Taxes on labor income have to be paid monthly in the case of employees (held at source) and bimonthly in the case of the self-employed. An annual filing is required except in the case of employees with only one job and eventual disparities should be closed out. The tax is equal to a primary tax minus tax credits.

The primary tax is calculated by applying the rate on the gross earnings of wage earners and on 70% of gross income of the self-employed. The tax schedule has seven marginal rates ranging from 0 to 30%.

The tax credits are comprised of worker contributions and taxes levied on labor income, a fixed amount per child (higher in the case of a disabled child) and mortgage payments when the house is used for permanent residence and its cost is lower than a threshold. The tax credit for children can be distributed between parents. When parents are divorced and they do not agree about this distribution, each one can deduct 50%. In order to calculate the amount of the tax credit, a progressive rate schedule applies that ranges from 10% in the first bracket to 30% in the sixth. After subtracting these tax credits, tenants are allowed to additionally subtract 6% of their rent. If this deduction generates a surplus, this surplus is not refunded by the tax office and cannot be transferred to the following year.

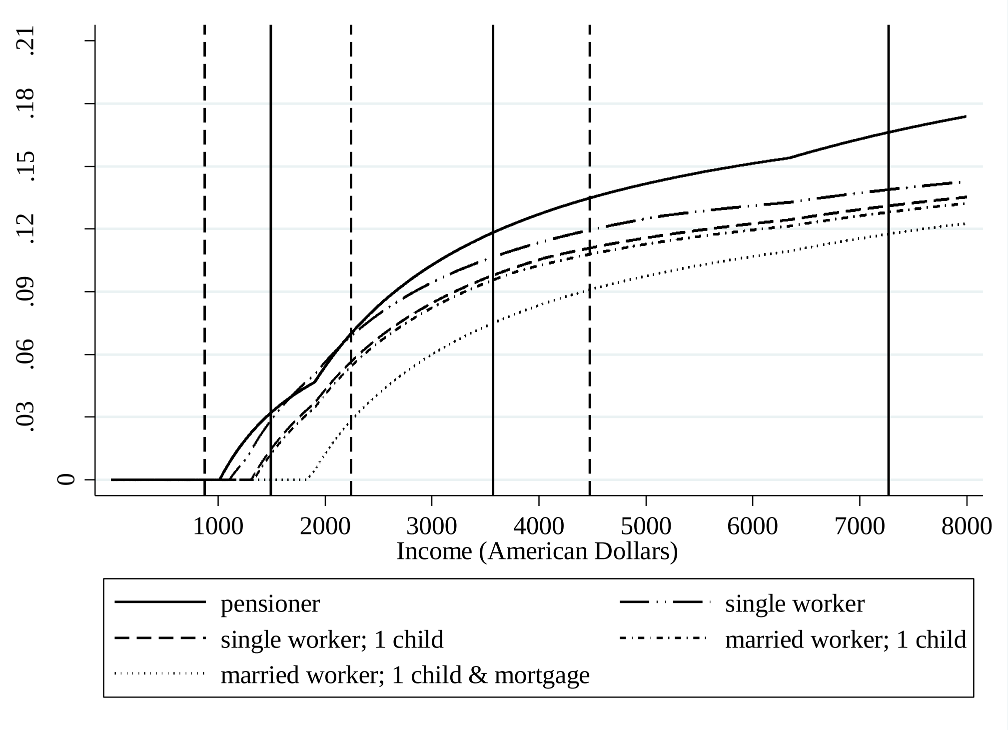
In Figure 3.1 we show the tax burden by monthly income according to the statutory rates under individual filing. We graph the cases of pensioners and four types of workers, in order to take into account that the tax-to-labor income ratio depends on the feasibility of using tax credits. We only show the tax burden for income below US$ 8000, although this amount falls inside the fifth bracket of the primary tax on labor earnings. A level of income (wage or pension) over US$ 8000 is rarely observed as shown by the overlapped vertical lines. Dotted lines indicate the 75th, 90th and 99th percentiles of the distribution of pensions and continuous lines indicate the same percentiles of the distribution of labor income.[6]

As shown in Figure 3.1, pensioners are exempt up to about US$ 1000 per month. The labor earnings schedule starts after a tax-free allowance of about US$ 900 but a single worker (who faces the highest burden among workers) pays taxes only when gross earnings exceed US$ 1100 because of tax credits. The actual applicability of these thresholds can be observed in the vertical lines. According to estimations by Burdin et al. (2015) based on tax records, in 2012 only 20.1% of pensioners and 33.6% of workers paid the PIT.

For most income levels, the tax burden is higher for pensioners than workers because tax credits are allowed for labor earnings but there is no tax-free threshold for pensions. Among workers, the highest burden corresponds to a single person without children followed by a single person with one child. To calculate the tax burden of a single parent worker with one child we assumed that he/she makes 100% use of the child deduction. The tax burden is a bit lower when the parent of a child is married or in union. Although there are no explicit legal differences, the single worker pays a higher share of income as PIT because contributions to the health system (eligible for tax credits) are lower for them than for married people. Finally, the lowest burden corresponds to a married worker with a child who is paying a mortgage equal to the maximum permitted value for the tax credit.

[6] Percentile values were provided by the Economic Institute at the School of Economics, *Universidad de la República* and are based on administrative records of the Tax Office.

FIGURE 3.1 Personal Income Tax burden by income for selected individual types



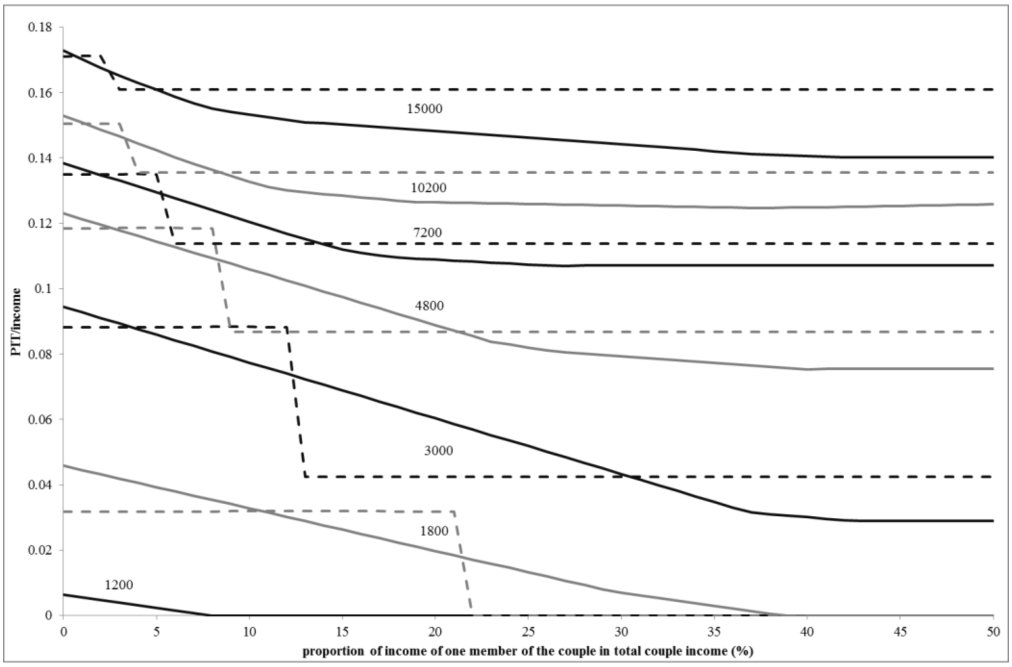
Source: author’s calculations based on tax schedule rates.
Note: Dotted vertical lines indicate the 75th, 90th and 99th percentiles of the distribution of pensions and solid vertical lines indicate the same percentiles of the distribution of labor income

To analyze joint filing we calculated the tax burden for selected couples. Specifically, we calculated taxes that would be paid under joint and under individual filing for couples with same labor market income but different participation of each spouse in its generation. We assumed that there are no children or mortgage credits. In Figure 3.2 we show the average tax rate paid by the couple for chosen income levels (which are indicated close to the curves) that reflect different position in the labor income distribution of couples: US$ 1200 (close to percentile 12), 1800 (22), 3000 (43), 4800 (66), 7200 (83), 10200 (92), 15000 (97) .

The solid lines depict the path of the tax burden under individual filing as the participation of one spouse in labor market income generation rises.

Participation ranges from 0 to 50%, so unsurprisingly the curves are decreasing (or at least non-increasing), reflecting the advantages of sharing labor market activities between spouses.

FIGURE 3.2 Personal Income Tax-to-income ratio for selected couples by participation of one spouse in generating labor income.



Source: author's calculations based on schedule rates.

Note: The tax burden is calculated for different levels of couples' labor income: US$ 1200 (close to percentile 12 of the labor income distribution of couples), 1800 (22), 3000 (43), 4800 (66), 7200 (83), 10200 (92), 15000 (97). Dotted lines represent the tax burden under joint filing; solid lines represent the tax burden under individual filing.

The dotted lines show the pattern of the tax burden with one spouse generating labor income under joint filing. We observe that all the joint filing curves show a one-step fall. This is easily explained. The tax schedule under joint filing distinguishes two cases: one is applied when the earnings of at least one spouse are below a threshold (12 times annual minimum wage) and the other one when earnings of both spouses exceed the threshold.

For all levels of labor income of the couples, when only one spouse participates in the labor market, the tax burden of the couple is lower under joint than individual filing. As seen in Figure 3.2, this holds for the lowest values of the x-axis.

Although the figure does not reflect all possible situations, a first look suggests that the code does not encourage uneven labor market participation between spouses to reach a level of income. Indeed, the most interesting aspect of the curves is that if the couple chooses the least burdensome option (given income), the resulting curve is non-increasing, reflecting that there are advantages to sharing labor market time between spouses, or at least that there are not disadvantages.

Figure 3.2 also helps to illustrate a gender related issue discussed by Nelson (1991): dedication of women to household services may be encouraged because of the non-recognition of home production as a taxable income. When only one spouse participates in the labor market, household services are provided by the other spouse without facing a burden tax. Meanwhile, the two-earner couple can reach higher levels of labor income and therefore bear a higher burden tax, though it would need for money to pay for market goods to replace home production. For all the income levels reported in Figure 3.2, we find that the tax burden faced by a one earner couple under joint taxation is lower than the burden faced a by two-earner couple that generates twice as much as the former.

3.3 Data and methods

3.3.1 Data and imputations

We use the household survey (ECH because of the Spanish abbreviation of *Encuesta Continua de Hogares*) carried out in 2013 by the National Statistical Office (INE, following the Spanish abbreviation *Instituto Nacional de Estadística*). It is a nation-wide representative survey that reported information of 46,622 households (89.3% response rate). Among several characteristics of household members, it registers post-tax in-kind and monetary income received in the month before the interview, by source.

Esponda & Vigorito (2014) assess the accuracy of the ECH comparing its information with Tax Office records for the period 2009-2011. To estimate gross income based on ECH, they follow a procedure quite similar to the one used in this paper and described below. They conclude that the ECH underestimates capital income but it is fairly accurate to measure labor income and pensions, though top incomes are not well registered. The ratio between capital income reported by ECH and administrative records had a decreasing trend in the period of study; it was on average 73% but only 48% in 2011. The difference was very important among high income individual for which capital income is noticeable underestimated in data survey. Meanwhile, the average ratio for 2009-2011 was 88% for pensions and 104% for labor income. It is worth to note that in the case of labor income data of the ECH, they only considered the information given by workers who declared to pay contributions of the Social Security System. In other words, they assumed that contributors pay PIT and workers that pay PIT are contributors.

Our variable of interest is the household tax rate measured as household PIT-to-(gross) income ratio. As the ECH asks about income after taxes and contributions, we estimated the individual taxes and contributions using the statutory rates in force in 2013, and we added them to the reported individual income in order to have a proxy of gross income. Then, we calculated the income and the paid PIT of the household adding information of its members, and finally, the household tax rate. We assigned to individuals their household tax rate.

In the case of capital income, we computed the taxable capital gains as the sum of all reported capital income and we assumed that there is no evasion. The ECH does not provide information to estimate tax deductions so we implicitly assumed that conditions for them were not present. This assumption should be tested in the future; anyway, the most important concern related to capital income is the underreporting.

The ECH reports whether or not the worker contributes to the Social Security System. We assumed that there is no partial evasion by contributors and that non-contributors do not pay taxes either[7] as in Vigorito & Esponda (2014). Because of the findings by Vigorito & Esponda when comparing ECH and Tax Office records, we expect that this is a reasonable assumption to estimate gross labor income of workers who do not evade their PIT payments. However we cannot assess the accuracy

[7] The ECH inquires whether or not private wage earners partially evade social security contributions. We did not take into account this information because it would require further assumptions about the percentage of evasion. In any case, we do not expect that assumptions about partial evasion based on this information have significant effects on our results: 58% of workers were private wage earners and among them, only 6% declared to partially evade.

of labor income reported in the survey by evaders. Regarding PIT credits, we considered contributions and child benefits, but we did not impute deductions related to mortgages and rents due to the lack of information for an appropriate assumption. Credits for children were assigned to the head of the household who is usually the household member who receives the highest income.

When estimating the amount of PIT paid we assumed that individuals opt for individual filing because joint filing is rarely used. Besides, the survey does not provide any information that would help distinguish couples that used different options. Thus, we performed a first analysis using estimations of gross income and PIT based on individual filing. Then, to analyze the effect of the joint filing option we estimated the amount of PIT under joint filing given the already estimated gross income.

To analyze sources of income we deflated them by the Consumer Price Index and classified them into four groups: capital income, labor income, other income (public and private transfers plus self-consumption), and imputed rental value of owner-occupied houses).

3.3.2 Gendered classification of the population

Personal income taxes are generally applied to individuals. However, studies on inequality and distributive effects of taxes chose the household as the proper unit of analysis under the understanding that household members share income and other resources. As our focus is the analysis of gendered distributive effects, the challenge is to provide an appropriate gender classification of households. To address the issue about the effects on allocation of time between labor market and home production and to take into account lack or time of lone parents, we are interested on identifying the typical cases of one-earner couple, two-earner couple and single female earner. Besides, we want to compare similar types of one-earner couple and single earner but supported by earners of different gender. Finally, in developing countries we have to take into account the existence of extended households (households where there are members related by other links than children or partner such as grand-parents, brothers-in-law, nephews, non-relatives, etc.) whose gendered nature is difficult to be captured.

Thus, we made a classification of the population that takes into account the household structure and the employment status of household members. The classification appears in the first column of Table 3.2.

We first distinguish extended from non-extended households (that are comprised of single individuals or couples, with or without children at any age). We distinguish eight household types within each group. In the rest of the paper we focus on the eight types of non-extended households.

Three categories represent the typical cases that are of interest from the gender perspective of tax studies. The “couple, male breadwinner” category includes non-extended households formed by a couple (with or without children) in which only the male participates in the labor market. Around 19% of individuals live in this type of household. The “single, female breadwinner” category consists of a non-extended household headed by a single worker woman, and accounts for 7.8% of population. The “couple, dual earner” category corresponds to non-extended households formed by a couple in which both the male and female work in the labor market. This category is the most frequent, accounting for 30.7% of individuals.

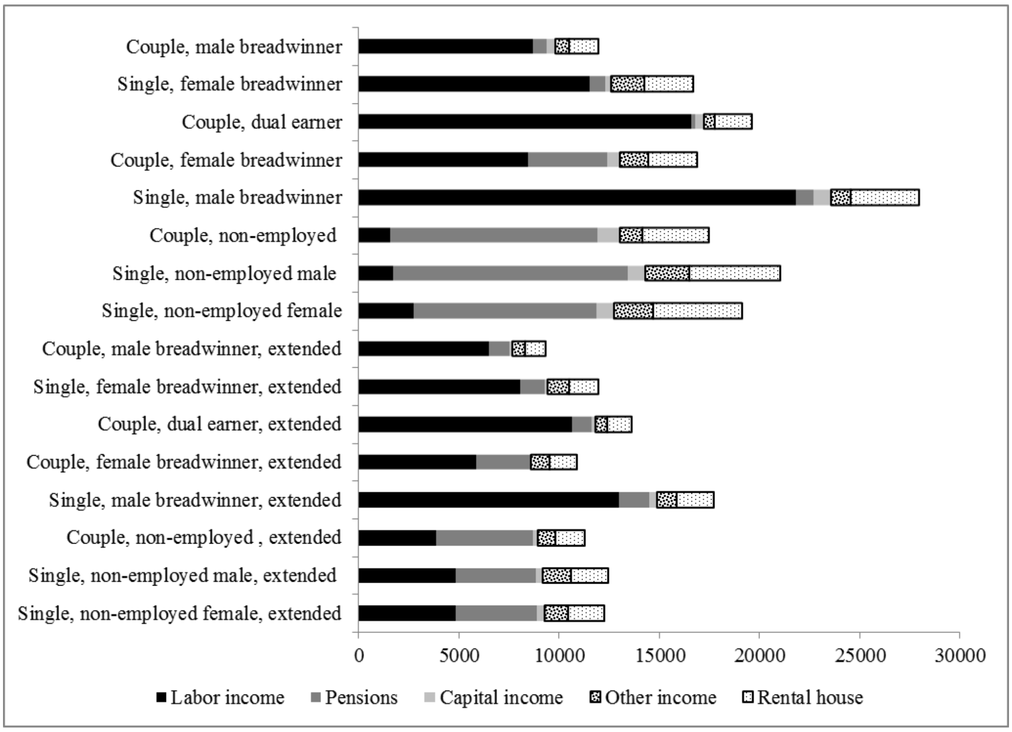
As reported in Table 3.2, most of the households in these three categories have children and the average age of the adults is fairly similar. In turn, as shown in Figure 3.3, the “couple, dual earner” category has the highest per capita income of the three types. Labor income is the most important source in all three categories and public transfers are more important for the “single, female breadwinner” type than for the others.

TABLE 3.2 Main characteristics of household categories.

Household Category	Frequency (weighted cases) (%)	Households with children (%)	Number of members	Number of earners	Lack of contribution to social security (%)	Age of the household head and spouse	Number of cases in the sample
All	100	59.8	3.7	1.9	22.5	48.9	124,987
Couple, male breadwinner	18.4	72.4	4.1	1.4	27.3	42.5	22,230
Couple, dual earner	30.7	72.1	3.8	2.3	19.9	41.4	37,082
Couple, female breadwinner	3.2	42.1	3.3	1.9	27.7	52.4	4,033
Couple, non-employed	7.0	9.1	2.6	1.7	4.5	68.5	9,008
Single, male breadwinner	3.2	20.1	1.7	1.2	31.6	47.1	4,125
Single, female breadwinner	7.8	60.6	2.9	1.5	30.4	45.2	11,225
Single, non-employed male	1.3	3.6	1.4	1.1	3.9	70.2	1,886
Single, non-employed female	6.1	22.0	2.2	1.1	9.4	65.9	8,670
Couple, male breadwinner, extended	4.0	83.1	5.8	2.3	34.2	48.5	4,721
Couple, dual earner, extended	4.5	80.5	5.4	3.2	28.1	45.8	5,268
Couple, female breadwinner, extended	0.8	70.1	5.2	2.8	31.2	56.5	943
Couple, non-employed , extended	2.2	65.2	5.0	2.7	14.1	66.5	2,615
Single, male breadwinner, extended	1.7	37.7	3.5	2.2	30.8	44.4	1,976
Single, female breadwinner, extended	4.1	71.8	4.4	2.2	33.7	47.9	5,113
Single, non-employed male, extended	0.8	50.1	3.9	2.0	19.2	65.6	974
Single, non-employed female, extended	4.2	62.8	4.3	2.2	20.1	65.8	5,118

Source: Authors' calculations based on *Encuesta Continua de Hogares* 2013, *Instituto Nacional de Estadística*
Note: The lack of contribution to social security is calculated at household level as the ratio between non-contributors and workers; the ratio takes value 0 when no one in the household participates in the labor market.

FIGURE 3.3 Per capita income of households by source



Source: Authors' calculations based on Encuesta Continua de Hogares 2013, Instituto Nacional de Estadística.

3.3.3 Empirical strategy

We aim to identify gender differences in the PIT burden and also to examine the role of some specific household characteristics in the explanation of those differences. A particular issue in our study is that the main variable of interest, the PIT-to-income ratio, includes many observations of 0 and no 1s (no household is taxed at 100%). These zeros can provide important information for the study of the lowest levels of taxation and they are included for theoretical and empirical reasons. Hence, we conduct the empirical analysis considering a dependent variable that assumes values in the interval [0, 1) and contains excess of zeros.

In a case like this, the dependent variable is not symmetrically distributed, so the predicted values of the linear regression model may lie outside the unit interval. As an alternative, Cook et al. (2008) proposed the zero-one inflated beta model (ZOIB) which properly addresses the issue related to the inflation process in the data.

Several authors (Paolino, 2001; Kieschnick & McCullough, 2003; Smithson & Verkuilen, 2006) argue that the beta regression model is the most suitable for distributional asymmetries and can be adjusted for data in the interval (0, 1) since the density function takes different shapes depending on the function parameters. Ferrari & Cribari-Neto (2004) proposed the following parameterization for the density function of the response variable y when it adopts a beta distribution $B(\mu, \phi)$:

$$f(y;\mu,\emptyset) = \frac{\Gamma(\phi)}{\Gamma(\mu\phi)\Gamma((1-\mu)\phi)} y^{\mu\phi-1}(1-y)^{(1-\mu)\phi-1}, \qquad y \epsilon (0,1)$$

where μ is the mean ($0 < \mu < 1$), ϕ a precision parameter ($\phi > 0$) and $\Gamma(.)$ is the gamma function.

In practice, the beta distribution is not suitable for modelling data that contains zeros or ones. But we want to consider observations where the dependent variable is zero. Therefore, we apply a combination of two distributions: a beta distribution when the variable is bounded by 0 and 1, and another distribution function that is in effect when the variable takes the value 0. For a detailed description of this methodology see Ospina & Ferrari (2010, 2012). The density is called a zero-inflated beta distribution and the probability function generated by the combination is:

$$b_c(y;\alpha,\mu,\phi) = \begin{cases} \alpha & if\ y = 0 \\ (1-\alpha)f(y;\mu,\phi) & if\ y \epsilon (0,1) \end{cases}$$

In this paper, we carry out all the estimations using the Stata module *zoib* developed by Buis (2012).[8] The *zoib* command consists of a maximum likelihood estimation of the combined model: a logistic regression of whether or not the income share paid to taxes equals zero and a beta regression for the proportions in the interval (0, 1). We perform all the estimations using robust standard errors.

Our explanatory variable of interest is a vector of dummy variables that captures household type, which provides the gendered classification of the population. We also use several variables that reflect household characteristics: the household per capita income, a dummy variable that

[8] We also run OLS estimations that are available by request. The estimated effects have the same signs than under the zoib estimation though the magnitudes are a bit different.

takes a value equal to 1 when there is at least one member younger than 18 in the household, the household size, the number of earners per household and the lack of contribution to social security measured as the ratio of the number of workers that are not contributors and the number of workers in the household (the ratio takes value 0 when there are no workers in the household). Additionally, we break down the household income by source in order to separately capture the incidence of all sources: capital income, labor income, pensions, other income (public and private transfers plus self-consumption) and rental value. The choice of these variables responds to the fact that they may explain differences in the PIT burden due to the characteristics of the tax detailed in Section 3.2.2. In particular, we aim to capture progressivity, the treatment to the different sources of income and the design of credits and deductions.

We compute and report the marginal effects of the dependent variables on the PIT-to-income ratio. In the case of the household type vector, the effect is the discrete effect of moving from "couple, dual earner" to each respective other household type. For the other variables, the effect is measured for the "couple, dual earner" household, valuing the rest of the variables at their mean.

3.4 Results

3.4.1 Tax incidence analysis

The PIT is a progressive tax. Its Kakwani index is positive (0.360) and the Gini index declines from 0.426 pre-tax to 0.413 post-tax, reflecting the PIT's equalizing effect. However, the distributive effect is limited because of the tax size and exemptions. Around 54% of the population lives in households that do not pay the tax, and the average PIT burden is 1.8% population wide and 3.9% among the population of households who face this tax.

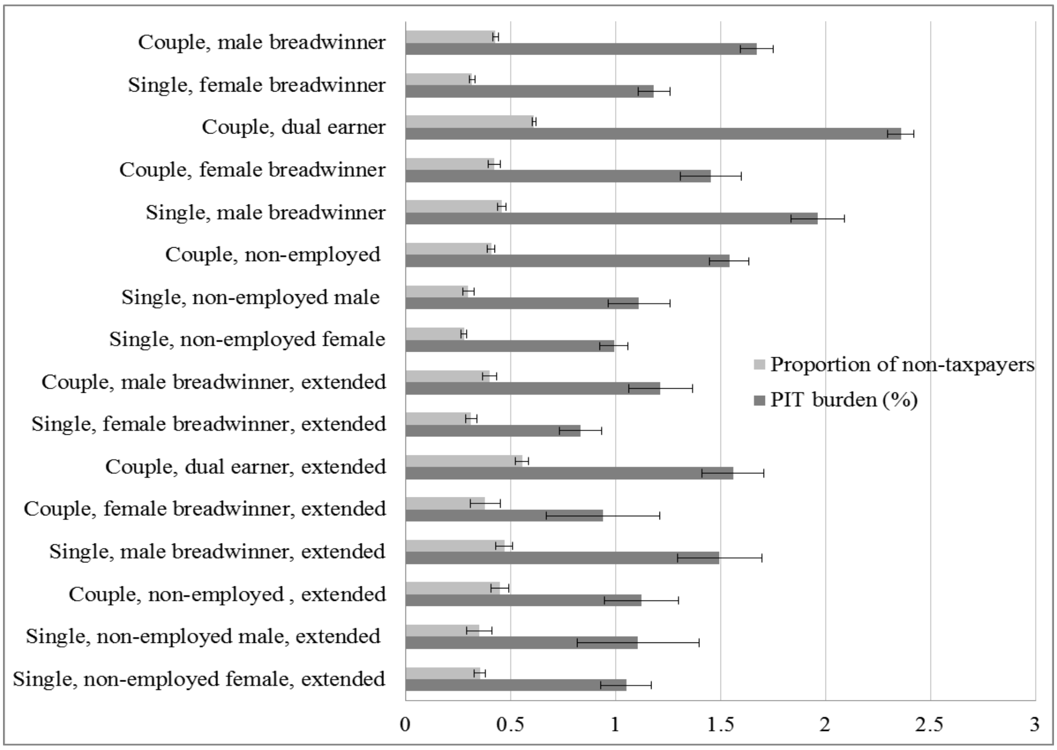
In Figure 3.4 we present the PIT incidence by household type. The dark bar shows the average burden and the pale bar shows the proportion of non-taxpayers; for both variables, a straight line indicates the 95% confidence interval of the estimation.

At the top we show the five types of non-extended working households. The "couple, dual earner" category bears the largest PIT burden (2.4%) and has the highest proportion of taxpayers (61%). The "couple, dual earner" category is followed by male breadwinner households which have an average burden of 2% when living with no partner and 1.8% when living with a partner. Finally, the lowest burden corresponds to female breadwinner types: 1.5% when in union or married and 1.2% when single.

The PIT burden is lower for non-employed households than households of workers. Among the latter ones, the highest tax incidence corresponds to the "couple, non-employed" type with an average burden of 1.5% whereas the single types pay an average of 1% of income in the form of the PIT. There are no significant gender differences between single types.

We report the PIT incidence for extended households following the same order as for non-extended households. The tax burden is lower among extended households. The gender differences within extended households are similar to those already depicted.

FIGURE 3.4 Average PIT burden and proportion of non-taxpayers by household type



Source: Authors' calculations based on *Encuesta Continua de Hogares* 2013, *Instituto Nacional de Estadística*

Note: in each bar, the straight line indicates the 95% confidence interval of the estimation

3.4.2 Exploring differences among non-extended workers' households

We analyze the tax burden differences between household types through the estimation of a ZOIB model. We include sixteen dummy variables that distinguish household types, but in this section we only show the results for the household types of interest.

In Table 3.3 we report the discrete effect of the household type relative to the "couple, dual earner" type. In column Model 1 we show the results of an estimation in which we do not include any control. Thus, these estimated effects replicate the patterns of the raw PIT burden differences already shown: all effects are negative, indicating that the dual earner type has a higher PIT-to-income ratio, and that male types have a higher ratio than female types regardless of whether comparing singles or couples.

TABLE 3.3 Marginal effects estimated by a zero-inflated beta regression

VARIABLES	Model 1	Model 2	Model 3
Couple, male breadwinner	-0.0067***	0.0048***	0.0046***
	(0.00005)	(0.00007)	(0.00007)
Single, female breadwinner	-0.0116***	-0.0141***	-0.0056***
	(0.00006)	(0.00006)	(0.00007)
Couple, female breadwinner	-0.0084***	-0.0071***	0.0035***
	(0.00008)	(0.00008)	(0.00009)
Single, male breadwinner	-0.0045***	-0.0184***	-0.0150***
	(0.00010)	(0.00006)	(0.00010)
Per capita income		0.0205***	
		(0.00004)	
Presence of children (yes=1)			0.0082***
			(0.00004)
Household size			0.0041***
			(0.00002)
Number of earners (labor, capital			-0.0044***
earnings or pensions)			(0.00003)
Lack of contribution to social			-0.0001***
security			(0.00000)
Per capita capital income			0.0574***
			(0.00075)
Per capita labor income			0.0286***
			(0.00008)

TABLE 3.3 (cont.) Marginal effects estimated by a zero-inflated beta regression

VARIABLES	Model 1	Model 2	Model 3
Per capita pension			0.0278***
			(0.00009)
Per capita public transfer			-0.0036***
			(0.00012)
Per capita imputed rent of owner-occupied house			-0.0051***
			(0.00011)
Observations	124987	124987	124987

Source: Authors' estimations based on *Encuesta Continua de Hogares* 2013, *Instituto Nacional de Estadística*

*** p<0.01, ** p<0.05, * p<0.1

Note: For household types, we report the discrete effect related to the "couple, dual earner" type, valuing the rest of the variables at their means. For the rest of the dependent variables, we report the 'marginal effect' by household type compared to the "couple, dual earner" type.

The purpose of the PIT is progressivity, so a proper analysis needs to control the results by income. Thus, we estimate Model 2 in which we add per capita gross income as a control. As expected, the PIT burden increases with income. The difference in income levels by household type affects the order of the three typical cases: now, the "couple, male breadwinner" type has the highest PIT-to-income ratio, followed by "couple, dual earner" and "single, female breadwinner".

These results are consistent with gender equality although we do not know (and we do not address the study of) the optimal magnitude of the gaps. The lower tax burden among dual earner than among male breadwinner households does not discourage female labor market participation. Also, there would be a fairness concern if the one earner household receives a better treatment than a female without a spouse. Nelson's argument is behind this gender equity concept: given income, welfare depends on the capacity of household's production which is not taxed.

Besides the three typical types, there are two other comparisons that may help to understand gender differences: "couple, male breadwinner" vs "couple, female breadwinner" and "single, female breadwinner" vs "single, male breadwinner". Both female types bear a lower tax burden than male types.

To analyze the PIT ratio differences between household types, we estimate Model 3 in which we include possible sources of those differences: presence of children, household size, number of earners and the lack of contribution to social security (a proxy of the percentage of worker tax evaders in the household). Also, the explanatory variable of income is split into several sources. As shown in Table 3.3, even after including all the variables that may explain the differences, the gaps decline although they do not vanish. .

Let's analyze the demographic controls. The tax burden is higher when there are children in the household and increases with household size. This result is not surprising: on the one hand, the tax burden is likely to increase with total household income because of the progressivity of marginal tax rates on pensions and labor earnings; on the other hand, in each level of per capita household income, total income of the household increases with its size. As the average values of household size and presence of children are higher for "couple, male breadwinner" than "couple, dual earner", the PIT burden tends to be higher for the former

We interpret that the presence of children and the household size are demographic characteristics mainly related to life-cycle stage. But tax evasion and the income sources are at least partially influenced by culture and socioeconomic arrangements, so the interpretation of the PIT ratio differences should be interpreted cautiously from a gender perspective.

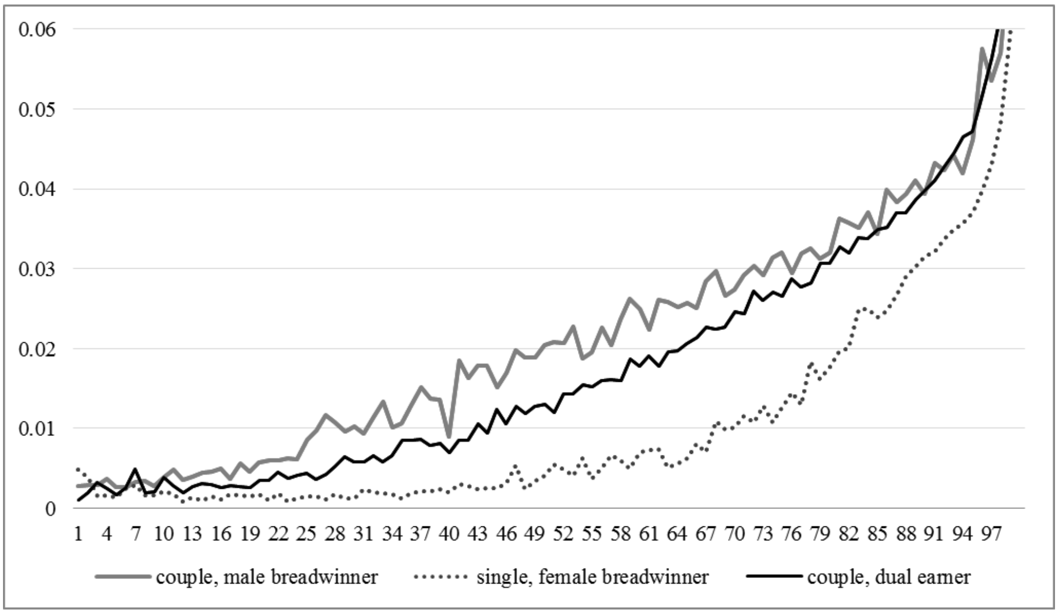
The effect of the number of earners is negative because of the progressivity of marginal taxes. I.e., at a given level of income, the PIT-to-income ratio is lower when the number of members receiving income is higher. As the number of earners is lower in the "couple, male breadwinner" category than the "couple, dual earner" category, the variable contributes to a higher gap between these types.

Unsurprisingly, the lack of contribution (tax evasion) has a negative effect. As it is higher in "couple, male breadwinner" than in "couple, dual earner" households, different behavior patterns in tax evasion do not contribute to explain the tax burden gap.

Finally, the marginal effects by income source indicate that the tax burden decreases when households are supported by non-taxable income (transfers and rental value). These sources are very important within the female type households so they contribute to explain their lower PIT burden. Public transfers are an important part of the non-taxable income. In Uruguay, most of the public programs of monetary transfers are directed to low-resources families. So, our findings suggest that the incidence of low income households is higher among female than male types. The share of non-taxable income is 13% among “couple, dual earner” but 25% for “single, female breadwinner”. In turn, for the “single, male breadwinner”, which tax burden is higher than its female counterpart, the non-taxable income accounts for 16% of their income. Finally, the incidence of non-taxed income for “couple, female breadwinner” (22%) is higher than for “couple, male breadwinner” (18%).

These results reflect the average situation. We also did an estimation based on Model 3 in which the household type is interacted with all the income sources. In Figure 3.5 we report the predicted PIT burden across the per capita income distribution for “couple, dual earner”, “couple, male breadwinner” and “single, female breadwinner”. The average depicted pattern is clearly identified in the central range of the income distribution: between the 25th and 75th percentile, the “couple, male breadwinner” type bears the highest burden whereas the “single, female breadwinner” exhibits the lowest one. But over the 75th percentile, the difference between the curves for the “couple, dual earner” and the “couple, male breadwinner” categories are not statistically significant at conventional levels. Meanwhile, “single, female breadwinner” has the lowest burden level across the entire distribution, although the magnitude of the gap is lower at the tails.

FIGURE 3.5 Predicted PIT across percentiles of per capita income distribution for three selected household types.



Source: Authors' estimations based on *Encuesta Continua de Hogares* 2013, *Instituto Nacional de Estadística*

3.4.3 Introducing joint taxation

Up to now we assumed that all individuals opt for individual filing. In this section we estimate the PIT amounts that would be paid under joint filing if we assume that couples choose the lowest burden option. Remind that we estimated that 5.4% of couples in the Tax Office records chose joint filing in 2013. In our simulation we find that 17% of the households with a labor income source (12% of total households) would benefit by choosing joint instead of individual filing. Thus, this estimation is much higher than the one based on tax records.

According to our simulation, joint filing is not only the best choice for the "couple, male breadwinner" type but also for one quarter of the "couple, dual earner" households in the database that pay PIT.

To analyze the potential effect of the joint filing option we estimate each model assuming that couples choose their best option. The results are reported in Table 3.4.

TABLE 3.4 Marginal effects estimated by a zero-inflated beta regression

VARIABLES	Model 1	Model 2	Model 3
Couple, male breadwinner	-0.0086***	0.0022***	0.0025***
	(0.00004)	(0.00006)	(0.00007)
Single, female breadwinner	-0.0107***	-0.0123***	-0.0031***
	(0.00006)	(0.00006)	(0.00007)
Couple, female breadwinner	-0.0095***	-0.0081***	0.0016***
	(0.00008)	(0.00007)	(0.00010)
Single, male breadwinner	-0.0036***	-0.0164***	-0.0122***
	(0.00010)	(0.00006)	(0.00010)
Per capita income		0.0201***	
		(0.00004)	
Presence of children (yes=1)			0.0084***
			(0.00004)
Household size			0.0045***
			(0.00002)
Number of earners (labor, capital earnings or pensions)			-0.0044***
			(0.00003)
Lack of contribution to social security			-0.0001***
			(0.00000)
Per capita capital income			0.0665***
			(0.00089)
Per capita labor income			0.0299***
			(0.00007)
Per capita pension			0.0302***
			(0.00009)
Per capita public transfer			-0.0032***
			(0.00013)
Per capita imputed rent of owner-occupied house			-0.0054***
			(0.00011)
Observations	124987	124987	124987

Source: Authors' estimations based on *Encuesta Continua de Hogares* 2013*, Instituto Nacional de Estadística*

*** p<0.01, ** p<0.05, * p<0.1

Note: For household types, we report the discrete effect related to the "couple, dual earner" type, valuing the rest of the variables at their means. For the rest of the dependent variables, we report the 'marginal effect' by household type compared to the "couple, dual earner" type.

The patterns between models are similar to those obtained under the assumption of individual filing. Model 2 indicates that the “couple, male breadwinner” type bears the highest burden, followed by “couple, dual earner” and “single, female breadwinner”. But the gap between “couple, male breadwinner” and “couple, dual earner” is smaller than under individual filing. This suggests that joint filing helps to offset the incentives of sharing labor market work between spouses implicit in individual filing. Also the difference between “single, female breadwinner” and “couple, dual earner” becomes smaller. This is due to the gains for some “couple, dual earner” households opting for joint filing.

4.4 The tax burden of non-employed

The estimation of Model 2 indicates that the “couple, non-employed” type bears a lower burden than the “couple, dual earner” type (a significant marginal effect of -0.0087). This difference between types responds mainly to the fact that households of non-employed are formed by small households of elders. Thus, a similar per capita income means a higher total income for the “couple, dual earner” type. Once we control by the demographic variables, the marginal effect of “couple, non-employed” is positive. Indeed, the elders tend to face a higher PIT burden because they are more likely supported by pensions and capital income than labor income.

In Table 3.5 we present the estimated effect of the “single, non-employed” types relative to the “couple, non-employed” type. The negative effects indicate that among non-employed households, the couple type has the highest burden. The interest for our purpose is that the difference between the female and male types is small in all models – i.e., the PIT seems to not have different gendered treatment among the non-employed.

TABLE 3.5 Marginal effects estimated by a zero-inflated beta regression

VARIABLES	Model 1	Model 2	Model 3
Single, non-employed female	-0.0045***	-0.0103***	-0.0128***
	(0.00013)	(0.00007)	(0.00016)
Single, non-employed male	-0.0049***	-0.0105***	-0.0122***
	(0.00007)	(0.00006)	(0.00011)
Controls	No	Yes	Yes
Observations	124987	124987	124987

Source: Authors' estimations based on *Encuesta Continua de Hogares* 2013, *Instituto Nacional de Estadística*

*** p<0.01, ** p<0.05, * p<0.1

Note: the vector of household types includes 16 categories (presented in Table 2); for the estimation we omitted "couple, non-employed". The rest of the variables are valued at mean. Models 2 and 3 include the control variables shown in tables 3 and 4.

In Figure 3.6 we present the predicted PIT burden across the per capita income distribution, calculated based on Model 3. The average pattern holds for all ranges of the per capita income distribution: we do not find gender differences.

FIGURE 3.6 Predicted PIT across percentiles of per capita income distribution for three selected household types

Source: Authors' estimations based on *Encuesta Continua de Hogares* 2013, *Instituto Nacional de Estadística*

3.5 Conclusions

Gender issues have been debated in the policy agenda of social security system and led to some modifications such as the use of similar mortality rates for women and men to calculate the retirement pension, and the computation for women of one year per child in the calculus of the number of years of contribution required to retire. Feminist movements also claim the reduction of indirect taxes is some female goods, especially the ones linked to reproductive health.

In this study, we analyze the gendered effects of the PIT in Uruguay. The PIT was introduced ten years ago by a left government and the discussions about it (before and after its creation) are centered on its distributive effect. However, gender equity has not been raised in this debate.

The analysis of the legislation indicates that there are no explicit gender differences in the code, which means that the PIT treats women and men on an equal basis regarding rates, credits and deductions. There is a flat tax rate for capital income and two different progressive schedules for pensions and labor income. It is a joint filing system though joint system is allowed for couple income. On the base of Tax records we estimate that only 5.4% of couples (with at least one labor income earner) used the joint filing option in 2013. This low incidence may be explained by the lack of incentives to opt for joint filing. However, on the base of survey data, we estimate that 17% of couples (with at least one labor income earner) would benefit for joint filing. We cannot assess the difference between these two estimations. Note that there are not simple rules (such ranges of income level or ranges of participation of one spouse in the couple’s labor income), except the case of one earner couples, to inform the population who benefit or not of joint filing. Thus, a possible explanation of the discrepancy is lack of information. Indeed, every year couples have to calculate their PIT payments under individual and joint filing to opt for the least costly. But there are probably other explanations that could be the scope of future research.

We conduct the analysis using microdata provided by the 2013 Household Survey. We estimated taxes and contributions using the statutory rates in force in 2013. There is an important limitation of the survey because of the underreporting of capital income (Esponda & Vigorito, 2014) whereas there are no assessments about the accuracy of the labor income reports of evader workers. Besides, as it informs income after taxes, we made several assumptions to estimate gross income. The most important are the ones related to evasion: we assume no evasion of income capital and full evasion of labor income when there is not contribution to the social security system. The evasion assumption related to labor income seems no to be too unrealistic: Esponda & Vigorito (2014) find that the aggregated labor income obtained under this assumption is similar to the total labor income informed by Tax Office records. However, the assumption of no evasion of income capital may be extreme and could bias the results: the highest share of income capital is observed for non-employed households (both single male and female) and one earner households (male and female breadwinner types). Future analysis should work on the underreporting and evasion of capital income and assess the sensitivity of the results to these issues.

The raw data indicate that households in which both spouses participate in the labor market bear the highest PIT burden followed by the typical patriarchal household in which the husband works in the labor market but not the wife. But his order changes when we control by household per capita income. Households supported by a working man who lives with a dependent housewife face the highest tax burden, followed by the dual-earner type. This finding is similar to the obtained for Argentina (Rossignolo, 2018) and eight countries (Argentina, United Kingdom, Ghana, Uganda, Morocco, South Africa, Mexico and India) (Grown & Valodia, 2010). When we control by different potential explanatory factors, a gap remains. One of the factors that explain the gap is the lower number of earners of male breadwinner households which is consequence of the individual filing design. But even in the analysis of the joint filing design, the PIT burden is higher for male breadwinner than dual earner households.

These findings indicate that there is an incentive towards equal gender time allocation within the family, which is consistent with gender equity. On one hand, PIT does not discourage labor market participation of a second earner due that it is not taxed at higher rates. On the other hand, given that male breadwinner households may reach higher levels of welfare from non-taxed home production, the result is potentially not inconsistent with neutrality in terms of allocation between household and market time. However we cannot assess the magnitudes of the estimated PIT burden gaps. We made an exercise in which we compare the tax burden of a one earner couple under joint taxation and a two-earner couple under individual couple. We assumed that the three earners of the example generated the same level of labor income and the fourth individual, a similar value of home production. For different income level, we obtained that the one earner couple has a lower PIT burden than the two earner couple. Thus, the assessment of gap magnitudes appears to be a relevant topic for further research.

Single mother households bear a lower burden than dual earner households when considering both raw data and income controlled gaps. Once again, this pattern is consistent with gender equity.

However, this pattern is partly explained by non-desirable aspects: the higher levels of informality and participation of non-taxable sources of income among single female households than dual earner households.

We also compare male and female breadwinner households, and single female and male households. In both comparisons we find that the male types bear a higher PIT burden than the female types, which is partly explained by the higher share of non-taxable income among female types. We also study three typical types of non-employed households and we do not find differences between female and male categories.

Our findings may contribute to the debate of future reforms of the PIT. In fact, once in a while there are social pressures to reduce taxes to alleviate the burden on families. The question is if a new design could worsen horizontal equality from a gender perspective. For example, it is not advisable to allow exemptions for dependent spouses but it would be helpful to take into account persons unable to support themselves. Also to eliminate the option for actual joint filing would improve equality and, on the other sides, changes in the schedule rate of the actual joint filing should be carefully assessed.

Chapter 4

Determinants of urban mobility with a focus on gender: A multilevel analysis in the Metropolitan Area of Montevideo, Uruguay[9]

4.1 Introduction

An urban area, comprising a group of individuals and institutional structures within a territory defined as its urban space, promotes efficient interactions between people and places. The more accessible these places are to the people, the greater the efficiency of these interactions and, hence, the greater the degree of urban development. Under this premise, equity can be evaluated in terms of accessibility and mobility, related to both aspects of transport policy and infrastructure (Trannoy, 2011). Indeed, from the perspective of the equality of opportunities, the objective of transport policy would be to maximize the set of opportunities for people, in terms of destinations that can be reached by transport.

Transport policies impact at a wide range of levels and affect social groups differently (Manaugh et al., 2015). The definition and measure of these impacts in terms of equity are far from easy, but are especially difficult in Latin American countries which have to face higher levels of transport-related social inequalities than those faced by the developed world (Avellaneda García, 2007; Gutiérrez, 2010; Vasconcellos, 2014; Dávila, 2013; Jirón & Mansilla, 2013; Falavigna & Hernández, 2016; Hernández & Titheridge, 2016; Hernández, 2018). This means that in order to make informed policy decisions that can ensure the achievement of efficiency and equity, the daily mobility of the population needs to be carefully examined.

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[9] The article in this chapter was jointly written with Xavier Fageda. I thank seminar audience at the Department of Economics, *Universidad de la República*, for helpful comments.

Studies of the equity dimension of transport have tended to focus on the different travel patterns presented by individuals. Here, the evidence suggests that people's commuting patterns are influenced and limited both by their personal characteristics and by contextual factors (Hanson, 1982). The latter are those factors related to place of residence, and are most typically represented by geographic variables, while in the case of the former, the literature emphasizes the role played by demographic characteristics, socioeconomic status and employment status. These factors, however, can operate in different ways depending on gender and the type of household in which the individual lives (Silveira Neto et al., 2015). Many studies not only identify a gender difference in travel patterns but also examine the factors that might account for it. The most frequent explanation provided is the greater household responsibilities that women have to bear, referred to, henceforth, as the household responsibility hypothesis.

In general, most studies of urban mobility have been undertaken in developed countries and, so, there is little evidence on this subject for the middle-income economies. This study seeks to fill this gap by conducting a case study of Montevideo, the capital city of Uruguay. Interestingly, while the sociodemographic characteristics of Montevideo are similar to those of developed countries, its transport infrastructure and the characteristics of its built environment are more similar to those of a city in the developing world.

Uruguay today finds itself in an advanced stage of demographic transition compared to its Latin American counterparts. Likewise, the level of education of women, their labor force participation and their marital status have undergone substantial changes since the middle of the 20th century. Today, Uruguayan women have on average 10.2 years of schooling and their participation rate is 67%, whereas the Latin American averages are, respectively, 8.7 years and 55% (ECLAC, 2016; World Bank, 2016). These socio-demographic changes have impacted household structures with the result that they are substantially different from the average Latin American household. Moreover, as the ageing process is more advanced in Uruguay, there is a relatively high incidence of one person households (mostly elderly) as well as couples without children.

During the 1980s and 1990s, an infrastructure gap opened up between Latin America's regions, due to major cuts in public investment. Indeed, Uruguay's transport infrastructure gap is notorious. Moreover, the country's poor infrastructure, in terms both of stock but primarily of quality, would appear to be hindering its potential economic growth (OECD, 2016). During the period 2008-2015, average annual investment in the road subsector in Latin America was 0.7%, while road investment in Uruguay was just 0.4% of GDP. In this same period, dividing annual road investment by a country's total population yields an average for Latin America of US$ 64 per capita (at 2010 constant prices); in the case of Uruguay, this figure fell below US$ 50 per capita. These figures place Uruguay among the Latin American countries that tended to invest least in transport infrastructure in relation to GDP and population (Chauvet & Albetrone, 2018).

This paper seeks to illustrate the factors that influence travel patterns in the Metropolitan Area of Montevideo, with a specific focus on social gender roles and relations. Accounting for the interactions between the individual and their zone of residence, it specifically analyzes whether there are differences between male and female travel patterns that can be linked to the household responsibility hypothesis. The results indicate that all dimensions of travel behavior are influenced by both individual traits and contextual factors. Thus, as regards personal attributes, the evidence shows the importance of family structure in accounting for gender differences in commuting patterns. Specifically, the interaction between the presence of a partner and the presence of children in the household appear to be key factors in accounting for these differences, pointing to the validity of the household responsibility hypothesis. The methodology we adopt is based on multilevel regression models, as previously used in geographical research to provide accurate estimates of both individual and contextual effects on travel behavior. Its adoption allows us to contribute to the extant literature by providing a link between research on commuting gender differentials and research on the impacts of neighborhood environment on travel behavior.

The rest of this article is organized as follows: Section 4.2 reviews the literature related to the household responsibility hypothesis and the context of individual travel behavior; section 4.3 describes the study area; section 4.4 outlines the data sources and the variables included in the analysis;

section 4.5 describes the methodological approach; and, section 4.6 reports the results. Finally, the last section presents the conclusions and discusses the main empirical findings.

4.2 Previous studies

An individual's commuting patterns are affected both by personal characteristics and contextual factors. In the literature, commuting patterns are typically described in terms of the commuting trip distance, time, frequency (count) and mode choice. Other units of measurement, such as vehicle miles traveled, are also employed. No distinction is drawn between the concepts of commuting patterns and travel behavior in much of the literature and they are also used as synonyms in this study.

The main contributions of this study to the body of knowledge accumulated in the previous literature are threefold. First, as stated, the study focuses on a city located in a middle-income country, while the vast majority of extant studies have focused on cities in high-income countries with a greater allocation of infrastructure transport. Second, the study undertakes a joint consideration of the various attributes or dimensions of urban mobility, while most previous studies have focused on just one specific aspect of urban mobility. Third, the study analyzes in detail the interaction between gender, family organization and contextual factors while the previous literature has tended to focus on just one of these aspects in isolation.

4.2.3 The household responsibility hypothesis

A consistent finding in the literature is that sociodemographic variables (i.e. the attributes of the individual and household) determine commuting patterns (Ericksen, 1977; Hanson & Johnston, 1985; Silveira Neto et al, 2015; Turner & Niemeier, 1997). Among the attributes identified as affecting travel behavior, we find age, income and employment status; however, their impact may differ depending on gender and family organization. Gender differences in travel patterns and their relevance from the point of view of urban planning were recognized early on in the literature (e.g. Giuliano, 1979; Madden, 1981; Rosenbloom, 1978; White, 1986). Crane (2007), for example, studied commute trends for the whole of the US over the period 1985-2005 and found that while the participation of women in the economy has not stopped growing, women's commuting has remained persistently and systematically unchanged.

These incipient studies launched a body of research focused on explaining the role of gender in transportation, housing and labor market dynamics and its implications for planning practice. One strand of the literature claims that gender differences in travel behavior arise from differences in the way women and men participate in household- related activities. The household responsibility hypothesis (Johnston-Anumonwo, 1992) relies on the notion that women – owing perhaps to perceptions of values and roles – tend to take greater responsibility for childcare and household chores than men. Furthermore, women have to reconcile these activities with paid work. As space and time are constrained, competing demands for time result in a reduction of women's mobility (Crane, 2007; Giuliano, 1998; MacDonald, 1999; Madden, 1981; Turner & Niemeier, 1997).

Empirical papers have sought to provide evidence in support of the household responsibility hypothesis by focusing on the time and distance dimensions of travel behavior. And, while there is a broad consensus that women's trips are shorter than men's, explanations as to how the household responsibility theory operates vary in the literature.

For example, childcare may be a factor that impacts negatively on women's travel time (Ericksen, 1977, Giuliano, 1998, Lee & McDonald, 2003, Madden, 1981, Turner & Niemeier, 1997); however, there is no consensual understanding of the influence of the presence of children (Gordon et al., 1989, Hanson & Johnston, 1985, Johnston-Anumonwo, 1992, White, 1986). Lee & McDonald (2003) analyze the case of Seoul and find that while the presence of children negatively affects women's travel time, the presence of parents or parents-in-law in the household reduces women's household responsibilities and increases women's commuting substantially.

Marital status and partner's employment status are also key determinants of women's travel time. Johnston-Anumonwo (1992) considers the number of workers in a household as a measure of household responsibility, given the major changes that have occurred in American household structure. The study finds that in the case of American travelers, traditional gender roles are only important in understanding women's shorter trips in the case of married women where both they and their partners work. Presumably, in such households, the additional responsibility of domestic activities will fall above all on women. In contrast, Lee & McDonald (2003) and Crane (2007) show that being married negatively affects women's travel time, regardless of whether the spouse works or not.

A recent study employing data from the 2003-2010 American Time Use Survey (Fan, 2017) indicates that traditional gender relations remain operative in the US households. The study shows that gender differences in work travel do not react solely to partner presence or parenthood but rather to household structures in which partner presence interacts with parenthood.

In the case of South America, Silveira Neto et al. (2015) test the household responsibility hypothesis in the São Paulo Metropolitan Region, Brazil. The results suggest that marital status exerts a strong influence on the commuting time of working women, while the presence of dependents (children and elderly) has a smaller influence. Additionally, gender differences are observed for single and formerly married working females, which suggest other cultural or environmental factors not fully captured by the household responsibility hypothesis.

The number of daily trips has also been studied as a relevant dimension of travel behavior (Best & Lanzendorf, 2005; Hanson, 1982; Kim & Wang, 2015) on the assumption that it will highlight differences related to typical gender roles and the presence of children in the household. Individuals reporting fewest trips are usually those who make single-purpose daily trips, such as the commute to work. In contrast, a greater number of trips are reported by those who perform other types of activities, such as home and care duties. For example, Prevedouros & Schofer (1991) find that the increasing number of working women in Chicago suburbs is associated with an increase in their travel frequency, with work trips being added to the large number of household maintenance trips made by women.

Several quantitative studies have identified significant gender differences in car use. The more infrequent use of cars and the more frequent use of other modes of transport by women have been associated with women's time poverty, i.e. the use of slower modes being associated with longer journeys (Turner & Grieco, 2000). However, findings are not conclusive (for more details, see Gordon et al., 1989; Dargay & Hanly, 2007; Best & Lanzendorf, 2005). Gender differences in mode choice have been specifically examined in households with fewer cars than drivers (Giuliano, 1983; Pickup, 1984; Scheiner & Holz-Rau, 2012). The evidence suggests that men have first choice in such households, but the increasing availability of licenses and cars during the 1990s have led to a convergence over time (Beckmann et al., 2006 for Germany; Crane, 2007 for the US; Frändberg & Vilhelmson, 2011 for Sweden; Hjorthol, 2008 for Norway; Noble, 2005 for the UK). However, clear differences remain. For example, Scheiner & Holz-Rau (2012), using data from the German Mobility Panel 1994-2008, find that mode choice may be affected by the gendered roles a person takes in a household. They report that, on average, women drive some 23% less of their trips than men. Moreover, they find no clear evidence that taking on the breadwinning role of employed work increases a person’s car use more than assuming household responsibilities. However, contributing to breadwinning increases men’s car use more than women’s. Yet, the presence of small children in the family decreases men’s but increases women’s car use.

4.2.4 The context of individual travel behavior

The impact of contextual factors on individual travel behavior has been the subject of an increasing number of analyses in the field of economics and represents a key input in the debate on sustainable urban development (Gordon et al., 1989; Cervero, 1996; Zhang, 2004; Lee et al., 2009). It is worth stressing that the concepts of the built environment, urban form and neighborhood environment characteristics are used interchangeably in the literature.

The attributes of the built environment are recognized as being a major contributor to household activity-travel decisions and a considerable body of literature on the subject is available (see Ewing and Cervero, 2010 for an in-depth review). Indeed, an increasing number of empirical studies explore the effects of the characteristics of neighborhood environment on citizen’s health and quality of life (Badland et al., 2009; Frank et al., 2010; Van Dyck et al., 2010).

However, the interactions between the built environment and travel patterns have been little explored in middle-income economies (Sun et al., 2017, an obvious exception). Clearly, the characteristics of urban areas and the built environment differ according to a city's level of development. Indeed, in many middle-income countries, the scope for catching up in terms of their urban planning is broad and constitutes something of a challenge in the medium and long terms. In this process, smaller cities, which find themselves in the 'growth' stage, can obtain huge benefits from the effective coordination of transport and urban development. For instance, built environments can be expected to have a stronger influence on travel decisions in such contexts (Cervero, 2013).

The built environment can be described in terms of various dimensions: density, diversity, design and destination accessibility (Cervero, 2013; Sun et al., 2017; Zahabi et al., 2015).

Many studies report that density, measured by population, housing units or employment, is negatively associated with travel distance, travel time and car use. High-density built environments shorten travel times and distances and encourage the use of means of transport other than the private car. In contrast, processes of urban dispersion are accompanied by a greater dependence on car use given increasing travel distances (Cervero, 1996; Susilo & Maat, 2007; Moilanen, 2010; Schwanen et al., 2004; Sandow, 2008; Tracy et al. 2011; Van Acker & Witlox 2011; Yang et al., 2012; Zhang, 2004). Zegras (2004; 2010) finds that higher urban densities in Santiago de Chile are associated with lower per capita levels of vehicle kilometers traveled. Moreover, a higher population density is also related to a lower likelihood of household car ownership (Zegras, 2012).

Likewise, land use diversity is found to be significantly related to less car use and vehicle travel (Cervero and Wu, 1997; Frank et al. 2000; Tracy et al. 2011). Land use mix is typically calculated by constructing entropy measures of diversity, where low values indicate a single use of built environments and high values indicate more varied land uses (Cervero, 2002; Cervero & Kockelman, 1997; Ewing & Cervero, 2010; Kim & Wang, 2015; Kockelman, 1997).

Another important dimension of the built environment is accessibility, that is, the ease with which valued destinations can be reached (Sun et al., 2017) or the extent to which land-use and transport systems enable individuals to reach activities or destinations by means of one or a combination of transport modes (Geurs & van Wee, 2004). Kitamura et al. (1997) examine neighborhoods in the San Francisco Bay Area and show that better accessibility by public transport results in more trips on public transport. According to Zegras (2004; 2010; 2012), proximity to metro stations reduces car ownership and the per capita levels of vehicle kilometers traveled in Santiago de Chile. Moreover, accessibility is found to be highly correlated with other land uses, particularly density.

Studies show that traditional neighborhood design and environments, in which parking space is limited, sidewalks are continuous and there is greater network connectivity, encourage walking, cycling and the use of public transport (Badland et al., 2009; Craig et al., 2002; Schwanen & Mokhtarian, 2005). Using US data, Cervero & Kockelman (1997) find that pedestrian-oriented designs generally reduce trip rates and encourage non-auto travel in statistically significant ways, though their influences appear to be fairly marginal. In a travel-diary study of 1500 Bogotá residents, Cervero et al. (2009) find that design attributes of neighborhoods – such as street connectivity and sidewalk provisions – have a greater influence on the amount of time spent walking and cycling than do density and land-use diversity.

The literature includes various methods for modeling the relationship between land use and household travel patterns. Early studies use aggregate data at the household (or at some other geographical unit) level and compare cities' travel patterns. Newman & Kenworthy (1989) adopt this approach in their analysis of the relationship between population density and gasoline consumption in Asian, European and North American cities. However, aggregate data are unsuitable for analyzing individual travel behavior. Later studies adopt a disaggregated approach and include microdata at the individual level. Some examine both land use and household travel as simultaneous decisions so as to take into account the endogeneity of these choices. Examples include Zahabi et al. (2012), who examine the potential impact of land-use, public transit supply and parking pricing strategies on the transport mode choice of commuters living in

Montreal, and Brownstone & Golob (2009), who estimate a joint model of residential density, vehicle use, and fuel consumption that accounts for both self-selection effects and missing data that are related to the endogenous variables. The model is estimated on the California subsample of the 2001 U.S. National Household Transportation Survey (NHTS).

Although these studies recognize the importance of the contextual environment, they do not consider the interactions between individual and neighborhood factors. A number of more recent analyses, however, show the effectiveness of incorporating multi-level models so as to control for level interactions. These models represent an alternative strategy and address some of the limitations of multiple regression analysis. Bottai et al. (2006), for example, use two- and three-level hierarchical linear and Poisson models to estimate the distance covered and the number of trips performed in a day by individuals residing in Pisa, Italy. Their results indicate that travel behavior is more similar for individuals within a family than for individuals from different families.

Likewise, Silveira Neto et al. (2007) estimate a series of frequency-based trip generation models for total trips and two different trip purposes (i.e. work and non-work) applying a mixed ordered probit model, in order to explore the hypothesis of geographical and demographic variations in trip-making behavior. They use data drawn from the Transport Tomorrow Survey, conducted in the Greater Toronto Area, Canada. Elsewhere, Mercado & Paez (2009) investigate the determinants of mean trip distance traveled by different mode types. Their study uses data from the Hamilton Census Metropolitan Area in Canada and multilevel models to investigate the variables that impact distance traveled, with a specific focus on demographic ageing factors.

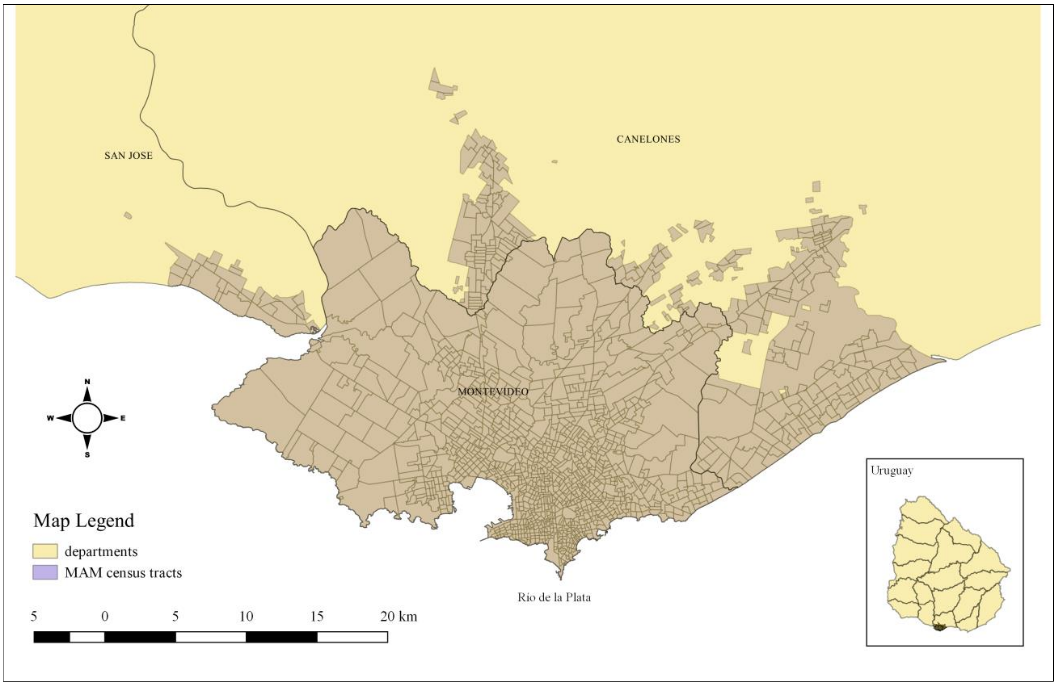
More recently, Antipova et al. (2011) have used a multi-level modeling approach to examine the combined effects of land-use types and socio-demographics (including both individual and neighborhood attributes) on commuting in Baton Rouge, USA. Data used in this research include the Baton Rouge Personal Transportation Survey (BRPTS) of individual households and the Census Transportation Planning Package (CTPP) at the TAZ level. Ding et al. (2014) provide additional evidence examining the effects of built environment factors measured at both home location and workplace on tour-based mode choice behavior. They employ a cross-classified multilevel probit model using a Bayesian approach to accommodate the spatial context in which individuals make travel decisions in Washington, D.C. Finally, Ding et al. (2017) apply a multilevel hazard model to accommodate the spatial context in which individuals generate commuting distance. In addition, this study provides insights into the effects of sociodemographics and the built environment on commuting distances using data from the Washington Metropolitan Area.

4.3 Study area

Uruguay’s population is unevenly distributed across its territory. The southern area of the country, in particular Montevideo (the capital city), has a high concentration of population as well as of economic activity and access to services. Internal migration from the country’s interior to the capital is notable.

This study focuses on the Metropolitan Area of Montevideo (MAM) which comprises the entire *departmento* of Montevideo and parts of the border *departmentos* of San José and Canelones (see Figure 4.1).

FIGURE 4.1 Census tracts of the Metropolitan Area of Montevideo



Source: Own elaboration

The last national census, conducted in 2011, recorded a total population of 3.3 million people, of whom around 1.9 million resided in the MAM, with 1.3 million residents in the capital. As Table 4.1 shows, the population density of MAM and most notably Montevideo, with a density of 2,488.9 inhabitants per square kilometer, contrast starkly with that of the rest of the country, where the average density is just 18.6 inhabitants per square kilometer.

TABLE 4.1 Population and Population Density of the study area

	Montevideo	Canelones	San José	MAM	Uruguay
Population	1,319,108	520,187	108,309	1,947,604	3,286,314
Urban	1,305,082	471,968	91,838	1,868,888	3,110,701
Rural	14,026	48,219	16,471	78,716	175,613
Area (Km^2)	530	4,536	4,992	10,058	176,215
Pop. Density	2,488.90	114.7	21.7	193.6	18.6
Census tracts	1,063	647	147	-.-	4,313
Pop by census tract	1,241	804	737	-.-	762

Source: Own elaboration based on *Instituto Nacional de Estadística*, 2011 Census.

Within the MAM, the areas with the highest population density are those near the center of the capital city and that extend out along the coastline (see Figure 4.2). Its territorial heterogeneity, with the coexistence of sectors of compact and diffuse city areas alternating in a given territory, is a particular characteristic of the MAM, resulting in a polycentric urban-territorial structure (Schelotto, 2008). The financial center, the most important government offices and the higher education institutions are located primarily in and around the city center. Exceptions include some large commercial areas, free zones and technology parks of recent development, which are located in the periphery. This could have served to relocate high value-added jobs that were previously located in the city center.

The MAM public transport network is based primarily on bus services, provided by private companies but regulated by the government (about 1 million trips a day in 2016). This urban transport system comprises about 1500 buses, 4718 stops and 3 exchange stations. It is organized around 145 lines that include several variants in both directions and of shorter coverage. The total number of bus lines, when each variant is considered separately, rises to 1383 (Massobrio, 2018). In addition, there are three railroad lines operated by the state railways administration which connect Montevideo primarily with other regions in the country, but demand is marginal (fewer than 1000 passengers a day in 2016).

A key feature of Montevideo's bus network is that the city center acts as a hub with most of the lines converging on that area. In fact, the density of bus stops is greatest in the city center, with more than one bus stop per block along some of the main avenues. Moreover, the average length of the bus lines (16.7 km with a standard deviation of 7.1) is high with respect to the area of the city (the densest urban area in Montevideo occupies only about 100 km^2 of its total area).

According to data from the 2016 mobility survey of the Metropolitan Area of Montevideo, on average, each household in the study area has 0.53 automobiles, 0.17 motorcycles and 0.64 bicycles. Of the total trips reported, the participation of the private car is relatively high (32.2% either as a driver or as a passenger) compared to 25.2% of journeys made by bus. The percentage of trips on foot is also high (33.5%) but this probably reflects the fact that it is not filtered by type of mobility, for example, short trips (see Table 4.2).

TABLE 4.2 Distribution of reported trips on working days by main mode of transport, in percentage

	Montevideo	Canelones and San José	MAM
Private car, driver	21.0	23.7	21.8
Private car, passenger	10.3	10.8	10.4
Motorcycle, driver	2.0	7.8	3.4
Motorcycle, passenger	0.5	1.9	0.8
Foot	34.2	31.4	33.5
Bicycle	1.7	5.2	2.6
Taxi, remise, apps	1.3	0.2	1.0
Bus	28.1	16.9	25.2
Scholar bus	0.7	1.2	0.9
Firm bus	0.1	0.8	0.3
Others	0.1	0.1	0.1
Total	100	100	100

Source: Own elaboration based on *Encuesta de movilidad del Área Metropolitana de Montevideo*, 2016.

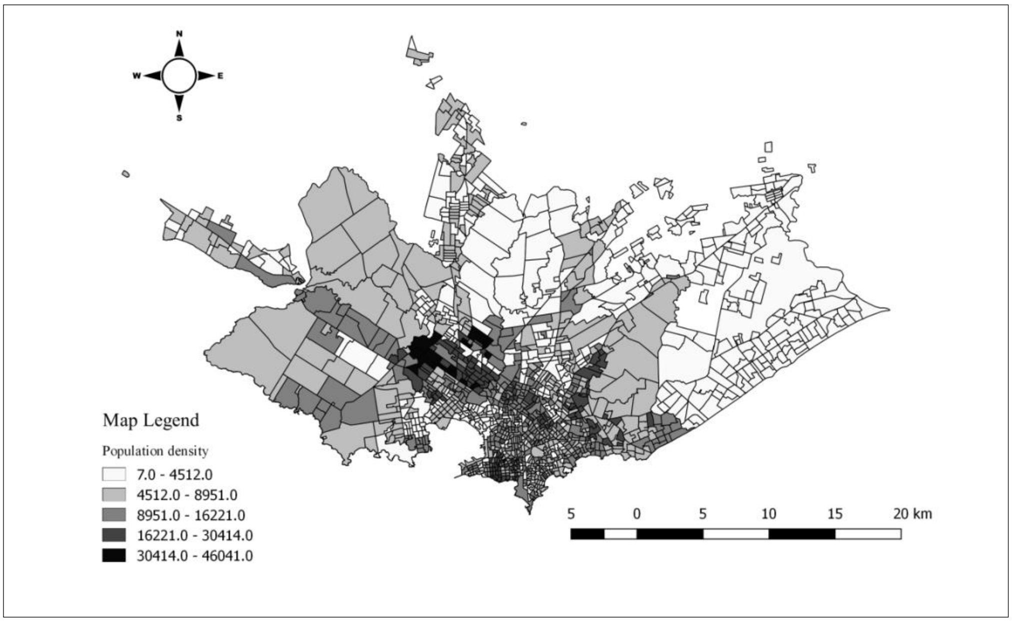
4.4 Data sources and variable specification

The main data source is the household mobility survey for the MAM (*Encuesta de movilidad del Área Metropolitana de Montevideo*) carried out in 2016. The purpose of the survey is to record information about all the daily trips made by each individual in every sampled household. Specifically, it inquires about trips (made between 4 a.m. on the previous day and 4 a.m. on the day of the survey, including the trip's purpose, time, origin and destination) and all the stages making up those trips (including the mode of transport and specific information about each mode). Households were only surveyed when the day of reference (i.e. the previous day) was a working day. No interviews were conducted when the reference days were holidays.

In addition, the survey records information about households (housing conditions, home comforts, vehicle ownership, household composition and income) and the individual members (education, employment status and mobility for each household member over the age of three). The survey includes 307 census tracts in Montevideo, 201 in Canelones and 27 in San José, making a total of 535 census tracts for the MAM. The overall sample comprises 2,230 households and 5,946 individuals of whom only 4,255 reported trips. Some observations were eliminated in order to ensure that every census tract incorporated had at least 5 individuals. Thus, the final sample includes 2,943 observations. The spatial distribution of the sample is shown in Figure 4.2.

Secondary sources of data used included the 2011 National Census and the Montevideo Municipality Open Data catalogue, which provide information about population density, aggregate educational attainment, number of bus stops and land use categories for calculating a land use mixture index, all of them referenced by census tract.

Figure 4.2 Population density in the Metropolitan Area of Montevideo's census tracts



Source: Own elaboration

Dependent variables

We focus on four dimensions of trip behavior: 1) *Trip time* is measured as the average overall travel time spent by an individual on trips made with a frequency greater than 1 or 2 days a week; 2) *Trip distance* is measured as an individual's average travel distance (trips made with a frequency greater than 1 or 2 days a week); 3) *Mode choice* is a binomial logit variable (1: automobile; 2: bus, walk, bicycle or combined) and 4) *Trip count* is the sum of the number of trips that are made with a frequency greater than 1 or 2 days a week.

Explanatory variables

Table 4.3 outlines the explanatory variables used in the analysis, which are nested in two levels: that is, the individual and census tract levels. The individual attributes included in the study are gender, age, income (included in the survey as a socioeconomic index), employment status, purpose of the trip and household type. We attempted to include other characteristics of an individual's economic activity but they were found to distort the model's fit.

TABLE 4.3 Explanatory variables

Level	Variable name	Description
Individual	Female	1 for female ; 0 for male
	Age	min: 18; max: 99; mean: 43.9
	Income (socioeconomic index)	min: 5; max: 82; mean: 42.2
	Full-time	1 for full-time employee; 0 for part-time employee, unemployed or inactive
	Household type	11 Male breadwinner 12 Male breadwinner with children 21 Female breadwinner 22 Female breadwinner with children 31 Dual earner 32 Dual earner with children 41 None employed 42 None employed with children
	Purpose of the trip	1 Return to home 2 Work 3 Study 4 Household related activities 5 Leisure
Zone	Population density	Population per square kilometer (in hundreds)
	Baccalaureate	Percentage of adults (> 18 years old) who acquire baccalaureate´s or above degrees
	Transportation accessibility	Total number of bus stops
	Land use mixture	Diversity index expressed by entropy (0-100)

Source: Own elaboration

As the specific focus of our study is to capture gender differences, we classified households on the basis of the employment status of their members and the presence of children below the age of 15. The “Male breadwinner” category includes households (with or without children) in which only men work; around 25% of individuals live in this type of household. The “Female breadwinner” category includes households in which only women work; around 18.7% of individuals live in this type of household. The “Dual earner” type corresponds to households in which both men and women work. This category is the most frequent, accounting for 36.8% of individuals. Households without workers are classified as “Non-employed” and account for 19.7% of the sample. In line with previous studies, mobility is associated with the working population and it is reflected in the lower mobility of the non-employed households, which present greater differences in their mobility patterns in relation to those of the other categories.

The study includes the following census tract level attributes: population density, the percentage of people educated to *baccalaureate* or degree level, the total number of bus stops and an entropy measure representing the evenness of distribution of several land use types.

4.5 Methodology

In this study, we use multilevel regression models as proposed in geographical research to provide accurate estimates of the effects of individual and contextual factors on travel behavior (Kim & Wang, 2015; Jones, 1991; Duncan & Jones, 2000; Paez & Scott, 2004; Mercado & Paez, 2009). The primary motive for using multilevel models is to be able to take into account the hierarchical structure of the data, in order to model their spatial heterogeneity.

In this context, we assume that individuals within a zone of residence (census tract) have certain characteristics in common and that these attributes differ from those residents in other zones. Thus the data are nested, that is, individuals (level 1) are grouped into zones (level 2).

In modes of this type the analysis is carried out in stages (Raudenbush & Bryk, 2002; Rabe-Hesketh & Skrondal, 2012). In the first stage, we estimate a null or “empty” model, with no explanatory variables included:

$$Y_{ij} = \beta_{0j} + r_{ij} \tag{4.1}$$

$$\beta_{0j} = \gamma_{00} + \mu_{0j} \tag{4.2}$$

where Y_{ij} is the outcome value for individual i in zone j, β_{0j} the average outcome within zone j and r_{ij} the deviation of the outcome of individual i from the mean outcome within zone j. Equation (4.2) discriminates the average outcome of the population (γ_{00}) from μ_{0j}, the deviation of the mean outcome of zone j from the grand mean across all zones. Combining (4.1) and (4.2), we obtain the random effect equation to be estimated:

$$Y_{ij} = \gamma_{00} + \mu_{0j} + r_{ij} \tag{4.3}$$

$$Var(Y_{ij}) = Var(\mu_{0j} + r_{ij}) = \tau_{00} + \sigma^2 \tag{4.4}$$

Equation (4.4) shows that the total variance of Y_{ij} is composed of the variance between zones (τ_{00}) and the variance within a given zone (σ^2).

We then gradually incorporate the different explanatory variables ($\beta_{1j}, \beta_{2j}, \dots, \beta_{nj}$). In a second stage, we include the level 1 variables and, finally, incorporate the level 2 variables. The models detailed above are known as "random intercept" models because only the intercept has a random component. However, the random variations between the different zones can also be found on the slope, giving rise to "random slope" models.

Several indicators can be employed to evaluate and compare multilevel models. The most widely used is the intraclass correlation coefficient (ICC) which determines the proportion of the total variability that is attributable to differences between zones: $\rho = \tau_{00}/(\tau_{00} + \sigma^2)$. A comparison of the models' ICC enables us to assess whether the addition of variables accounts for the zone variation. This is commonly expressed as a percentage and only applies to random intercept models.

The likelihood-ratio test compares the log-likelihoods of two models, one contained in the other: $L = 2(l_1 - l_0)$. In our framework, the conventional regression model is a reduced form of the multilevel model (when the random components are removed); thus, we test the hypothesis that the variables that appear in just one of the models are jointly statistically equal to zero. Specifically, to select the best models we estimate multilevel models and test for significance relative to their respective multiple regression models.

4.6 Results

In this section we present the outcomes of our application of multilevel models to the analysis of urban mobility in the metropolitan area of Montevideo. As outlined above, urban mobility is considered as comprising the following four dimensions: trip time, trip count, trip distance and mode choice. In addition, the determinants are considered at two levels: the individual (level-1) and the geographical (census tract) (level-2). The tables below show the estimated coefficients for the three specifications (the Null model, Model 1, and Model 2) of each dependent variable. All the specifications include a random intercept across census tracts. To compare the models, we present the intraclass correlation coefficient and the likelihood-ratio test results. For the goodness of fit, we present the typical statistics (AIC and BIC).

4.6.1 Multilevel regression analysis for trip time

Table 4.4 shows the estimated results of the multilevel regression analysis for trip time. Each model was estimated using the maximum likelihood method fitted with the *xtmixed* Stata command. The first specification is the Null model in which no explanatory variables are included. In Model 1 we add the individual-level variables and in Model 2 the contextual variables described above. We also include an alternative specification for Model 2 (*Model 2b*) that incorporates the variable *Mode of transport*.

On average, we estimate that daily travel time is about 30 minutes (see Null model). The variance component corresponding to the random intercept is 68.44, while the variance between census tracts is 629.31. The ICC for the Null model indicates that 9.81% of the variance is attributable to the geographical level.

The estimation results of Model 1 indicate that, on average, commuting time is differentiated by gender. The variable *Female* is positive and significant, which means that women's travel times are longer than men's, given the same individual characteristics. This outcome, however, is not supported by the literature reviewed herein. For that reason, we opted to estimate the alternative model (Model 2b), which includes mode of transport as a control variable. The intuition behind this outcome is that regardless of the distance, men and wealthier residents tend to travel by faster means of transport. Indeed, in Model 2b the variable *Female* loses its significance, reflecting the differentiated use of transport modes according to an individual's gender (we return to this question in greater detail in section 4.6.4).

TABLE 4.4 Estimated coefficients for trip time

	Null model	Model 1	Model 2	Model 2b
Fixed effects				
Intercept	29.547***	40.788***	45.138***	36.256***
	(0.63)	(3.8)	(3.86)	(3.37)
Level-1 variables				
Age		-0.078	-0.102	0.056
		(0.16)	(0.16)	(0.13)
Age2		0.000	0.000	0.000
		(0.00)	(0.00)	(0.00)
Income		-1.473***	-0.572	-0.671**
		(0.32)	(0.36)	(0.31)
Female		1.747*	1.779*	-0.924
		(0.97)	(0.96)	(0.80)
Full time		4.123***	4.103***	1.230
		(1.21)	(1.20)	(0.98)
Purpose				
Home return		4.230***	4.369***	1.988**
		(1.13)	(1.12)	(0.91)
Work		#	#	#
Study		8.009***	8.889***	1.544
		(2.53)	(2.52)	(2.05)
HH related activities		-16.471***	-16.615***	-6.881***
		(1.43)	(1.42)	(1.18)
Leisure		-10.598***	-10.334***	-4.521***
		(1.90)	(1.88)	(1.53)
Mode of transport				
Foot (less than 10 blocks)				-11.890***
				(1.18)
Foot/bike/motorbike				-7.476***
				(1.23)
Payed vehicle				14.081***
				(3.38)
Car				#
Bus				26.498***
				(1.04)
Household type				
MaleBreadwinner		-2.747*	-2.437	-1.732
		(1.63)	(1.62)	(1.31)
MaleB_children		-5.657***	-5.096***	-2.481
		(1.93)	(1.92)	(1.56)

TABLE 4.4 (cont.) Estimated coefficients for trip time

	Null model	Model 1	Model 2	Model 2b
FemaleBreadwinner		2.52	3.058*	-1.610
		(1.84)	(1.83)	(1.48)
FemaleB_children		-6.530***	-6,065***	-4.601***
		(1.99)	(1.97)	(1.60)
DualEarner		#	#	#
DualE_children		-3.659**	-3.281**	-2.641**
		(1.47)	(1.46)	(1.18)
NoneEmployed		-1.852	-1.459	-0.313
		(2.11)	(2.10)	(1.70)
NoneE_children		-8.379**	-7.416**	-2.524
		(3.39)	(3.37)	(2.73)
Level-2 variables				
Transport_access			0.123	-0.179*
			(0.15)	(0.12)
Baccalaureate _above			-9.939***	-6.653***
			(3.58)	(2.86)
Pop_density			-0.030***	-0.038***
			(0.01)	(0.01)
Land_use mixture			-0.514**	-4.992**
			(2.82)	(2.24)
Random effects				
var(Intercept)	68.438***	55.640***	44.050***	25.992***
	(11.68)	(10.16)	(9.02)	(5.77)
var(Residual)	629.309***	536.727***	534.099***	349.957***
	(17.70)	(15.26)	(15.12)	(9.93)
ICC	9.81%	9.39%	7.62%	6.91%
-2LL	-13773.64	-13388.54	-13363.52	-12714.58
AIC	27553.29	26815.07	26773.05	25483.16
BIC	27571.25	26928.62	26910.50	25644.47
N	2,943	2,911	2,911	2,905

Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: Standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1, # indicates the reference category

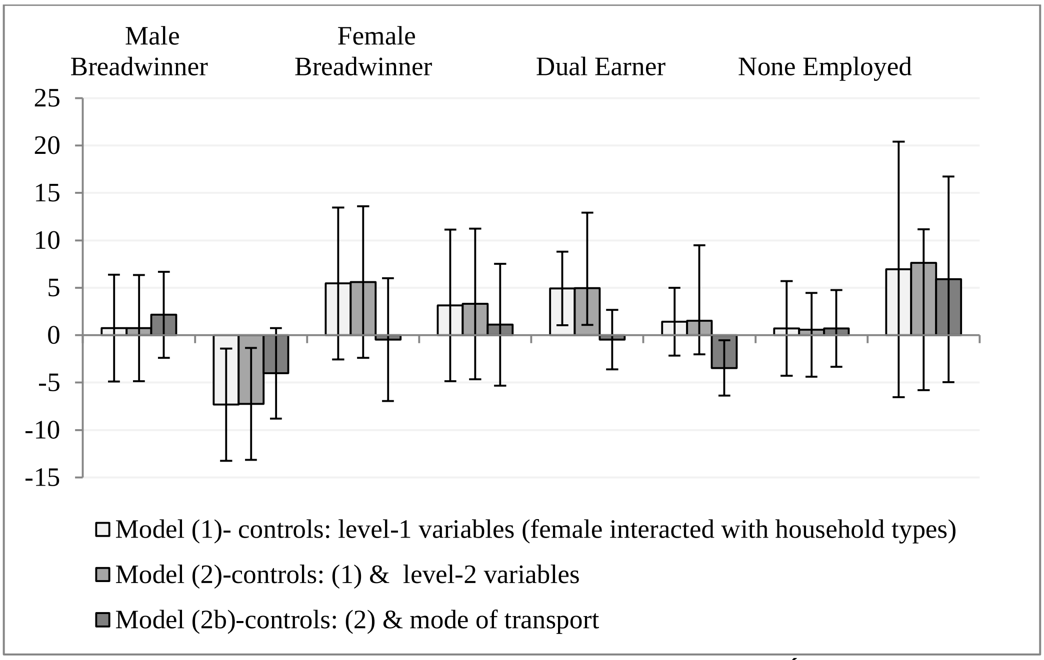
The model's specification also incorporates eight dummy variables that distinguish four types of family organization, each broken down between "with children" and "without children" categories. Table 4.4 reports the estimated coefficients of *Household type* corresponding to the "Dual earner without children" category. It can be seen that, on average, households with children present shorter travel times. A comparison of the four main types of family organization shows that the presence of children reduces the travel time in all categories (see the expected difference in Table A1 of the Annex). However, the effect is stronger for dual earner types; moreover, they maintain their significant effect when controlling for the mode of transport in Model 2b.

Households with children are particularly relevant for understanding gender inequalities in mobility patterns. To refine our analysis, we examine the interaction between the variables *Female* and *Household type*. A comparison of the four main household categories shows that the presence of children significantly reduces women's travel time in all household types, with the exception of the non-employed. The changes in men's trip times are not significant (see Table A2 in the Annex). This pattern is considered as being evidence in support of the household responsibility hypothesis (Fan, 2017; Lee & McDonald, 2003; Silveira Neto et al., 2015) and may indicate that women in such households take on additional family responsibilities that foster relocation strategies that seek a greater proximity between work and home.

Figure 4.3 shows the expected gender difference (contrast of prediction if *Female* equals 1 minus prediction if *Female* equals 0) in trip time by household type. The white bar shows the Model 1 estimation, the light gray bar the Model 2 estimation, and the dark gray bar the Model 2b estimation; in all three, a straight line indicates the 95% confidence interval of the estimation. This information is also presented in table format in the Annex (Table A3).

Figure 4.3 shows that only the male breadwinner with children type presents a negative and significant difference in travel time. In other words, women's trip times are shorter than male's when they live in households with children and in which only men work. Male breadwinner types are represented primarily by the traditional family of a working man and a woman who does not go out to work (82%), which contrasts with the female breadwinner types composed primarily by single mothers (55%). This distribution of household types is evidence of the continuing existence of traditional gender roles in Uruguayan society.

FIGURE 4.3 Differences in trip-time between women and men (prediction of Female – prediction of Male), by household type



Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: Contrast of predictive margins, the straight line indicates the 95% confidence interval

In contrast, dual earner without children households present a positive and significant difference in travel time. This result can be attributed to the use of different transport modes by women and men from the same household (women traveling on public transport and men in their own vehicles). Unlike the previous models, Model 2b shows that women make significantly shorter trips in the "Dual earner with children" category, in line with the household responsibility hypothesis (see Figure 3).

In the case of the individual controls, the variable *Age* is expected to present a positive and significant sign (Kim & Wang, 2015; Crane, 2007). However, Table 4.4 shows that an individual's age is not statistically related to daily trip time. The estimated coefficient of the variable *Income* indicates that a higher socioeconomic status is associated with shorter trips, which contradicts travel patterns for most developed cities but is consistent with previous findings for the Brazilian case (Silveira Neto et al., 2015). As expected, full-time workers present longer trip times than the rest of the population (Kim & Wang, 2015; Lee & McDonald, 2003; Fan, 2017).

Besides, the travel time of women in full-time work is significantly greater than that of men in full-time work (not shown in the table). In the case of the purpose of the trip, Table 4.4 shows the results in relation to the “work” category. Here, in line with the literature, household-related activities are those associated with the shortest commute time, followed by leisure activities. In contrast, study and work are associated with the longest commute activities.

According to the Model 2 estimates, of the contextual factors only *Transportation accessibility* cannot explain the significant zone-level variation. In general, most of the areas with high population density and high land-use diversity are close to jobs, shopping centers and educational establishments, which cuts trip times. Thus, women’s options in terms of access to public transport are likely to be poorer; this aspect of social inequality leaves them especially vulnerable. Moreover, the educational attainment of residents in an area is highly correlated with their socioeconomic status. The negative coefficient presented by the variable *Baccalaureate or degree level* is not in line with the literature, since in general the richest people make longer commutes from residential areas to the city center. However, the results do reflect the polycentric urban-territorial structure described above. In this same region, Silveira Neto et al. (2015) evidence the same pattern for Brazilian cities, in this case due to centralization of income.

As mentioned above, when we control for mode of transport (Model 2b), our time differences are smoothed because public transport tends to be much slower. Indeed, some level-1 variables lose their significance, which reflects the differentiated use of transport modes according to certain attributes of individuals. In particular, the variables *Female* and *Full time* and the category “Study” present these changes. The zone-related variables reinforce the above results, with the novelty of *Transport accessibility* which presents a negative and significant sign as expected. Once we control for the means of transport, the greater availability of public transport reduces travel time.

4.6.2 Multilevel regression analysis for trip distance

Table 4.5 shows that the average daily distance traveled in the MAM is about 7,130 meters (see Null model). The high ICC (15.18%) and the statistically significant variance suggest that the variation in travel distance can be explained by both individual and neighborhood attributes.

In the estimations, the variable *Female* presents a negative and significant sign. Thus, in line with previous research and unlike trip time, women on average travel less distance than men.

Table 4.5 reports the estimated coefficients of *Household type* relative to the “Dual earner without children” category. As expected, households with children travel shorter distances on average. However, while the point estimates point to these shorter distances, the presence of children only significantly reduces travel distance in the female breadwinner category (see expected difference in Table A4 of the Annex). Given that the presence of children significantly reduces travel times in all household types but does not reduce travel distance, it could be argued that the strategy of households is based, at least in part, on a shift towards faster means of transport. The exceptions here are the dual earner and female breadwinner households.

If we examine gender roles in each category (that is, by analyzing the interaction between the *Female* and *Household type* variables), it can be seen that in the presence of children, the women in female breadwinner households reduce their trip distance while men in male breadwinner households increase this distance. As the household responsibility hypothesis argues, in households with children, the gender difference in trip distance is sensitive to spouse/partner presence. In households where the woman does not work, the presence of children increases the distance travelled by the man. In contrast, in households with a single female breadwinner, the presence of children leads to a relocation of the residence or workplace towards zones of greater proximity to that household’s daily activities (see Table A5 of the Annex).

TABLE 4.5 Estimated coefficients for trip distance

	Null model	Model 1	Model 2
Fixed effects			
Intercept	7129.56***	6573.10***	9500.96***
	(245.90)	(1378.90)	(1382.84)
Level-1 variables			
Age		44.91	34.35
		(56.11)	(55.36)
Age2		-0.83	-0.72
		(.61)	(.60)
Income		204.75*	421.79***
		(120.68)	(128.90)
Female		-595.11*	-573.46*
		(344.48)	(342.14)
Full time		1723.73***	1733.19***
		(435.40)	(429.71)
Porpose			
Home return		621.3	715.18*
		(403.93)	(398.01)
Work		#	#
Study		3339.75***	3620.90***
		(909.17)	(896.79)
HH related activities		-4528.47***	-4653.75***
		(512.27)	(504.76)
Leisure		-2327.833***	-2117.76***
		(685.45)	(675.10)
Household type			
MaleBreadwinner		-495.411	-227.48
		(593.79)	(577.87)
MaleB_children		-100.219	91.98
		(702.43)	(684.61)
FemaleBreadwinner		970.07	1320.06**
		(666.87)	(650.28)
FemaleB_children		-1667.028**	-1486.92**
		(721.32)	(701.55)
DualEarner		#	#
DualE_children		-404.274	-298.05
		(535.82)	(520.43)
NoneEarner		-580.271	-255.57
		(763.10)	(745.88)

TABLE 4.5 (cont.) Estimated coefficients for trip distance

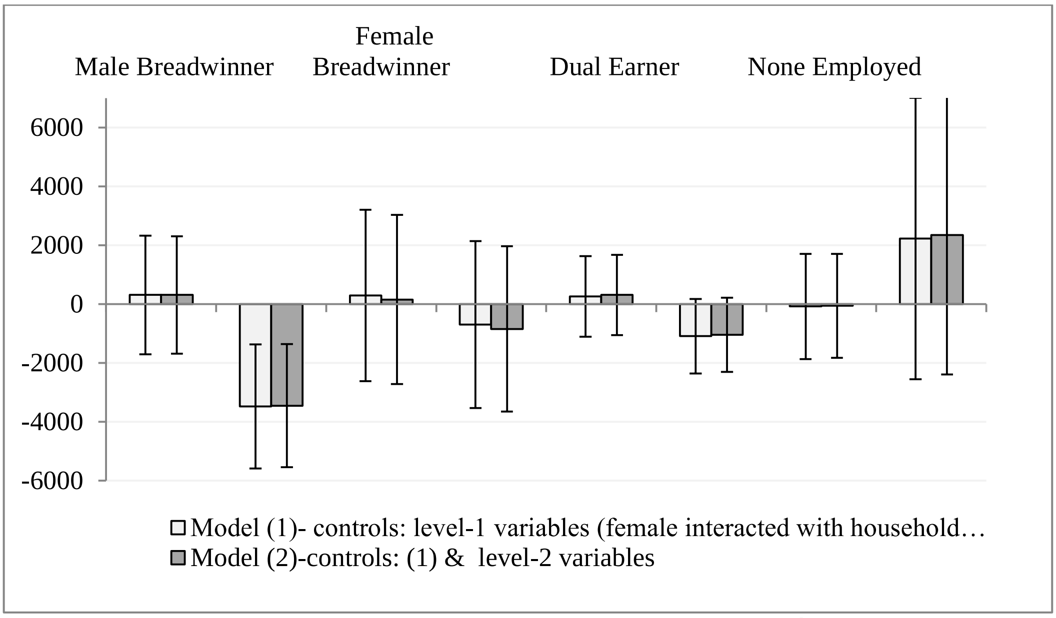
	Null model	Model 1	Model 2
NoneE_children		-1267.006	-923.4
		(1214.45)	(1193.87)
Level-2 variables			
Transport_access			-333.768***
			(57.31)
Bachelor_above			-738.16
			(1319.77)
Pop_density			-31.353***
			(3.87)
Land_use mixture			-1902.235*
			(1046.32)
Random effects			
var(Intercept)	13579204***	14229988***	7112882***
	(1909777.00)	(1877188.00)	(1339810.79)
var(Residual)	75879380***	65826516***	65917348***
	(2176580.00)	(1908166.00)	(1903009.43)
ICC	15.18%	17.77%	9.74%
-2LL	-30629.17	-30131.18	-30061.39
AIC	61264.34	60300.37	60168.78
BIC	61282.26	60413.67	60305.94
N	2,904	2,874	2,874

Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: *** p<0.01, ** p<0.05, * p<0.1, Standard errors in brackets, # indicates the reference category

Figure 4.4 shows the expected gender difference (contrast of prediction if *Female* equals 1 minus prediction if *Female* equals 0) in trip distance by household type. The figure shows that women travel shorter distances in the male breadwinner with children and dual earner with children households (this information is also presented in table format in the Annex, Table A6). This evidence reinforces the argument presented above that females in dual earner with children households seem to prefer working nearer to home or opt for part-time jobs.

In the case of the level-1 control variables, socioeconomic status, job type and trip purpose are significant factors in explaining travel distance on weekdays. The signs of these impacts, moreover, are as expected.

FIGURE 4.4 Differences in trip distance between women and men (prediction of Female – prediction of Male), by household type



Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo,* 2016. Note: Contrast of predictive margins, the straight line indicates the 95% confidence interval

At the zone level, transport accessibility and population density both seem to impact on the distance travelled by MAM residents (see Model 2). The level-2 results show that individuals residing in the most densely populated zones, with the greatest public transport accessibility and land-use diversity, travel shorter distances. This evidence is consistent with findings in the literature related to travel distance (Kim & Wang, 2015; Tracy et al., 2011; Van Acker & Witlox, 2011).

Here again, the evidence presented in this section suggests that more densely populated areas with greater accessibility to public transport and greater diversity of land use are associated with shorter trips. Therefore, women's options in terms of access to public transport are likely to be poorer in less central areas, making them especially vulnerable to this aspect of social inequity. Similarly, it is more likely that female breadwinner with children and dual earner with children households are located in more densely populated areas, while male breadwinner with children households are more likely to be located in less central areas, where women's travel distances are shorter and men's are longer.

We conducted an additional estimate including the variable *Mode of transport* but the results did not change substantially and so opted not to include them here.

4.6.3 Multilevel regression analysis for trip count

We assume that the number of trips can be explained by both family structure and gender roles. In general, trips made on weekdays are not solely single-purpose (for example, trips just to undertake household-related activities) but are likely to be multiple- purpose (for example, work, school run, or shopping). Given that household-related activities are mainly the preserve of women, the latter can be expected to complete more multiple-purpose trips. As Table 4.6 shows, the average number of daily trips made by MAM residents is about 2.71. The inter-individual variation is about 0.18, while the inter-zone variation is about 1.74, with an ICC of 9.48%.

According to our estimations, the variable *Female* presents a negative coefficient which means fewer trips, on average, for women. This outcome runs contrary to expectations but is in line with findings published elsewhere, including Bottai et al. (2006). However, if we consider the purpose of the trips made – in particular, those to complete household-related activities – then we can see that they are associated with a greater number of trips than the daily commute to work. Indeed, trips associated with household-related activities are important in explaining the trip count. Moreover, as expected, the presence of children is related to a significant increase in the number of trips made in the “Male breadwinner”, “Dual earner” and “Non-employed” categories (see Table A6 in the Annex).

As for gender roles within each household category, the presence of children is significant in explaining the greater number of trips made by women in all household types. In the case of men, we document a significant increase in the number of trips in the dual earner and non-employed households. Our evidence suggests that in traditional family units only the mobility of women increases in the presence of children, albeit with a reduction in travel time. In contrast, in male breadwinner households the travel distance of men increases but not the number of trips.

TABLE 4.6 Estimated coefficients for trip count

	Null model	Model 1	Model 2
Fixed effects			
Intercept	2.705***	1.787***	1.661***
	(.03)	(.21)	(.21)
Level-1 variables			
Age		0.030***	0.030***
		(.01)	(.01)
Age2		-0.000***	-0.000***
		.00	.00
Income		0.057***	0.043**
		(.02)	(.02)
Female		-0.102*	-0.104*
		(.05)	(.05)
Full time		-0.03	-0.029
		(.07)	(.07)
Porpose			
Home return		0.054	0.048
		(.06)	(.06)
Work		#	#
Study		0.204	0.181
		(.14)	(.14)
HH related activities		0.499***	0.507***
		(.08)	(.08)
Leisure		0.381***	0.372***
		(.10)	(.10)
Household type			
MaleBreadwinner		-0.016	-0.027
		(.09)	(.09)
MaleB_children		0.232**	0.219**
		(.11)	(.11)
FemaleBreadwinner		0.049	0.024
		(.10)	(.10)
FemaleB_children		0.339***	0.328***
		(.11)	(.11)
DualEarner		#	#
DualE_children		0.317***	0.312***
		(.08)	(.08)
NoneEarner		-0.254**	-0.276**
		(.12)	(.12)
NoneE_children		0.326*	0.31
		(.19)	(.19)

TABLE 4.6 (cont.) Estimated coefficients for trip count

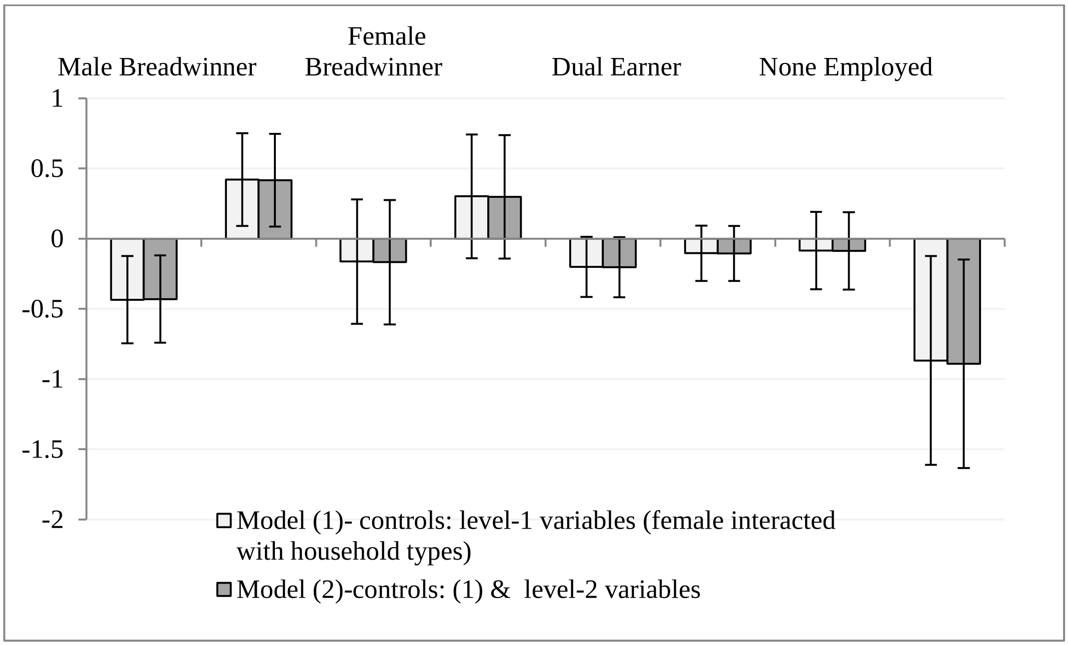
	Null model	Model 1	Model 2
Level-2 variables			
Transport_access			0.015*
			(.01)
Bachelor_above			-0.053
			(.20)
Pop_density			0.001**
			.00
Land_use mixture			0.118
			(.16)
Random effects			
var(Intercept)	0.182***	0.163***	0.150***
	(.03)	(.03)	(.03)
var(Residual)	1.738***	1.642***	1.641***
	(.05)	(.05)	(.05)
ICC	9.48%	9.02%	8.38%
-2LL	-5100.256	-4958.333	-4950.911
AIC	10206.51	9954.666	9947.822
BIC	10224.47	10068.21	10085.28
N	2,943	2,911	2,911

Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: *** p<0.01, ** p<0.05, * p<0.1, Standard errors in brackets, # indicates the reference category

Figure 4.6 shows the differences (contrast of prediction if *Female* equals 1 minus prediction if *Female* equals 0) in trip count between women and men by household type. Trip frequency is significantly higher for women only in male breadwinner households with children. In contrast, in male breadwinner households without children and in dual earner and non-employed households with children the number of trips is significantly lower for females. This result reinforces our previous findings: that is, women are more likely to present a lower frequency of mobility with the exception of those residents in “Male breadwinner with children” households. This higher number of trips can probably be attributed to their specific purposes, i.e. an association with activities of care and/or domestic chores.

As for individual controls, the estimated coefficient of *Age* presents an inverted-U shape, consistent with greater mobility in the working-age population. Furthermore, in line with previous studies (Hanson, 1982), a higher socioeconomic status is also related to increase mobility in turns of trip count.

FIGURE 4.5 Differences in trip count between women and men (prediction of Female – prediction of Male), by household type



Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: Contrast of predictive margins, the straight line indicates the 95% confidence interval

Model 2 includes the zone-related variables. As shown in Table 4.6, transport accessibility and population density are associated with a greater frequency of trips, though the impact is very small. As expected, the most densely populated residential areas with better supplies of public transport enable residents to access a greater diversity of services and activities, which may be associated with a greater number of trips.

The inclusion of the variable "Mode of transport" supports, in the main, the Model outcomes and, so, these results are not reported here.

4.6.4 Multilevel regression analysis for mode choice

The probability of an individual traveling by car (*Mode choice* equals 1 when automobile and 0 if other means of transport) is estimated using a binomial logit multilevel model fitted with the *melogit* Stata command. In non-linear multivariate models, such as logit, the impact of the independent variables can be analyzed using alternative measures. We display the estimated coefficients, whose signs allow us to analyze the positive or negative association with the individual's car use, that is, it shows the direction of the change but not its size. In addition, we examine the marginal effects, which show the effect on the probability of traveling by car when changing exogenous variables. Finally, we perform the likelihood-ratio test to compare each model using ordinary logistic regression, and find high statistical significance in all cases.

Table 4.7 reports the fixed effects estimated coefficients and the estimated variance components of the binomial logit multilevel models. According to our results, the estimated intercept of the Null model is -1.107, indicating that the average probability of travelling by car is about 24.8%. The ICC, which denotes how much of the total variation in the probability of choosing a car is accounted for by the zone of residence, is quite large, almost 20%. When controlling for the level-1 variables (Model 1), women are 24.5% less likely, on average, than men to travel by car.

Household types also play an important role in determining the individual's mode choice. Controlling for all other variables, the "Male breadwinner with children", "Dual earner with children" and "Female breadwinner with children" households are more likely to use an automobile than their counterparts without children, a finding that is in line with the literature. In the case of "Non-employed with children", the expected difference is not statistically significant, but as discussed above these households present a number of atypical characteristics in relation to the other categories (see Table A10 in the Annex).

When we interact the household type with gender, no differences are found in the behavior of males and females. The presence of children suggests that both women and men are more likely to travel by car, with the exception of non-employed households (see Table A11 in the Annex).

TABLE 4.7 Estimated coefficients for mode choice

	Null model	Model 1	Model 2
Fixed effects			
Intercept	-1.107***	-6.683***	-6.564***
	(.07)	(.52)	(.52)
Level-1 variables			
Age		0.096***	0.094***
		(.02)	(.02)
Age2		-0.001***	-0.001***
		0	0
Income		0.744***	0.775***
		(.04)	(.05)
Female		-1.113***	-1.098***
		(.12)	(.12)
Full time		0.419***	0.420***
		(.15)	(.15)
Purpose			
Home return		-0.294**	-0.283**
		(.13)	(.13)
Work		#	#
Study		-0.912**	-0.829**
		(.36)	(.36)
HH related activities		0.373**	0.350**
		(.16)	(.16)
Leisure		0.803***	0.821***
		(.21)	(.21)
Household type			
MaleBreadwinner		-0.006	0.025
		(.18)	(.18)
MaleB_children		1.294***	1.339***
		(.22)	(.22)
FemaleBreadwinner		-0.055	-0.013
		(.21)	(.21)
FemaleB_children		0.839***	0.849***
		(.24)	(.24)
DualEarner		#	#
DualE_children		0.957***	0.966***
		(.16)	(.16)
NoneEmployed		-0.085	-0.045
		(.25)	(.25)
NoneE_children		0.178	0.204
		(.52)	(.52)

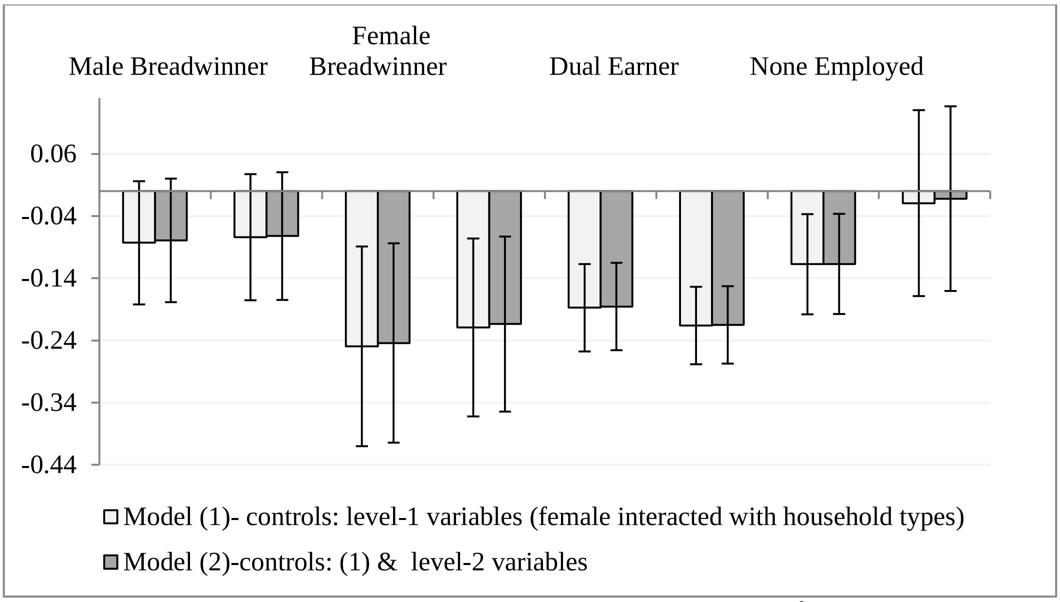
TABLE 4.7 (cont.) Estimated coefficients for mode choice

	Null model	Model 1	Model 2
Level-2 variables			
Transport_access			-0.017
			(.02)
Baccalaureate _above			-0.137
			(.39)
Pop_density			-0.003***
			(.00)
Land_use mixture			0.329
			(.32)
Random effects			
var(Intercept)	0.816***	0.507***	0.455***
	(.15)	(.13)	(.13)
ICC	19.87%	13.34%	12.14%
-2LL	-1677.671	-1337.985	-1332.091
AIC	3359.342	2711.969	2708.182
BIC	3371.312	2819.505	2839.615
N	2,937	2,905	2,905

Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: *** p<0.01, ** p<0.05, * p<0.1, Standard errors in brackets, # indicates the reference category

As for gender differences by household type, women present a significantly lower probability of travelling by car in "Dual earner" and "Female breadwinner" households with and without children and in "Non-employed" households without children (see Figure 4.6 and Table A12 in the Annex).

FIGURE 4.6 Differences in mode choice between women and men (prediction of Female – prediction of Male), by household type



Source: Authors' estimations based on Encuesta de Movilidad del Área Metropolitana de Montevideo, 2016. Note: Contrast of predictive margins, the straight line indicates the 95% confidence interval

As Table 4.7 shows, the likelihood of using a private vehicle increases with age. Moreover, and as expected, the probability of traveling by car is significantly and positively related to socioeconomic status. To illustrate this, Figure A1 (Annex) displays the predicted probabilities of choosing to travel by car by household type and gender and for selected values of the income variable. It is worth noting that in all types of household, the predicted gender difference in the probability of travelling by car increases in medium-high positions of the income distribution (see Figure A2 in the Annex).

In model 2, in which we include the contextual variables, only the estimated coefficient of the *Population density* variable is statistically significant, indicating that an individual's mode choice is not so strongly influenced by the attributes of their zone of residence. This result is in line with previous studies; in general, the need of those living in the most densely populated areas to use a car is not so great because of the greater service supply within the same neighborhood.

4.7 Discussion and concluding remarks

In this paper, we have taken a multilevel approach to examine the determinants of commuting patterns in the Metropolitan Area of Montevideo, with a specific focus on social gender roles and relations. The methodology allows us to contribute to the previous literature by providing a link between research on commuting gender differentials and studies examining the impact of the neighborhood environment on travel behavior.

This study has, additionally, tested the household responsibility hypothesis by seeking to identify interactions between an individual's attributes and the contextual factors of their zone of residence, links that have previously gone unexplored. We have considered four aspects of trip behavior: namely, trip time, distance, and frequency and the choice of transport mode, while the travel data we employ are stratified in two levels: that of the individual and that of the zone of residence (census tract).

Our results indicate that all dimensions of travel behavior are influenced by both individual and contextual characteristics. As regards the former, our findings stress the importance of family structure in accounting for gender differences in commuting patterns. Specifically, the interaction between the presence of children and the presence of a partner in a household appears to be a key factor in explaining these differences, demonstrating, moreover, the relevance of the household responsibility hypothesis.

We distinguish four types of family organization, each broken down between "with children" and "without children" categories: male breadwinner, female breadwinner, dual earner and non-employed households. In what follows, our discussion of the main findings does not include the non-employed households, since they are integrated primarily by the inactive population and their patterns of behavior are markedly different from those of the other households.

Overall, we present evidence pointing to the existence of differences in the commuting patterns of males and females resident in the MAM. On average, women travel shorter distances and make fewer trips. Travel time does not differ significantly between genders, because women tend to use slower means of transport, as demonstrated by their less frequent use of cars.

As discussed, previous studies (e.g. MacDonald, 1999) have theorized that women's lower mobility may be associated, among other factors, with the unequal internal distribution of domestic chores within households (corresponding to the household responsibility hypothesis). Women, who traditionally spend more time undertaking domestic work than do men (owing perhaps to perceptions of values and roles), have to reconcile these activities with paid work. Given the limited number of hours in each day, women are obliged to adopt a strategy: either they choose to live close to their workplace or, in cases where the residential choice is made jointly with other members of the household, they choose to work closer to home. In either case, however, the outcome is the same: women's mobility is not as great as men's. Households with children are particularly important for understanding gender inequalities related to mobility patterns. Indeed, the concept of household responsibility and its impact appear to be closely linked to child care. In this regard, the literature reports a negative effect of children on women's travel time and travel distances (Crane, 2007; Ericksen, 1977; Giuliano, 1998; Lee & McDonald, 2003; Madden, 1981; Silveira Neto et al., 2015; Turner & Niemeier, 1997).

Our results are in line with those of the literature: Households with children present shorter travel times than those of their counterparts without children, especially in dual earner households. Moreover, the trip distances of female breadwinner households with children are also shorter. Hence, it would seem that the strategy of households is based, at least in part, on a shift towards faster means of transport. In fact, the presence of children increases the probability of travelling by car in all household types. At the same time, the reduction in distance may indicate a mixed strategy, involving the relocation of daily activities to reduce the distance to work and, in this way, increasing the number of household support activities.

In a second stage, by analyzing gender roles, we have provided key insights into how a family's organization may shape the differences between households with and without children. The results show, in line with previous studies, that women in all types of household with children tend to have shorter commute times than those of their counterparts in households without children. In the case of women in female breadwinner households, this shorter commute is apparent both in terms of time and distance. Similarly, the presence of children increases the frequency of trips for women in all households, while the probability of travelling by car increases with the presence of children in all household types and for both genders. Meanwhile, men present higher travel distances in male breadwinner households with children and a higher frequency of trips in dual earner households with children.

This additional information seems to indicate that besides the presence of children, the presence of a spouse/partner in the household also has an effect on mobility patterns. Some papers provide evidence that household responsibilities are only important for understanding the reduced mobility of women in the case of those couples where both partners work, since the additional responsibility of domestic chores falls disproportionately on women (Johnston-Anumonwo, 1992). However, other studies emphasize that the presence of a spouse/partner negatively affects the mobility of women regardless of whether both partners work or not (Crane, 2007; Lee & McDonald, 2003).

Our findings indicate that the behavior of women in dual earner households is similar to that of women in male breadwinner households, regardless of the fact that in the former they participate in the labor market. In couple households, the presence of children has a marked effect on the mobility of women, who tend to reduce their travel time by incorporating faster means of transport (increased car use), increase the number of trips by assuming a greater number of tasks associated with care, while maintaining their total travel distance (probably reflecting the net effect of a decrease in distance associated with the relocation of their workplace, compensated by an increase in distance due to their taking on more domestic chores and activities related to care).

In contrast, in couple households where only men participate in the labor market, their travel distance increases in the presence of children. However, this increase in distance is not accompanied by an increase in trip time or frequency of travel. Thus, it seems that men in households of this type fail to assume part of the responsibilities of childcare and, moreover, they extend the time they spend outside the home. In the case of men in dual earner households, the significant increase in the frequency of their trips, together with a greater probability of travelling by car, may be indicative of their undertaking some childcare activities.

In households where the presence of couples is lower and women undertake paid work (i.e. female breadwinner type), the relocation strategy of daily activities takes on considerable relevance insofar as trip and total travel time both fall. This behavior occurs despite the greater use of faster means of transport and an increase in trip frequency.

In the case of expected gender differences within each household type, our results reinforce the above findings and are in line with the outcomes identified in the literature: women are less mobile than men above all in couple households with children. We should also stress that the probability of travelling by car is significantly lower for females (in dual earner and female breadwinner households). Here, there would appear to be broader cultural and environmental factors that lie outside the scope of enquiry of the present study that might help explain this pattern.

As for the specific zone of residence, most of the contextual variables provide a significant explanation of the variation between census tracts. In the case of the trip time and distance variables, our findings suggest that residing in the most densely populated zones, with the greatest degree of public transport accessibility and land-use diversity, is associated with shorter trip distances and time. Similarly, the residents' educational attainment results are also a close reflection of the polycentric urban-territorial structure that characterizes the MAM. Trip count, transport accessibility and population density variables are associated with a greater frequency of trips, though the impact is very small. As expected, the most densely populated residential areas with the best supply of public transport enjoy better access to a wider diversity of services and activities, which may be associated with a greater number of trips.

In the final regression, only the estimated coefficient of the *Population density* variable is statistically significant, indicating that the individual's mode choice is less influenced by the attributes of the zone of residence. This result is in line with previous studies; in general, most areas of high population density have a weakened need to use automobiles due to a greater supply of services in the same neighborhood.

According to our results, women's options in terms of access to public transport are likely to be poorer in less centrally located areas of residence, an aspect of social inequality to which they are especially vulnerable. Overall, our evidence suggests that women make more intensive use of public transport; thus, in residential areas with less access to public transport, women's mobility in particular will be affected. This finding has obvious implications for public policy, given that the promotion of public transport in less central areas could help reduce the negative consequences of gender inequality.

In short, the mobility patterns described in this article demonstrate the presence of multiple gender differences (conditioned by the type of family organization) that need to be addressed simultaneously through the implementation of different policies. It has been the aim of this article to present information that might help determine the magnitude of the problem.

Annex

TABLE A1 Differences in trip-time between households with children and households without children, by household type

Household type	Model 1	Model 2	Model 2b
MaleBreadwinner	-3.84*	-3.52*	-2.50
	(2.11)	(2.09)	(1.69)
FemaleBreadwinner	-7.77***	-7.86***	-3.73
	(2.86)	(2.84)	(2.29)
DualEarner	-3.53**	-3.16**	-2.63**
	(1.46)	(1.44)	(1.17)
NoneEmployed	-6.40*	-6.02	-4.02
	(3.70)	(3.67)	(2.96)

Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: *** p<0.01, ** p<0.05, * p<0.1, Standard errors in brackets, Contrast of predictive margins: prediction of household type with children minus prediction of household type without children.

TABLE A2 Differences in trip-time between households with children and households without children, by household type and gender

Household type # Gender	Model 1	Model 2	Model 2b
MaleBreadwinner # Man	0.36	0.60	0.90
	(2.25)	(2.23)	(1.80)
MaleBreadwinner # Woman	-7.71**	-7.31**	-5.64**
	(3.34)	(3.31)	(2.68)
FemaleBreadwinner # Man	-6.57	-6.74	-4.28
	(5.26)	(5.22)	(4.21)
FemaleBreadwinner # Woman	-8.87***	-8.90***	-3.22*
	(2.34)	(2.32)	(1.89)
DualEarner # Man	-1.71	-1.41	-1.04
	(1.98)	(1.97)	(1.60)
DualEarner # Woman	-5.21***	-4.77**	-4.09***
	(1.96)	(1.95)	(1.58)
NoneEmployed # Man	-9.64	-9.71	-6.40
	(6.27)	(6.24)	(5.03)
NoneEmployed # Woman	-3.42	-2.63	-1.82
	(3.96)	(3.94)	(3.18)

Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: *** p<0.01, ** p<0.05, * p<0.1, Standard errors in brackets, Contrast of predictive margins: prediction of household type with children minus prediction of household type without children.

TABLE A3 Gender differences in trip-time
(prediction of Female – prediction of Male), over household types.

Household type	Model 1	Model 2	Model 2b
MaleBreadwinner	0.74	0.74	2.15
	[-4.89 ; 6.37]	[-4.87 ; 6.34]	[-2.39 ; 6.69]
MaleB_children	-7.33**	-7.24**	-4.02*
	[-13.26 ; -1.40]	[-13.14 ; -1.33]	[-8.81 ; 0.76]
FemaleBreadwinner	5.45	5.60	-0.47
	[-2.57 ; 13.48]	[-2.38 ; 13.58]	[-6.94 ; 5.99]
FemaleB_children	3.15	3.30	1.11
	[-4.84 ; 11.14]	[-4.65 ; 11.24]	[-5.33 ; 7.54]
DualEarner	4.92**	4.95**	-0.46
	[1.05 ; 8.80]	[1.09 ; 8.81]	[-3.61 ; 2.68]
DualE_children	1.42	1.52	-3.45**
	[-2.14 ; 4.99]	[-2.03 ; 5.07]	[-6.36 ; -0.55]
NoneEmployed	0.72	0.59	0.72
	[-4.28 ; 5.72]	[-4.39 ; 5.56]	[-3.32 ; 4.75]
NoneE_children	6.94	7.61	5.89
	[-6.54 ; 20.41]	[-5.79 ; 21.02]	[-4.94 ; 16.73]

Source: Authors' estimations based on Encuesta de Movilidad del Área Metropolitana de Montevideo, 2016. Note: *** p<0.01, ** p<0.05, * p<0.1, Contrast of predictive margins, 95% confidence intervals in brackets

TABLE A4 Differences in trip-distance between households with children and households without children, by household type

Household type	Model 1	Model 2
MaleBreadwinner	-72.80	-136.15
	(766.87)	(748.44)
FemaleBreadwinner	-1933.09*	-2112.28**
	(1035.84)	(1012.37)
DualEarner	-268.21	-178.56
	(531.51)	(516.39)
NoneEmployed	-230.81	-260.43
	(1317.80)	(1297.13)

Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: *** p<0.01, ** p<0.05, * p<0.1, Standard errors in brackets, Contrast of predictive margins: prediction of household type with children minus prediction of household type without children.

TABLE A5 Differences in trip-distance between households with children and households without children, by household type and gender

Household type # Gender	Model 1	Model 2
MaleBreadwinner # Man	1911.00**	1832.29**
	(813.47)	(797.76)
MaleBreadwinner # Woman	-1880.21	-1929.55
	(1196.15)	(1177.80)
FemaleBreadwinner # Man	-1412.90	-1588.27
	(1902.52)	(1870.43)
FemaleBreadwinner # Woman	-2407.03***	-2589.69***
	(840.54)	(824.03)
DualEarner # Man	438.99	530.34
	(715.68)	(703.74)
DualEarner # Woman	-912.53	-824.43
	(706.49)	(694.27)
NoneEmployed # Man	-1439.67	-1516.42
	(2233.13)	(2205.06)
NoneEmployed # Woman	870.56	883.87
	(1414.22)	(1394.03)

Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: *** p<0.01, ** p<0.05, * p<0.1, Standard errors in brackets, Contrast of predictive margins: prediction of household type with children minus prediction of household type without children.

TABLE A6 Gender differences in trip-distance (prediction of Female – prediction of Male), over household types

Household type	Model 1	Model 2
MaleBreadwinner	309.98	310.29
	[-1702.02 ; 2321.98]	[-1681.10 ; 2301.67]
MaleB_children	-3481.23***	-3451.55***
	[-5588.00 ; -1374.46]	[-5546.04 ; -1357.07]
FemaleBreadwinner	297.14	156.76
	[-2614.14 ; 3208.42]	[-2719.96 ; 3033.48]
FemaleB_children	-696.99	-844.66
	[-3535.56 ; 2141.58]	[-3651.82 ; 1962.51]
DualEarner	260.56	311.30
	[-1110.55 ; 1631.67]	[-1055.15 ; 1677.75]
DualE_children	-1090.97*	-1043.48*
	[-2353.57 ; 171.64]	[-2303.21 ; 216.26]
NoneEmployed	-81.12	-58.89
	[-1871.95 ; 1709.71]	[-1828.15 ; 1710.37]
NoneE_children	2229.10	2341.41
	[-2554.29 ; 7012.50]	[-2389.88 ; 7072.70]

Source: Authors' estimations based on Encuesta de Movilidad del Área Metropolitana de Montevideo, 2016. Note: *** p<0.01, ** p<0.05, * p<0.1, Contrast of predictive margins, 95% confidence intervals in brackets

TABLE A7 Differences in trip-count between households with children and households without children, by household type

Household type	Model 1	Model 2
MaleBreadwinner	0.43***	0.43***
	(0.12)	(0.12)
FemaleBreadwinner	0.15	0.16
	(0.16)	(0.16)
DualEarner	0.32***	0.32***
	(0.08)	(0.08)
NoneEmployed	0.77***	0.78***
	(0.21)	(0.21)

Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: *** p<0.01, ** p<0.05, * p<0.1, Standard errors in brackets, Contrast of predictive margins: prediction of household type with children minus prediction of household type without children.

TABLE A8 Differences in trip-count between households with children and households without children, by household type and gender

Household type # Gender	Model 1	Model 2
MaleBreadwinner # Man	-0.01	-0.01
	(0.12)	(0.12)
MaleBreadwinner # Woman	0.84***	0.84***
	(0.19)	(0.19)
FemaleBreadwinner # Man	-0.09	-0.08
	(0.29)	(0.29)
FemaleBreadwinner # Woman	0.37***	0.39***
	(0.13)	(0.13)
DualEarner # Man	0.27**	0.26**
	(0.11)	(0.11)
DualEarner # Woman	0.37***	0.36***
	(0.11)	(0.11)
NoneEmployed # Man	1.18***	1.20***
	(0.35)	(0.35)
NoneEmployed # Woman	0.39*	0.39*
	(0.23)	(0.23)

Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: *** p<0.01, ** p<0.05, * p<0.1, Standard errors in brackets, Contrast of predictive margins: prediction of household type with children minus prediction of household type without children.

TABLE A9 Gender differences in trip-count
(prediction of Female – prediction of Male), over household types

Household type	Model 1	Model 2
MaleBreadwinner	-0.43***	-0.43***
	[-0.75 ; -0.12]	[-0.74 ; -0.12]
MaleB_children	0.42**	0.42**
	[0.09 ; 0.75]	[0.09 ; 0.75]
FemaleBreadwinner	-0.16	-0.17
	[-0.61 ; 0.28]	[-0.61 ; 0.28]
FemaleB_children	0.30	0.30
	[-0.14 ; 0.74]	[-0.14 ; 0.74]
DualEarner	-0.20*	-0.20**
	[-0.41 ; 0.01]	[-0.42 ; 0.01]
DualE_children	-0.10	-0.11
	[-0.30 ; 0.09]	[-0.30 ; 0.09]
NoneEmployed	-0.08	-0.09
	[-0.36 ; 0.19]	[-0.36 ; 0.19]
NoneE_children	-0.87**	-0.89**
	[-1.61 ; -0.12]	[-1.63 ; -0.15]

Source: Authors' estimations based on Encuesta de Movilidad del Área Metropolitana de Montevideo, 2016. Note: *** p<0.01, ** p<0.05, * p<0.1, Contrast of predictive margins, 95% confidence intervals in brackets

TABLE A10 Differences in mode-choice between households with children and households without children, by household type

Household type	Model 1	Model 2
MaleBreadwinner	0.20***	0.20***
	(0.04)	(0.04)
FemaleBreadwinner	0.13**	0.13**
	(0.05)	(0.05)
DualEarner	0.14***	0.14***
	(0.02)	(0.02)
NoneEmployed	0.02	0.01
	(0.08)	(0.08)

Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: *** p<0.01, ** p<0.05, * p<0.1, Standard errors in brackets, Contrast of predictive margins: prediction of household type with children minus prediction of household type without children.

TABLE A11 Differences in mode-choice between households with children and households without children, by household type and gender

Household type # Gender	Model 1	Model 2
MaleBreadwinner # Man	0.21***	0.21***
	(0.04)	(0.04)
MaleBreadwinner # Woman	0.19***	0.20***
	(0.06)	(0.06)
FemaleBreadwinner # Man	0.17*	0.16*
	(0.10)	(0.10)
FemaleBreadwinner # Woman	0.10***	0.10***
	(0.04)	(0.04)
DualEarner # Man	0.18***	0.18***
	(0.03)	(0.03)
DualEarner # Woman	0.10***	0.10***
	(0.03)	(0.03)
NoneEmployed # Man	-0.03	-0.04
	(0.13)	(0.13)
NoneEmployed # Woman	0.06	0.06
	(0.09)	(0.09)

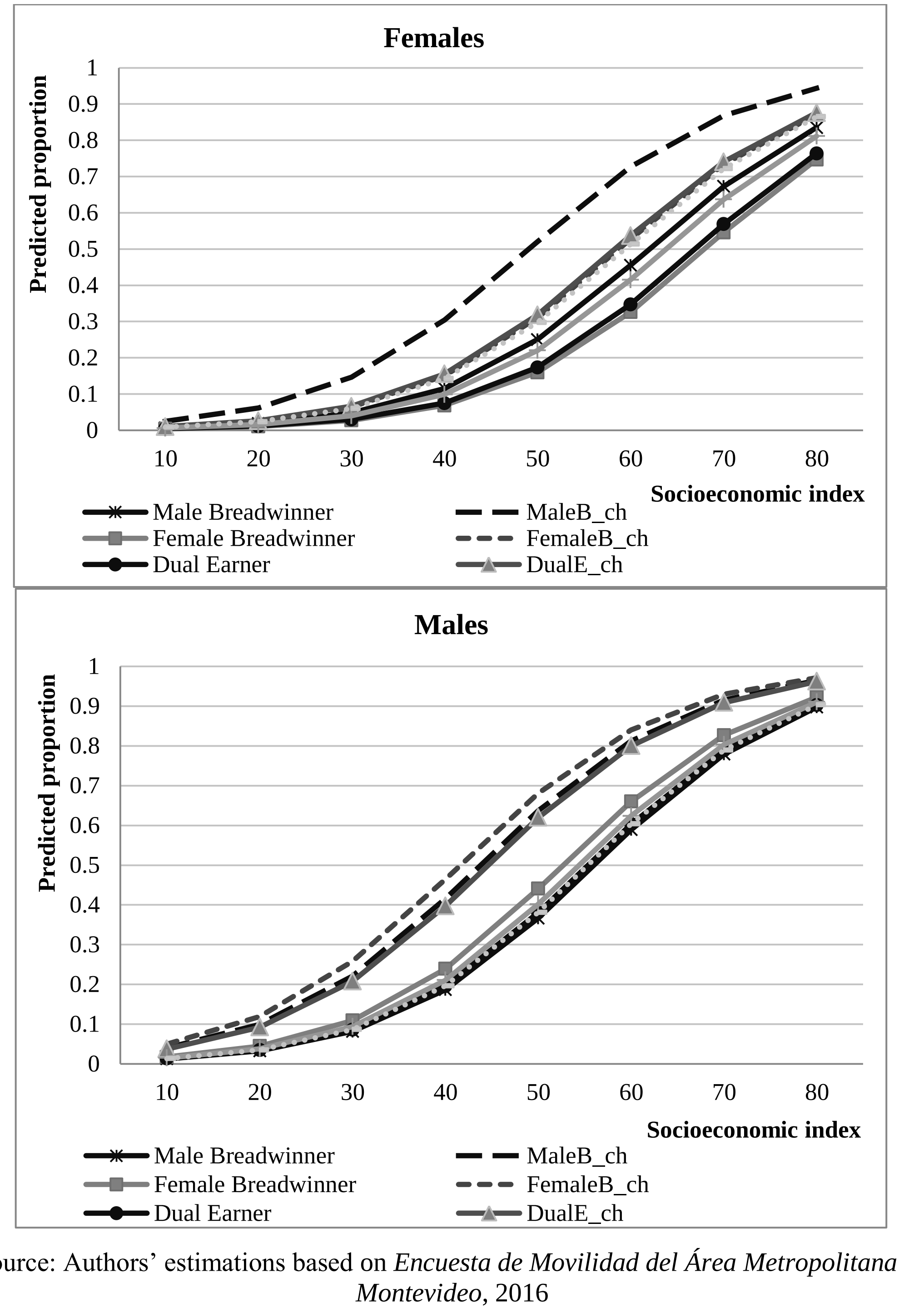
Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: *** p<0.01, ** p<0.05, * p<0.1, Standard errors in brackets, Contrast of predictive margins: prediction of household type with children minus prediction of household type without children.

TABLE A12 Gender differences in mode-choice
(prediction of Female – prediction of Male), over household types

Household type	Model 1	Model 2
MaleBreadwinner	-0.08	-0.08
	[-0.18 ; 0.02]	[-0.18 ; 0.02]
MaleB_children	-0.07	-0.07
	[-0.18 ; 0.03]	[-0.17 ; 0.03]
FemaleBreadwinner	-0.25***	-0.24***
	[-0.41 ; -0.09]	[-0.40 ; -0.08]
FemaleB_children	-0.22***	-0.21***
	[-0.36 ; -0.08]	[-0.35 ; -0.07]
DualEarner	-0.19***	-0.19***
	[-0.26 ; -0.12]	[-0.26 ; -0.12]
DualE_children	-0.22***	-0.21***
	[-0.28 ; -0.15]	[-0.28 ; -0.15]
NoneEmployed	-0.12***	-0.12***
	[-0.20 ; -0.04]	[-0.20 ; -0.04]
NoneE_children	-0.02	-0.01
	[-0.17 ; 0.13]	[-0.16 ; 0.14]

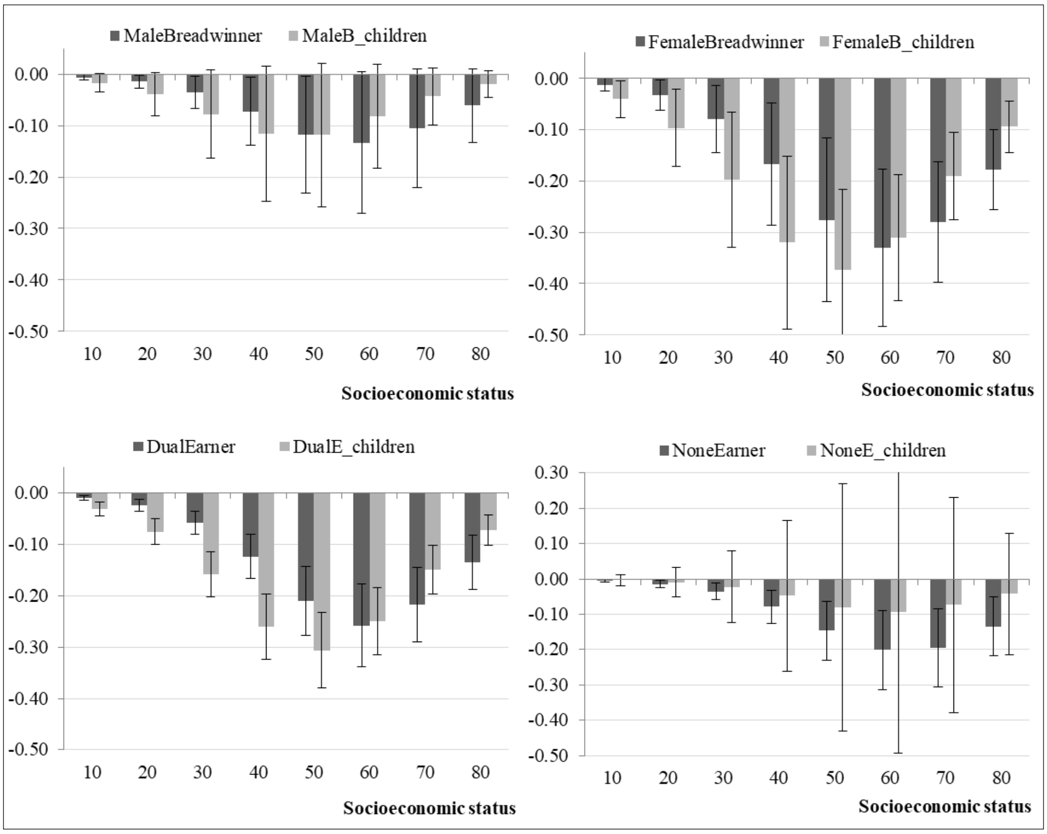
Source: Authors' estimations based on Encuesta de Movilidad del Área Metropolitana de Montevideo, 2016. Note: *** p<0.01, ** p<0.05, * p<0.1
Contrast of predictive margins, 95% confidence intervals in brackets

FIGURE A1 Predicted probabilities of choosing automobile, by household type and gender. Selected values of the income variable



Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016

FIGURE A2 Gender differences in mode-choice
(prediction of Female – prediction of Male)
for selected values of income variable, by household types



Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: Contrast of predictive margins, the straight line indicates the 90% confidence interval

Chapter 5

Conclusions and policy implications

This dissertation addresses the analysis of inequality in various aspects of the economy and aims to contribute to the evaluation of public policies, as well as to the identification of possible effects derived from alternative public interventions. In particular, the main goal of this research has been to better understand the economic impact of public policies (or of the absence of them) in terms of transport infrastructure and gender differences that stem from personal income taxation and urban mobility.

In Chapter 2, spatial econometric techniques have been used to analyze both, the absolute and conditional β-convergence-type processes. Furthermore, an analysis on whether transport investment has been guided by efficiency, redistribution and/or equity concerns was conducted to explain the role of transportation on such regional convergence. Withdrawing of data from 1980 to 2008, strong evidence of absolute convergence occurring across Spanish provinces has been found. This result also holds when considering conditional convergence, as well as the explicit role of transport infrastructure. However, only roads seem to have contributed to the process of regional convergence in Spain. In contrast, the other types of transport infrastructure have not played an important role in this process. It was also found that the main destination of investment has been to equalize the infrastructure endowment between the different Spanish regions. The reduction in inequality between regions, in terms of roads endowment, could explain its positive contribution to the regional convergence in Spain.

These findings may contribute to the debate on the distribution of public resources. In Spain, regional policies have been widely promoted by successive governments using investment to equalize the endowment of transport infrastructure. However, massive investment in transport infrastructure does not necessarily contribute to the reduction of regional disparities. For instance, the development of an extensive high-speed rail network and the high amount of resources devoted to ports and airports have not been effective in reducing economic inequalities between Spanish regions. Hence, these results suggest that efficiency and redistribution need to be taken into account in order to achieve the best possible allocation of public resources.

In Chapter 3, zero-one inflated beta models have been applied to analyze the gendered effects of the Personal Income Tax (PIT) in Uruguay, using microdata provided by the 2013 Household Survey. The analysis of the legislation has indicated no explicit gender differences in the PIT code, which indicates women and men are treated on an equal basis regarding rates, credits and deductions: a flat tax rate for capital income and two different progressive schedules for pensions and labor income. Despite that, a joint filing system is allowed for couple's incomes. On the base of tax records, an estimate of only 5.4% of couples (with at least one of them being an income earner) have used the joint filing option in 2013. The cause cannot be assessed, but a possible explanation may be the lack of information. However, there are probably other explanations that could be the scope of future research.

It has also been found in the study that when assessing household per capita income, households supported by a working man who lives with a dependent housewife face the highest tax burden, followed by the dual-earner type. When evaluating different potential explanatory factors, a gap remained. These findings indicate that there has been an incentive towards equal gender time allocation within the family, which is consistent with gender equity. On the one hand, PIT has not been discouraging labor market participation of a second earner due to the fact that it is not taxed at higher rates. On the other hand, given that male breadwinner households may have been reaching higher levels of welfare from non-taxed home production, the result is potentially consistent with neutrality in terms of allocation between household and market time.

As well, single mothers' households bear a lower burden than dual earner households when considering both, raw data and income-controlled gaps. Once again, this pattern is consistent with gender equity. However, this pattern is partly explained by non-desirable aspects: higher levels of informality and participation in non-taxable sources of income among single female households than in dual earner households. The analysis also provides a comparison between male and female breadwinner households, and single female and male households. In both comparisons it has been found that the male types bear a higher PIT burden than the female types, which is partly explained by the higher share of non-taxable income among female types. Finally, no differences were found between female and male categories of three typical types of non-employed households.

These empirical findings may promote a debate for future reforms of the PIT. In fact, there is an increasing social pressure to reduce taxes to alleviate the burden on families. The question is if a new design could worsen horizontal equality from a gender perspective. For example, it is not advisable to allow exemptions to dependent spouses/partners but it would be helpful to take into account people unable to support themselves. Also, eliminating the option of joint filing would improve equality. On the other hand, changes in the schedule rate of the actual joint filing should be carefully assessed.

Finally, in Chapter 4, a multilevel econometric approach has been applied to examine the determinants of commuting patterns in the Metropolitan Area of Montevideo (MAM), addressing the household responsibility hypothesis. The data was stratified in two levels: individual and zone of residence (census tract). It has been found that all dimensions of travel behavior (trip time, trip distance, trip count and transportation mode choice) are influenced by both, individual and contextual characteristics. With concerns to the personal attributes, results suggest the existence of differences in commuting patterns between male and female residents in the MAM. On average, women travel smaller distances with a lower frequency of trips. Travel time does not differ significantly, but it is based in the use of slower means of transport, shown by the smaller use of cars. In relation to the zone of residence, residing in the most densely populated zones, with greater public transport accessibility and land-use diversity is associated with traveling lower distances and less time. It is also associated with a greater frequency of trips, though the impact is very small. In contrast, individual’s mode choice is less influenced by the attributes of the zone of residence and more associated to socioeconomic level.

The analysis also provides evidence of the importance of family structure to explain the gender differences in commuting patterns. In particular, the interaction between the presence of children and the presence of spouse/partner in the household appeared to be key factors to explain those differences, proving the household responsibility hypothesis. Women in all types of households with children tend to have smaller commute time than their counterpart in households without children. In the case of women in female breadwinner households, the shorter commute is measured both in terms of time and distance. Also, the presence of children increases the frequency of trips for women belonging to all household categories. The probability of travelling by car increases with the presence of children in all households and genders. Meanwhile, men exhibit higher travel distance in male breadwinner households with children and higher frequency of trips in the dual earner with children type.

These findings indicate that in couples' households, the presence of children mostly affects women's mobility. In particular, women decrease their travel time by incorporating faster means of transport. Furthermore, they increase the number of trips by assuming a greater number of tasks associated with childcare. In the end, they maintain the original travel distance. This latter result may be due to the net effect of a decrease in distance associated with a relocation of the workplace, compensated by an increase in the distance, due to assumed domestic chores and care.

In contrast, in couples' households where only men are in the labor market, men exhibit an increase in travel distance in the presence of children. The increase in distance is not accompanied by an increase in the time or the frequency of travel. This suggests that men in this type of households, not only do not appear to bear part of the responsibilities associated with childcare, but also extend the day away from home. In the case of men belonging to dual earner households, the significant increase in the frequency of trips, together with the greater probability of travelling by car, may indicate some support of the childcare responsibilities. In households where there is a lower presence of couples and women have a paid job (female breadwinner type), the relocation strategy of daily activities is relevant so that there is a decrease in distance and total travel time. This occurs despite the use of faster means of transport and an increase in the travel frequency.

Regarding the expected gender difference inside each type of household, the results reinforced the findings described above and are according to previous studies: women exhibit a lower mobility than men, particularly in couples' households with children. As well, it is important to highlight that the probability of travelling by car is significantly lower for females (in dual earner and female breadwinner types). There appeared to be broader cultural and environmental factors that exceed the purpose of this work which may help in explaining this pattern.

The geographical location of urban spaces requires individuals to travel to participate in social and economic activities. Understanding the interaction between individuals and transport systems is essential to design and implement policies that aim at improving mobility in a city. It is known that public transport plays an important role in urban mobility, since it represents the most equitable system, while being efficient and sustainable. The evidence presented in this chapter suggests that women make more intensive use of public transport. Thus, in residential areas with less access to public transport (the less centrally-located areas), women would be particularly vulnerable and affected in their mobility. In this regard, in terms of public policy, the promotion of public transport in less central areas may lead to a reduction of negative consequences of gender inequality. Furthermore, the mobility patterns described in this article demonstrate the presence of multiple gender differences (conditioned by the type of family organization) that should be addressed simultaneously with different policies.

References

Agrawal A, Galasso, A, Oettl A (2017) Roads and innovation. *The Review of Economics and Statistics* 99: 417-434.

Albalate D, Bel G, Fageda X (2015) When supply travels far beyond demand: Institutional and regulatory causes of oversupply in Spain's transport infrastructure. *Transport Policy* 41: 80-89.

Albalate D, Bel G, Fageda X (2012) Beyond the efficiency-equity dilemma: Centralization as a determinant of government investment in infrastructure. *Papers in Regional Science* 91(3): 599-615.

Alesina A., Ichino A., Karabarbounis L. (2011) Gender-based taxation and the division of family chores, *American Economic Journal: Economic Policy*, 3(2):1-40.

Álvarez A, Arias C, Orea L (2006) Econometric testing of spatial productivity spillovers from public capital. *Hacienda Pública Española/Revista de Economía Pública 178*(3): 9-21.

Amarante V., Espino A. (2004) La segregación ocupacional de género y las diferencias en las remuneraciones de los asalariados privados. Uruguay, 1990-2000, *Desarrollo Económico*, 44(173): 109-129.

Amarante V, Bucheli M, Olivieri C, Perazzo I (2012) Distributive impacts of alternative tax structures: the case of Uruguay. In: Urzúa, C.M. (ed.) Microsimulation Models for Latin America, pp. 139–158. ITESM, Ciudad de México.

Andrienko Y., Apps P., Rees R. (2014) Gender Bias in Tax Systems Based on Household Income, *Annals of Economics and Statistics*, 117-118:141-155.

Anselin L (1988) Lagrange multiplier test diagnostics for spatial dependence and spatial heterogeneity. *Geographical analysis 20*(1): 1-17.

Anselin L (2001) Spatial econometrics. In: Baltagi B (ed) *A companion to theoretical econometrics*. Blackwell, Oxford.

Antipova A., Wang F., Wilmot C. (2011). Urban land uses, socio-demographic attributes and commuting: A multilevel modeling approach. *Applied Geography*, 31(3), 1010-1018.

Apps P., Rees R. (2009) Public economics and the household, Cambridge University Press.

Apps P., Rees R. (2010) Family labor supply, taxation and saving in an imperfect capital market, *Review of Economics of the Household*, 8(3):297-323.

Arbués P, Baños J, Mayor M (2015) The spatial productivity of transportation infrastructure. *Transportation Research Part A: Policy and Practice 75:* 166-177.

Arellano M, Bond S (1991) Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies* 58: 277–97.

Arellano M, Bover O (1995) Another look at the instrumental variables estimation of error components models. *Journal of Econometric*, 68: 29–51.

Aschauer D (1989) Is public expenditure productive? *Journal of Monetary Economics* 23(2): 177–200.

Atkinson AB (2009) Economics as a moral science. *Economica* 76: 791-804.

Atkinson AB (2016) Inequality What Can Be Done? Cambridge, MA: Harvard University Press.

Avellaneda García, P. (2007). *Movilidad, pobreza y exclusión social un estudio de caso en la ciudad de Lima.* Universitat Autònoma de Barcelona.

Bach S., Haan P., Ochmann R. (2013) Taxation of married couples in Germany and the UK: One-earner couples make the difference, *International Journal of Microsimulation*, 6(3):3-24.

Badland H., Schofield G., Witten K., Schluter P., Mavoa S., Kearns R., Ergler C. (2009). Understanding the Relationship between Activity and Neighbourhoods (URBAN) Study: research design and methodology. *BMC Public Health*, 9(1), 224.

Baños J, González P, Mayor M (2013) Productivity and accessibility of road transport infrastructure in Spain. A spatial econometric approach.

Working paper, University of Oviedo.

Barreix A., Roca J. (2007) Strengthening a fiscal pillar: the Uruguayan dual income tax, *CEPAL Review*, 92:121-140.

Barro R, Sala-i-Martin X (1992) Convergence. *Journal of Political Economy*, April.

Baumol W (1986) Productivity growth, convergence, and welfare: what the long-run data show. *The American Economic Review:* 76: 1072-1085.

Baum-Snow N (2007) Did Highways Cause Suburbanization? *Quarterly Journal of Economics* 122: 775–805.

Baum-Snow N, Brandt L, Henderson J, Turner M, Zhang Q (2017) Roads, railroads, and decentralization of Chinese cities. *The Review of Economics and Statistics* 99: 435–448

Baum-Snow N, Henderson J, Turner M, Zhang Q, Brandt L (forthcoming). Does investment in national highways help or hurt hinterland city growth? *Journal of Urban Economics*, forthcoming.

Beckmann, K.J., Chlond, B., Kuhnimhof, T., von der Ruhren, S., Zumkeller, D. (2006). Multimodale Verkehrsmittelnutzer im Alltagsverkehr. *Internationales Verkehrswesen* , 58 (4), 138–145.

Bel G (2011) Infrastructure and nation building: The regulation and financing of network transportation infrastructures in Spain (1720-2010). *Business History* 53(5): 688-705.

Bel G, Fageda X (2009) Preventing competition because of “solidarity”: Rhetoric and reality of airport investments in Spain. *Applied Economics* 41(22): 2853-2865.

Best H., Lanzendorf M. (2005). Division of labour and gender differences in metropolitan car use: an empirical study in Cologne, Germany. *Journal of Transport Geography*, 13(2), 109-121.

Blonigen B, Cristea A (2015) Airports and urban growth, Evidence from a quasi-natural policy experiment. *Journal of Urban Economics* 86: 128–146.

Blundell R, Bond S (1998) Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics* 87: 11–143.

Bond S, Hoeffler A, Temple J (2001) GMM Estimation of Empirical

Growth Models. CEPR, Discussion Papers No. 3048.

Bottai M., Salvati N., Orsini N. (2006). Multilevel models for analyzing people's daily movement behavior. *Journal of Geographical Systems*, 8(1), 97-108.

Bottasso A, Conti M, Ferrari C, Merk O, Tei A (2013) The impact of port throughput on local employment: Evidence from a panel of European regions. *Transport Policy* 27: 32–38.

Brownstone D., Golob T. (2009). The impact of residential density on vehicle usage and energy consumption. *Journal of urban Economics*, 65(1), 91-98.

Bucheli M., Sanromán G. (2005) Salarios femeninos en Uruguay: ¿existe un techo de cristal?, *Revista de Economía*, 12(2): 63-88.

Bucheli M, Lara C. (2018). Revealing Gender Gap Changes in Home Production and Labor Income in Uruguay WP 5/18, Departamento de Economía, Facultad de Ciencias Sociales, UDELAR.

Buis, M. (2012) ZOIB: Stata module to fit a zero-one inflated beta distribution by maximum likelihood, Statistical Software Components.

Burdín G., De Rosa M., Vigorito A. (2015) Sectores de altos ingresos en Uruguay: participación relativa y patrones de movilidad en el período 2009-2012, Serie Documentos de Trabajo, DT 03/2015, Instituto de Economía, Facultad de Ciencias Económicas y Administración, Universidad de la República, Uruguay.

Cadot O, Röller L, Stephan A (2006) Contribution to productivity or pork-barrel? The two faces of infrastructure investment. *Journal of Public Economics* 90: 1133-1153.

Calderón C, Chong A (2004) Volume and Quality of Infrastructure and the Distribution of Income: An Empirical Investigation. *The Review of Income and Wealth* 50 (1): 87-106.

Canaleta C, Arzoz P, Garate M (2004) Regional economic disparities and decentralisation. *Urban Studies* 41: 71-94.

Caselli F, Esquivel G, Lefort F (1996) Reopening the Convergence Debate: A New Look at Cross-Country Growth Empirics. *Journal of Economic Growth* 1(3): 363-389.

Castells A, Solé-Ollé A (2005) The regional allocation of infrastructure investment: The role of equity, efficiency and political factors. *European Economic Review* 49: 1165 – 1205.

Cervero, R. (1996). Jobs-housing balancing revisited. *Journal of the American Planning Association*, 62(4), 492-511.

Cervero R., Wu K (1997). Polycentrism, commuting, and residential location in the San Francisco Bay area. *Environment and Planning A*, 29(5), 865-886.

Cervero R., Kockelman K. (1997). Travel demand and the 3Ds: Density, diversity, and design. *Transportation Research Part D: Transport and Environment*, 2(3), 199-219.

Cervero R. (2002). Built environments and mode choice: toward a normative framework . *Transportation Research Part D: Transport and Environment*, 7(4), 265-284.

Cervero R., Sarmiento O., Jacoby E., Gomez L., Neiman A. (2009). Influences of built environments on walking and cycling: Lessons from Bogota. *International Journal of Sustainable Transportation*, 3(4):203–226.

Cervero, R. (2013). Linking urban transport and land use in developing countries . *Journal of Transport and Land Use*, 6(1), 7-24.

Chauvet P., Albertone B. . (2018). Road transport in Latin America: evolution of its infrastructure and impact between 2007 and 2015. *FAL Bulletin - ECLAC*, Issue No. 367 – Number 7/2018 .

Checherita C (2009) Variations on economic convergence: The case of the United States. *Papers in Regional Science* 88(2): 259-279.

Chen Z, Haynes K (2015) Regional impact of public transportation infrastructure: A spatial panel assessment of the US Northeast megaregion. *Economic Development Quarterly 29*(3): 275–291.

Cohen J (2010) The broader effects of transportation infrastructure: Spatial econometrics and productivity approaches. *Transportation Research Part E: Logistics and Transportation Review* 46(3): 317-326.

Cook D., Kieschnick R., McCullough B. (2008) Regression analysis of proportions in finance with self-selection, *Journal of Empirical Finance*, 15.5: 860-867.

Cosci S, Mirra L (2018) A spatial analysis of growth and convergence in Italian provinces: The role of highways. *Regional Studies 52*(4): 516–527.

Costa-Font J, Rodríguez-Oreggia E (2005) Is the Impact of Public Investment Neutral Across the Regional Income Distribution? Evidence from Mexico. *Economic Geography* 81 (5): 305-322.

Craig C., Brownson R., Cragg S., Dunn A. (2002). Exploring the effect of the environment on physical activity: a study examining walking to work. *American journal of preventive medicine*, 23(2), 36-43.

Crane, R. (2007). Is there a quiet revolution in women's travel? Revisiting the gender gap in commuting. *Journal of the American Planning Association*, 73: 298–316.

Crescenzi R, Rodríguez-Pose A (2012) Infrastructure and regional growth in the European Union. *Papers in Regional Science* 91: 487–513.

Dargay J., Hanly M. (2007). Volatility of car ownership, commuting mode and time in the UK. *Transportation Research Part A: Policy and Practice,* 41(10), 934-948.

Dávila, J. (2013). *Urban mobility and poverty: Lessons from Medellín and Soacha.* Columbia, Development Planning Unit, UCL & Faculty of Architecture, Universidad Nacional de Colombia, Medellín campus.

De la Fuente A (2004) Second-best redistribution through public investment: a characterization, an empirical test and an application to the case of Spain. *Regional Science and Urban Economics* 34: 489– 503.

Del Bo C, Florio M, Manzi G (2010) Regional infrastructure and convergence: growth implications in a spatial framework. *Transition Studies Review* 17(3): 475-493.

Del Bo C, Florio M (2012) Infrastructure and growth in a spatial framework: evidence from the EU regions. *European Planning Studies* 20 (8): 1393–1414.

Delgado M, Álvarez I (2007) Network infrastructure spillover in private productive sectors: evidence from Spanish high capacity roads. *Applied Economics 39*(12): 1583-1597.

Di Giacinto V, Esposito L (2012) Convergence of financial structures in Europe: an application of factorial matrices analysis. In: *The Financial Systems of Industrial Countries*. Springer, Berlin, Heidelberg.

Ding C., Lin Y., Liu C. (2014). Exploring the influence of built environment on tour-based commuter mode choice: A cross-classified multilevel modeling approach. *Transportation Research Part D: Transport and Environment*, 32, 230-238.

Ding C., Mishra S., Lu G., Yang J., Liu C. (2017). Influences of built environment characteristics and individual factors on commuting distance: a multilevel mixture hazard modeling approach. *Transportation Research Part D: Transport and Environment*, 51, 314-325.

Donaldson D (2018) Railroads of the Raj: Estimating the impact of transportation infrastructure. *American Economic Review* 108: 899–934

Duncan C., Jones K. (2000). Using Multilevel Models to Model Heterogeneity: Potential and Pitfalls. *Geographical Analysis*, Vol. 32, No. 4.

Duranton G (2016) Determinants of city growth in Colombia. *Papers in Regional Science* 95: 101-132.

Duranton G, Turner M (2012) Urban growth and transportation. *Review of Economic Studies* 79: 1407–1440.

ECLAC. (2016). CEPALSTAT Databases. Accessed April,2019.

ECLAC. (2018). CEPALSTAT Databases. Accessed April, 2019.

Elhorst JP (2010) Applied Spatial Econometrics: Raising the Bar. *Spatial Economic Analysis* 5 (1): 9-28.

Elhorst JP (2014) Spatial panel data models. In: *Spatial Econometrics*. Springer Berlin Heidelberg.

Elson, D. (2006) Budgeting for women´s rights: monitoring government budgets for compliance with CEDAW. New York: UNIFEM

Ericksen, J. (1977). An analysis of journey to work for woman. *Social Problems* , 24(4): 428–435.

Espino, A. (2013) Brechas salariales en Uruguay: género, segregación y desajustes por calificación, *Revista Problemas del Desarrollo;* 174 (44): 89-117. DOI: 10.1016/S0301-7036(13)71889-3

Espino A, Salvador S, Azar P. (2014) Desigualdades persistentes: mercado de trabajo, calificación y género. El futuro en foco: Cuadernos sobre Desarrollo Humano. Montevideo: PNUD.

Ewing R., Cervero R. (2010). Travel and the built environment. *Journal of the American Planning Association*, 76(3), 265-294.

Falavigna C., Hernandez D. (2016). Assessing inequalities on public transport affordability in two latin American cities: Montevideo (Uruguay) and Córdoba (Argentina). *Transport Policy, 45*, 145-155.

Fan, Y. (2017). Household structure and gender differences in travel time: spouse/partner presence, parenthood, and breadwinner status. *Transportation*, 44(2), 271-291.

Ferrari S., Cribari-Neto F. (2004) Beta regression for modeling rates and Proportions, *Journal of Applied Statistics*, 31:799–815.

Forbes KJ (2000) A reassessment of the relationship between inequality and growth. *American Economic Review*, 90(4): 869–87.

Frändberg, L., Vilhelmson, B. (2011). More or less travel: personal mobility trends in the Swedish population focusing gender and cohort. *Journal of Transport Geography* , 19 (6), 1235–1244.

Frank L. D., Stone Jr B., Bachman W. (2000). Linking land use with household vehicle emissions in the central Puget Sound: methodological framework and findings. *Transportation Research Part D: Transport and Environment*, 5(3), 173-196.

Frank L., Sallis J., Saelens B., Leary L., Cain K., Conway T., Hess, P. (2010). The development of a walkability index: application to the Neighborhood Quality of Life Study. *British journal of sports medicine*, 44(13), 924-933.

García-López MA, Holl A, Viladecans-Marsal E (2015) Suburbanization and highways in Spain when the romans and the bourbons still shape its cities. *Journal of Urban Economics* 85: 52–67

García-Milà T, McGuire T (1992) The contribution of publicly provided inputs to states' economies. *Regional Science and Urban Economics* 22: 229-241.

Genser B., Reutter A. (2007) Moving towards dual income taxation in Europe, FinanzArchiv: *Public Finance Analysis*, 63(3):436-456.

Geurs K. T., Van Wee B. (2004). Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport geography*, 12(2), 127-140.

Giuliano, G. (1979). Public transportation and the travel needs of women. *Traffic Quarterly*, 33(4), 607-616.

Golden MA, Picci L (2008) Pork-barrel politics in postwar Italy, 1953–94. *American Journal of Political Science* 52(2): 268-289

Gómez-Antonio M, Garijo A (2012) Evaluating the Effect of Public investment on Productivity Growth Using an Urban Economics Approach for the Spanish Provinces. *International Regional Science Review 35*(4): 389-423.

Gómez-Antonio M, Fingleton B (2012) Analyzing the impact of public capital stock using the NEG wage equation: A spatial panel data approach. *Journal of Regional Science 52*(3): 486-502.

Goñi E, López H, Servén L (2008) Fiscal redistribution and income inequality in Latin America. *Policy Research Working Paper Series* 4487. World Bank.

Gordon P., Kumar A., Richardson H. (1989). Gender differences in metropolitan travel behaviour. *Regional Studies*, 23(6), 499-510.

Grown C., Valodia I. (Eds.). (2010). *Taxation and Gender Equity: A comparative analysis of direct and indirect taxes in developing and developed countries* (Vol. 58). IDRC.

Grown, C. (2010). Taxation and gender equality: A conceptual framework. In *Taxation and Gender Equity* (pp. 29-50). Routledge.

Grown C., Komatsu H. (2015) Gender Equity and Taxation in Latin America and the Caribbean. Comparative Chapter. Non-published.

Guner N., Kaygusuz R., Ventura G. (2011) Taxation and household labor supply, *The Review of Economic Studies*, 79(3):1113-1149.

Gutiérrez, A. (2010). Movilidad, transporte y acceso: una renovación aplicada al ordenamiento territorial. *Scripta Nova* , 14(331), 86.

Hanson, S. (1982). The determinants of daily travel-activity patterns: relative location and sociodemographic factors. *Urban Geography, 3*, 179 - 202.

Hanson S., Johnston I. (1985). Gender differences in work-trip lengths: Explanations and implications. *Urban Geography*, 6(3), 193-219.

Hernández, D. (2018). Uneven mobilities, uneven opportunities: Social distribution of public transport accessibility to jobs and education in Montevideo. *Journal of Transport Geography, 67*, 119-125.

Hernández D., Titheridge H. (2016). Mobilities of the periphery: Informality, access and social exclusion in the urban fringe in Colombia. *Journal of transport geography, 55*, 152-164.

Hjorthol, R. (2008). Daily mobility of men and women – a barometer of gender equality. In Uteng, T.P., Cresswell, T. (Eds.), *Gendered Mobilities* (pp. 193–210). Ashgate, Aldershot.

Holtz-Eakin D, Newey W, Rosen H (1988) Estimating vector autoregressions with panel data. *Econometrica* 56: 1371-1395.

Holtz-Eakin D, Schwartz A (1995) Infrastructure in a structural model of economic growth. *Regional Science and Urban Economics* 25(2): 131-151.

Jirón P., Mansilla P. (2013). Atravesando la espesura de la ciudad: vida cotidiana y barreras de accesibilidad de los habitantes de la periferia urbana de Santiago de Chile. *Revista de Geografía Norte Grande, (56),* 53-74.

Johnston-Anumonwo, I. (1992). The influence of household type on gender differences in work. *The Professional Geographer*, 44(2), 161-169.

Jones, K. (1991). Specifying and estimating multi-level models for geographical research. *Transactions of the institute of British geographers*, 148-159.

Kemmerling A, Stephan A (2002) The contribution of local public infrastructure to private productivity and its political economy: Evidence from a panel of large German cities. *Public Choice* 113(3-4): 403-424.

Kemmerling A, Stephan A (2008) The politico-economic determinants and productivity effects of regional transport investment in Europe. EIB papers *13*(2): 36-60.

Kieschnick R., McCullough B. (2003) Regression analysis of variates observed on (0, 1): percentages, proportions and fractions, *Statistical*

Modelling, 3(3):193-213.

Kim C., Wang S. (2015). Empirical examination of neighborhood context of individual travel behaviors. *Applied Geography*, 60, 230-239.

Kitamura R., Mokhtarian P., Laidet L. (1997). A micro-analysis of land use and travel in five neighborhoods in the San Francisco Bay Area. *Transportation*, 24(2), 125-158.

Kockelman, K. (1997). Travel behavior as function of accessibility, land use mixing, and land use balance: evidence from San Francisco Bay Area. *Transportation research record*, 1607(1), 116-125.

LeSage J, Pace RK (2009) *Introduction to Spatial Econometrics*. Ney York: Chapman and Hall/CRC, Taylor and Francis Group.

LeSage J, Fischer M (2008) Spatial Growth Regressions: Model Specification, Estimation and Interpretation. *Spatial Economic Analysis* 3(3): 275-304.

Lee B., McDonald J. (2003). Determinants of commuting time and distance for Seoul residents: The impact of family status on the commuting of women. *Urban Studies*, 40(7), 1283-1302.

Lee B., Gordon P., Richardson H., Moore J. (2009). Commuting trends in US cities in the 1990s. *Journal of Planning Education and Research*, 29 (1), 78–89.

Lessmann C, Seidel A (2017) Regional inequality, convergence, and its determinants – A view from outer space. *European Economic Review* 92: 110-132.

Levine R, Loayza N, Beck T (2000) Financial intermediation and growth: Causality and causes. *Journal of Monetary Economics* 46: 31–77.

Lo Cascio I, Mazzola F, Epifanio R (forthcoming). Territorial determinants and NUTS 3 regional performance: A spatial analysis for Italy across the crisis. *Papers in Regional Science*, forthcoming.

MacDonald, H. (1999). Women's employment and commuting: Explaining the links. *Journal of Planning Literature*, 13(3), 267-283.

Madden, J. (1981). Why women work closer to home. *Urban Studies*, 18(2), 181-194.

Manaugh K., Badami M., El-Geneidy A. (2015). Integrating social equity into urban transportation planning: A critical evaluation of equity objectives and measures in transportation plans in North America. *Transport policy*, *37*, 167-176.

Massobrio, R. (2018). Urban mobility data analysis in Montevideo, Uruguay. Masters dissertations, Faculty of Engineering, Universidad de la República.

Mercado R., Páez A. (2009). Determinants of distance traveled with a focus on the elderly: a multilevel analysis in the Hamilton CMA, Canada . *Journal of Transport Geography*, 17, 65–76.

Moilanen, M. (2010). Matching and settlement patterns: the case of Norway. *Papers in Regional Science*, 89 (3), 607–623.

Möller J, Zierer M (2018) Autobahns and jobs: A regional study using historical instrumental variables. *Journal of Urban Economics* 103: 18–33.

Monastiriotis V, Psycharis Y (2014) Between equity, efficiency and redistribution: An analysis of revealed allocation criteria of regional public investment in Greece. *European Urban and Regional Studies* 21(4): 445-462.

Moreno R, López-Bazo E (2007) Returns to local and transport infrastructure under regional spillovers. *International Regional Science Review 30*(1): 47-71.

Morrison CJ, Schwartz AE (1996) Public infrastructure, private input demand, and economic performance in New England manufacturing. *Journal of Business & Economic Statistics* 14(1): 91-101.

Munnell A, with the assistance of Cook L (1990) How Does Public Infrastructure Affect Regional Economic Performance? *New England Economic Review*, Federal Reserve Bank of Boston, September/October: 11-32.

Nadiri MI, Mamuneas TP (1994) Infrastructure and public R&D investments, and the growth of factor productivity in US manufacturing industries. *National Bureau of Economic Research,* No. w4845.

Nelson, J. A. (1991). Tax reform and feminist theory in the United States: Incorporating human connection. *Journal of Economic Studies, 18*(5/6).

Newman P., Kenworthy J. (1989). Gasoline consumption and cities: a comparison of US cities with a global survey. *Journal of the American planning association*, 55(1), 24-37.

Noble, B. (2005). Women's travel: can the circle be squared? In Transportation Research Board (Ed), *Research on Women's Issues in Transportation Vol. 2: Technical Papers. Transportation Research Board Conference Proceedings 35* (pp. 196–209). Washington, D.C.: National Research Council.

OECD. (2016). *Development Pathways Multi-dimensional Review of Uruguay Volume 2. In-depth Analysis and Recommendations.* OECD Publishing: ISBN 9264251669, 9789264251663.

Ospina R., Ferrari S. (2010) Inflated beta distributions, *Statistical Papers*, 51(1):111-126.

Ospina R., Ferrari S. (2012) A general class of zero-or-one inflated beta regression models, *Computational Statistics & Data Analysis*, 56(6):1609-1623.

Páez A., Scott D.M. (2004). Spatial statistics for urban analysis: A review of techniques with examples. *GeoJournal*, 53–67.

Paolino, P. (2001) Maximum likelihood estimation of models with beta-distributed dependent variables, *Political Analysis*, 9(4):325-346.

Percoco M (2016) Highways, local economic structure and urban development. *Journal of Economic Geography* 16: 1035-1054.

Pereira A, Andraz J (2006) Public investment in transportation infrastructures and regional asymmetries in Portugal. *Annals of Regional Science* 40: 803–817.

Pickup, L. (1984). Women's gender-role and its influence on travel behavior. *Built environment,* 10 (1), 61–68.

Prevedouros P., Schofer J. (1991). Trip characteristics and travel patterns of suburban residents. *Transportation Research Record*, (1328).

Rabe-Hesketh S., Skrondal A. (2012). *Multilevel and Longitudinal Modeling Using Stata.* (3rd Edition) College Station TX: Stata Press.

Ramalho E., Ramalho J., Murteira J. (2011) Alternative estimating and testing empirical strategies for fractional regression models, *Journal of Economic Surveys*, 25:19–68.

Raudenbush S., Bryk A. (2002). *Hierarchical linear models: Applications and data analysis methods.* (Vol. 1): Sage.

Robbins, L. (1932). The nature and significance of economic science. *The philosophy of economics: An anthology* 1: 73-99.

Rodríguez Enriquez C., Gherardi N., Rossignolo, D (2010) Gender equality and taxation in Argentina. In Grown and Valodia (eds) Taxation and Gender Equity: A comparative analysis of direct and indirect taxes in developing and developed countries, London: Routledge, Chapter 3.

Rodríguez-Pose A, Psycharis Y, Tselios V (2012) Public investment and regional growth and convergence: Evidence from Greece. *Papers in Regional Science* 91: 543–568.

Rosenbloom, S. (1978). Editorial: The need for study of women's travel issues. *Transportation*, 7, 347–350.

Sala-i-Martin, X. (1996) Regional cohesion: Evidence and theories of regional growth and convergence, *European Economic Review* 40: 1325-1352.

Sandow, E. (2008). Commuting behaviour in sparsely populated areas: evidence from northern Sweden . *Journal of Transport Geography*, 16 (1), 14–27.

Scheiner J., Holz-Rau C. (2012). Gendered travel mode choice: a focus on car deficient households. *Journal of Transport Geography*, 24, 250-261.

Schelotto, S. (2008). La ciudad de Montevideo: ¿una metrópoli policéntrica? *Centro-h, [online]*, (2), 37-46. Available in: https://www.redalyc.org/articulo.oa?id=115112535004.

Schwanen T., Mokhtarian P. (2005). What affects commute mode choice: neighborhood physical structure or preferences toward neighborhoods? *Journal of Transport Geography*, 13(1), 83-99.

Schwanen T., Dieleman F. M., Dijst M. (2004). The impact of metropolitan structure on commute behavior in the Netherlands: a multilevel approach. *Growth and Change*, 35(3), 304-333.

Silveira Neto R., Duarte G., Páez A. (2015). Gender and commuting time in São Paulo metropolitan region. *Urban Studies, 52(2)*, 298-313.

Smithson M., Verkuilen J. (2006) A better lemon squeezer? Maximum-likelihood regression with beta-distributed dependent variables, *Psychological Methods*, 11(1):54.

Stotsky, J. (1996) Gender bias in tax systems, IMF Working Paper, No. 96/99.

Sun B., Ermagun A., Dan B. (2017). Built environmental impacts on commuting mode choice and distance: Evidence from Shangha. *Transportation research part D: transport and environment*, 52, 441-453.

Susilo Y., Maat K. (2007). The influence of built environment to the trends in commuting journeys in the Netherlands. *Transportation*, 34: 589.

Tracy A., Su P., Sadek A., Wang Q. (2011). Assessing the impact of the built environment on travel behavior: a case study of Buffalo, New York. *Transportation*, 38(4), 663-678.

Trannoy, A. (2011). Equity Dimensions of Transport Policy. In A. L. De Palma, *Handbook of Transport Economics* (pp. 624-649). Edward Elgar Publishing.

Turner J., Grieco M. (2000). Gender and time poverty: the neglected social policy implications of gendered time, transport and travel. *Time & Society*, 9(1), 129-136.

Turner T., Niemeier D. (1997). Travel to work and household responsibility: New evidence. *Transportation*, 24: 397–419.

Van Acker V., Witlox F. (2011). Commuting trips within tours: how is commuting related to land use? . *Transportation*, 38(3), 465-486.

Van Dyck D., Cardon G., Deforche B., Sallis J. F., Owen N., De Bourdeaudhuij I. (2010). Neighborhood SES and walkability are related to physical activity in Belgian adults. . *Preventive Medicine*, 50, S74-S79.

Vasconcellos, E. (2014). *Urban Transport Environment and Equity: The case for developing countries.* Routledge.

World Bank (2009) *Reshaping Economic Geography: World Development Report 2009.* Washington, DC: World Bank.

World Bank (2016). World Bank Open Data. "https://data.worldbank.org/" Accessed April, 209.

White, M. (1986). Sex differences in urban commuting patterns. *The American Economic Review*, 76(2), 368-372.

Xu H, Nakajima K (2017) Highways and industrial development in the peripheral regions of China. *Papers in Regional Science* 96: 325-356.

Yamano N, Ohkawara T (2000) The regional allocation of public investment: Efficiency or equity? *Journal of Regional Science* 40(2): 205-229.

Yang, J., Shen, Q., Shen, J., He, C. (2012). Transport impacts of clustered development in Beijing: compact development versus overconcentration. *Urban Studies*, 49 (6), 1315–1331.

Yu N, De Jong M, Storm S, Mi J (2013) Spatial spillovers effects of transport infrastructure: evidence from Chinese regions. *Journal of Transport Geography 28:* 56–66

Zahabi S., Miranda-Moreno L., Patterson Z., Barla P. (2012). Evaluating the effects of land use and strategies for parking and transit supply on mode choice of downtown commuters. *Journal of Transport and Land Use* , 5(2), 103–119.

Zahabi S., Miranda-Moreno L., Patterson Z., Barla P. (2015). Spatio-temporal analysis of car distance, greenhouse gases and the effect of built environment: A latent class regression analysis. *Transportation Research Part A: Policy and Practice*, 77, 1-13.

Zegras, C. (2004). Influence of land use on travel behavior. *Transportation Research Record: Journal of the Transportation Research Board*, 1898(1):175–182.

Zegras, C. (2010). The built environment and motorvehicle ownership and use: Evidence from Santiago de Chile. *Urban Studies*, 47(8):1793–1817.

Zegras, C. (2012). Dynamics of automobile ownership under rapid growth. *Transportation Research Record: Journal of the Transportation Research Board*, 2323(1):80–89.

Zhang, M. (2004). The role of land use in travel mode choice: Evidence from Boston and Hong Kong. *Journal of the American Planning Association*, 70(3):344–360.