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The Impact of Highway Tolls on Business Sector Performance - Evidence from a Natural Experiment

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Abstract

This paper analyzes the effect of a switch from free to charged highway provision on firm level outcomes for the period 2006-2016. To establish causality, this study relies on a natural experiment which resulted from Portuguese authorities being forced to introduce tolls on previously toll-free highways in the course of the sovereign debt crisis. A difference-in-difference and event study specifications were used to estimate this effect using firm-level data covering all business in the country. Estimations show that this policy resulted in a 7,6% decrease of firms' turnover. Furthermore, firms in the secondary sector and large firms seem to have been affected more than others. Both sales to the internal market and exports were significantly hit. Lastly, there was also a significantly negative impact on number of employees, average wage and labor productivity.

Keywords: SCUT, Natural experiment, Highway tolls, Difference-in-Difference

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1 Introduction

Transport infrastructure is key for economic development. Not only does it allow for circulation of people, it is a fundamental piece in the exchange of goods. At the same time transport infrastructure is rather expensive. Thus, it is essential to understand the relationship between transport infrastructure and economic outcomes in order to adequately design transport policy. Given the importance of this topic, studies on the effect of transport infrastructure on aggregate economic outcomes are quite abundant.[2] However, micro level studies on the effect of transport infrastructure on firms performance are rather limited. According to Holl (2016), the focus of researchers has traditionally been on macro-economic analyses and only recently has their focus started to shift to micro-level studies.[3] This paper contributes to this still growing literature by studying the impact of an exogenous increase in transport infrastructure on on a series of financial indicators of firm performance using micro-level data.

It is not straightforward to estimate the causal effect of transport infrastructure on economic outcomes as this kind of infrastructure is usually not assigned at random. This could lead to biased results as it would not be clear if firms outcomes are varying due to a change in this kind of infrastructure or other unobserved characteristics. A common solution in the literature for this endogeneity problem is to use an Instrumental Variable (IV): planned routes IV, historical routes IV or the inconsequential places approach (Redding and Turner, 2015). Although less common, some papers alternatively use a natural experiment.[4] This paper contributes to this growing literature by using a recent natural experiment that occurred in Portugal.

[2]In an extensive survey made by Redding and Turner (2015) most studies focus on studying the impact of transport infrastructure on: population growth (Baum-Snow (2007), Baum-Snow et al. (2017), Michaels, Rauch and Redding (2012), García López, Holl and Viladecans Marsal (2013)), aggregate trade (Duranton, Morrow and Turner (2014), Donaldson (2018)), GDP (Banerjee, Duflo and Qian (2012), Faber (2014)).

[3]Some studies that do explore the effect of transport infrastructure on micro-level outcomes, such as: firms' exports (Martincus, Carballo and Garcia (2012), Martincus and Blyde (2013), Martincus et al. (2014), Martincus, Carballo and Cusolito (2017*b*), Martincus, Carballo and Cusolito (2017*a*)) and inventories (Datta (2012),Li and Li (2013),Shirley and Winston (2004)), productivity (Lall, Shalizi and Deichmann (2004), Gibbons et al. (2016), Holl (2012), Holl (2016), Martin-Barroso, Núñez-Serrano and Velázquez (2015), Graham (2007*b*), Graham (2007*a*)).

[4]For some examples of papers which also use a natural experiment as source of exogenous variation in infrastructure see Martincus et al. (2014) and Martincus and Blyde (2013). Pereira, Pereira and Pereira dos Santos (2017) and Audretsch, Pereira dos Santos and Dohse (2018) study the same natural experiment used in this paper but they use municipal-level data.

The SCUT highway system started being built in 1990 and came into completion in 2008 in Portugal. Portuguese authorities made this network toll free for its users, hence the name SCUT ("**S**em **C**usto para o **Ut**ilizador" or "Without Cost for the User"). One of the main motivations behind its conception was to create an alternative network to the old and deteriorated roads. This new and more modern system sought to make traveling safer and lot faster. By the end of 2008, SCUTs accounted for almost 1000km which was nearly a third of the Portuguese highway grid at that time (Insituto Nacional de Estatística, INE).

However, following the Portuguese sovereign debt crisis in 2010, the Portuguese government was forced to consolidate its financial position, cutting public spending and increasing public revenues. Thus, it could no longer sustain the provision of a toll free network. The tolls were introduced in two waves, first by the end of 2010 and, then, by the end of 2011. According to the Financial Times, this led to angry protests, increases in business costs and confused tourists (Financial Times, 2013).

This event provides an unique setting for a natural experiment, which allows one to study the impact of an exogenous variation of transportation costs on firm related outcomes. This is only possible because tolls were introduced purely out of the necessity to regulate government budget. In other words, this decision was made without special consideration for the firms in those regions.[5]

Using a difference-in-difference and event study specification, this paper demonstrates that the introduction of tolls had a strong impact on firms' performance. This is evident in the results that show a substantial decrease in firms' turnover. Moreover, this analysis shows that large firms and firms in the secondary sector were struck the hardest by this shock. Furthermore, exports were significantly affected specially the ones to other EU countries. In addition, sales to to the internal market suffered with the increase in transportation costs. Lastly, other firm-level outcomes, such as, number of employees, average wage and labor productivity also experienced a significant

[5]Other studies use this natural experiment in their analyses to access the impact of this shock on other economic outcomes. Pereira, Pereira and Pereira dos Santos (2017) show that the introduction of tolls resulted in the increase of the number of accidents and road injuries. Moreover, another study by Audretsch, Pereira dos Santos and Dohse (2018) concludes that this shock had a significant negative impact on the number of firms and employment for the affected municipalities.

decrease.[6]

The rest of the paper is structured as follows. Section 2 presents a brief literature review pertaining to the topic at hand. Section 3 presents the data and methodology being used. Section 4 discusses the results and Section 5 summarizes and concludes.

2 Literature Review

The core problem of trying to estimate the causal effect of transportation infrastructure on economic outcomes is that transport infrastructure is not assigned at random. This creates an endogenity problem which impedes us from understanding whether variation in the outcome variables originates from the variation in transportation infrastructure or other non observable factors related to the location. The most recurrent strategy found in the literature to solve this problem is the use of an instrumental variable. According to Redding and Turner (2015) the use of instrumental variables in this literature can be categorized into three main strategies: planned route IV, historical route IV and the inconsequential place approach.[7]

The planned route IV strategy consists on using planning maps as source of quasi-random variation in observed infrastructure. In their study, Baum-Snow (2007) use the US 1947 interstate highway network plan to determine whether the construction of access highways can account for population decline in central cities. The validity of this approach relies on the the fact that the plan was created for military purposes. Hence, the authors argue that these purposes and post war commuters' needs are orthogonal to each other. They found that one new highway passing through central city results in population decreasing by 18%. The planned route IV approach has been employed in other studies using highway projects in locations, such as, the US (Michaels, 2008; Michaels, Rauch and Redding, 2012), 19^{th} century Prussia (Hornung, 2015), Africa (Jedwab and Moradi, 2016), Paris (Mayer and Trevien, 2017) and West Germany (Möller and Zierer, 2018).

[6] On a side note, it is worth mentioning that, in Portugal, the transportation of goods in mainly done through road transports. According to Insituto Nacional de Estatística (INE), in 2010, 76% of goods were delivered via road transportation.

[7] See Redding and Turner (2015) for a comprehensive survey on this literature

The historical route IV makes use of old transportation routes as a source of quasi-random variation in observed infrastructure. Duranton and Turner (2012) use maps of historical transportation networks, such as, the 1898 map of US railroads, as well as, maps of major explorations of the US for the period of 1535 to 1850 to estimate economic outcomes at the level of Metropolitan Statistical Area. They argue that through this, they acquire a source of quasi-random variation in the modern US interstate highway network. The validity of this strategy requires that the factors which determine the composition of the US historical routes do not affect economic outcomes of US cities between 1983 and 2003. In addition to this paper, Duranton and Turner wrote a series of papers using the historical route IV strategy to estimate kilometers traveled by cars, changes in metropolitan employment and trade flows between cities as function of the interstate highway grid (Duranton and Turner, 2011; Duranton, Morrow and Turner, 2014). There are several examples of studies where historical route IV is employed in other regions. Baum-Snow et al. (2017) resort to old Chinese roads and urban rail networks from 1962 to study urban form in Chinese cities. Another study by García López, Holl and Viladecans Marsal (2013) uses Spanish 18^{th} century postal routes and Roman roads to study the effect of highways on the sub-urbanization of Spanish cities.(Hsu and Zhang, 2014) rely on historical railroad networks in Japan to study the elasticity of traffic to road capacity. Finally, (Martincus, Carballo and Cusolito, 2017*b*) utilize the Inca roads from Peru to study the impact of road infrastructure on exports and employment.

The inconsequential units approach basis itself on the fact that infrastructure connecting big cities traverses economically small units, lying between them, only at random. Following this reasoning, the unobserved characteristics of units lying between large cities are inconsequential to the decision of the route (Redding and Turner, 2015, p.21). Chandra and Thompson were the pioneers of this strategy with their study on the effect of access to the US interstate highways system in rural counties (Chandra and Thompson, 2000). They deliberately chose rural counties with the intent of selecting regions which received interstate highways "accidentally". In other words, they have access to this network only because they are situated between large cities. Another example of this approach is the study by Banerjee, Duflo and Qian (2012) where an hypothetical transportation network is created linking historical treaty ports to large interior trading centers. Just like in the previous example, they argue that counties next to these predicted network are there “accidentally”. Other studies employing inconsequential units approach have been performed by Datta (2012), Faber (2014), Ghani, Goswami and Kerr (2016) and Fretz, Parchet and Robert-Nicoud (2017).

The strategies described above have become the standard approach in the recent literature. However, it’s important to note that these identification strategies have their own shortcomings. In fact, according to Redding and Turner (2015), their plausibility depends on the details of their implementation and is sometimes debatable. In the case of planned routes, one should be cautious when using them as sources of quasi-random variation in infrastructure. If a country’s strategy on infrastructure decision is consistent across time, then it is unreasonable to assume that choosing to implement only a part of the planned route and not the other is done at random(Audretsch, Pereira dos Santos and Dohse, 2018). Therefore, in some cases similar to this one, locations crossed by planned routes, which never came to completion, are an inappropriate comparison group for the ones where the infrastructure was actually constructed. Even though, the inconsequential units approach does not face this problem, its external validity is quite limited since it can only be applied to certain regions. In other words, since this approach only looks at economically small locations, one cannot use it to estimate the effect of infrastructure in economically larger cities. An alternative to the approaches that were mentioned so far is natural experiments. Although they’re less common in this field - presumably because they’re not easily extended to other applications - they are a plausible source of quasi-random variation. This paper, will focus on such a natural experiment, namely, the introduction of highway tolls on the formerly toll-free SCUT highways in Portugal.

3 Data and Empirical Approach

3.1 Data

For the purpose of this study, both municipal- and firm-level data was used. The firm-level information was gathered from the *Central Balance Sheet* database provided by *Banco de Portugal*.[8] It consists of economic and financial information on Portuguese firms (such as financial balance sheet indicators, location, number of employees, size, among others). This is quite an extensive dataset comprising 554,133 firms during the period of 2006-2016, amounting to a total of 3,677,473 observations.[9] Note that it is an unbalanced dataset as not all firms have observations for all the years in this period. Additionally, only firms in Portugal mainland were considered, hence firms from Madeira and Azores are not part of the analysis.

From here, the following firm-level variables were gathered: turnover, number of workers, average wage, labor productivity, exports and sales (discriminated by geographical destiny), and inventories.[10]Note that the variables for turnover, number of workers, exports and sales, average wage, labor productivity and inventories were logarithmized with the intention of bringing skewed data closer to a normal distribution. To prevent the loss of observations equal to zero and thus avoiding biased estimates, an extra value of one was added (e.g. $Log(Turnover+1)$) when using the log transformation on these variables.

Additionally, this dataset was used to create the variables $Exit$ and $Moved$. $Exit$ is a binary variable that takes the value 1 when a firms suspends or ceases activity and 0 otherwise.[11] The

[8]The data in this database is collected through *Simplified Business Information (IES - Informação Estatística Simplificada)* since 2006. *IES* is an annual report that must be filled online by firms. This report is mandatory and non-compliants are penalized. The quality of this data is then monitored by Statistics Portugal who check with respondents on a regular basis.

[9]This corresponds to the total number of observations after dropping firms with no municipality reported, non positive levels of turnover and non positive number of employees. This last drop is meant to eliminate cases of self-employment from the sample.

[10]Average wage and labor productivity were computed by the author. Average wage was calculated as the ratio between total salaries of employees and number of employees. Labor productivity was computed as the ratio between turnover and number of employees.

[11]The variable *Exit* was created based on information on firm status provided by *Banco de Portugal.* Note that this information was subject to quality control using complementary sources to the data gathered from *Simplified Business Information (IES - Informação Estatística Simplificada).*

variable *Moved* is a dummy variable that equals 1 when a firm changes municipality and 0 otherwise. These variables are later used to analyse the impact of the introduction of tolls on these firm level outcomes and the probabilities of firms changing municipality or exiting the market.[12]

This data was supplemented with municipal information which allows to control for time-variant municipal-level covariates. Municipal socio-demographic characteristics were gathered from *Instituto Nacional de Estatística* (INE). Informationon per capita electricity consumption was retrieved from *Direção Geral de Energia e Geologia* (DGEG) and data on municipal expenditures was acquired from *Direção Geral das Autarquias Locais* (DGAL). With this data, the variables *age dependency ratio, population density, electricity consumption per capita* and *municipal expenditures per capita* were created and later added to the model to control for municipal time varying characteristics (which will be later discussed in the next section).

Table 1 presents descriptive statistics on the dependent variables and the controls variables used in the study.[13]

3.2 Empirical Strategy

The validity of this model relies on the fact that the introduction of tolls on SCUT highways was forced by an exogenous shock (the sovereign debt crisis) upon the Portuguese political authorities. Being a national matter, municipal authorities played no role in this decision nor were they able to directly intervene.[14]At the same time, there was no discrimination nor favoritism towards these municipalities.[15]

The treatment under study is the introduction of tolls in the SCUT highways. As such, municipalities are divided into a treatment group and a control group. All municipalities that have a segment of the SCUT highway network belong to the treatment group. These amounts to 59 mu-

[12]Ideally, this study would also include a binary variable *Enter* that takes the value 1 when a firm enters the market and 0 otherwise. However due to data restrictions, it was not possible to include such a variable.

[13]Additionally, for a more indepth description of each variable see Table A.1 in the Appendix.

[14]Even though, there were huge protests made by SCUT highway users and local mayors, they had no saying in this decision. (See `https://www.jornaldenegocios.pt/empresas/transportes/detalhe/municipios_e_utentes_perdem_accoes_contra_portagens`)

[15]Audretsch, Pereira dos Santos and Dohse (2018) show that there was no political attempt to favor municipalities of the same political party.

nicipalities in the treatment group and 219 in the comparison group.[16] Note that the municipalities in the control group do have other non-SCUT highways. However, it is important to point out that these other highways were already subject to charges a long time before this crisis and that these charges were not affected by the shock (the crisis). As far as the treatment period goes, note that in some treated municipalities, tolls were introduced on the 15^{th} of October 2010 and in others, this happened on the 8^{th} of December 2011.

The effect of an increase in transportation costs on the outcome y_{it} was estimated using the following difference-in-difference specification for firm f in municipality i and year t, during the period 2006-2016:

$$y_{fit} = \beta_0 + \alpha_i + \lambda_t + \gamma Treated_i \times PostPeriod_{it} + X_{it}^{'}\beta_1 + \varepsilon_{fit} \tag{1}$$

where y_{fit} is the firm-level outcome variables of interest, turnover, α_i denotes municipality fixed effects, λ_t represents year fixed effects and $X_{it}^{'}$ is a vector of economic and socio-demographic municipal level controls. Additionally other outcomes, such as, probability of exiting the market, probability of switching municipalities, firms' exports and sales, number of employees, average wage and labor productivity will also be analyzed.

The vector $X_{it}^{'}$ was added to control for time-varying municipal characteristics. This helps mitigate by design possible bias that might be caused by omitted variables. To control for socio-demographic characteristics, the variables age dependency ratio and population density are accounted for in the model. Additionally, the model includes electricity consumption per capita and municipal expenses per capita to control for municipal income.

The variable of interest is $Treated \times PostPeriod$ which represents the interaction between the $Treated$ dummy and the $PostPeriod$ treatment dummy. The $Treated$ variable takes the value 1 for municipalities in the treatment group and 0 otherwise, whilst the variable $PostPeriod$ equals 1 from the year the treatment starts onward. Note that for firms in municipalities where the tolls were introduced on the 15^{th} of October 2010, $PostPeriod$ dummy equals 1 from 2011 onward. As

[16] In Table A.2, there's a list with the municipalities which were affected by this shock and in Figure A.1, there's a geographical display of these municipalities.

for the firms in municipalities where the tolls were introduced on the 8^{th} of December 2011, the *PostPeriod* dummy equals 1 from 2012 onward. When looking at the results in a later section, the coefficient of interest will be γ as it gives us the treatment effect.

Robust standard errors are clustered at the municipal level municipality to correct for heteroskedasticity and autocorrelation since treatment varies at this level (Bertrand, Duflo and Mullainathan, 2004). However, some firms change municipality during the period under study. Therefore, the municipality at the time of the treatment was used to cluster the standard errors i.e. the location of the firm in the year 2009 just before the treatment. Additionally, for firms that do not have an observation for this year (since this is an unbalanced panel), the location of the firm at the time it first appears in the sample was used.

4 Result Analysis

4.1 Testing for Internal Validity

The internal validity of a Difference-in-Difference estimation model relies on the parallel trends assumption being satisfied. This assumption states that in absence of treatment, the average outcome of the treatment group would have changed in same way as the average outcome of the control group. A common technique used to test this is to compare the evolution of the outcomes variable in the treated and control group during the per-treatment period (Angrist and Pischke, 2008). Figure 1 displays the mean evolution of the main dependent variable, the logarithm of turnover. This graphical representation does not show proof of distinct per-treatment trends between treatment and control groups capable of compromising the empirical strategy. As such, this inspection supports the validity of the model. For a more rigorous test on the validity of the parallel trends assumption an event study is conducted below.

An event study has two main advantages. On the one hand, it allows us to observe whether the strength of the treatment varies with time. On the other hand, it provides a more rigorous test of the common trend assumption then the plot previously made. The estimating equation for the event study is:

$$y_{fit} = \beta_0 + \alpha_i + \lambda_t + \sum_{t=2006}^{2008} \delta_t Treated_i \cdot Year_t + \sum_{t=2010}^{2016} \delta_t Treated_i \cdot Year_t + X_{it}^{'} \beta_1 + \varepsilon_{fit} \qquad (2)$$

Notice that in equation 2 the interaction terms for all pre- and post-treatment years are included except for 2009. This way, all the coefficients are estimated relative to the year 2009 which is the last year before the treatment started. Figure 2 shows the event study for the main dependent variable, the logarithm of turnover.[17]

For all the pre-treatment years, the interaction terms are small and not significantly different from zero. This shows strong proof in favor of the validity of the common trend assumption and confirms the results from visual plot previously analyzed. Furthermore, notice from 2014 on the coefficient becomes significantly negative. This already suggests that the introduction of tolls has introduced a statistically significant difference between treated regions and the comparison group. Additionally, it further implies that this effect may have not been immediate (as the coefficient only becomes significant in 2014).[18]

Lastly, a balance test was computed on Table 2. This allows one to compare mean differences between treatment and control group in the pre-treatment period (2006-2009) Looking at the results, there seems to be no statistical significant difference for the variables *Electricity Consumption pc* and *Expenses pc.* As for the other two variables, although the difference is statistical significant, it is also very small.

[17]If any other shocks other than the treatment occur during the time period under analysis, it's important that they affect the treatment and control group similarly (Tavares and Pereira dos Santos, 2018). In this study, the time period includes one of the greatest recessions in history, the world's financial crisis and the European sovereign debt crisis that directly hit Portugal, forcing the country to request an international bailout. Given that this crisis might have affected municipalities differently, a NUTS2*year dummy is used in the model's specification to mitigate this problem. Moreover, Tavares and Pereira dos Santos (2018) show that the allocation of European funds is important for business firms dynamics. Since this allocation is done at the NUTS2-level, using a NUTS2*year dummy can help accounting for this effect.

[18]Table A.3 presents the results of the Event Study in more detail.

4.2 Baseline Specification

After estimating Equation 1 one obtains the following results as shown in Table 3 for the main dependent variable, turnover. In this table, all columns include firm, year and municipality fixed effects. Column (1), (2) and (3) add regional year fixed effects: NUTS2*year, district*year and NUTS3*year fixed effects, respectively.[19] Notice that the Column with NUTS2*year is the least demanding specification from these three columns, whilst the one with NUTS3*year is the most demanding one. This is due to the fact that by including NUTS3*year, 21 dummies are being added to the model. On the other hand, with NUTS2*year and district*year less dummies are included in the specification (5 and 18 respectively).[20] Columns (4), (5) and (6) add sector fixed effects to these first three columns. Lastly, Column (7) adds a set of municipal controls variables (described in the previous chapter) to the first column specification. For all specifications, Table 3 shows the treatment effect (γ) of the introduction of tolls on firms' turnover, here represented by the term $Treated \times PostPeriod$.

Looking at the estimates for the treatment effect (γ) in table 3, notice they're all negative and statistically significant at a 1% level in Columns (2), (3), (5), (6) and at the 10% level in Columns (1), (4), (7). When controlling for regional NUTS2 year fixed effects one obtains a result of $-7,6\%$ which does not vary by much when adding sector fixed effects or municipal level controls. This means that firms located in treated municipalities experienced an average decrease of $-7,6\%$ turnover vis à vis firms located in comparison regions. If instead, one uses regional NUTS3 or district year fixed effects, the estimates decrease to $-11,5\%$ and -10% respectively. The estimated coefficient is relatively stable. However, notice that when using a more demanding specification, this coefficient becomes slightly larger.

These findings suggest a sizable effect of the introduction of tolls on firms' turnover and thus on firms' performance. Take for instance Column (1). According to this result, firms' turnover in the treatment group decreased by 7,6% after the tolls were introduced in SCUT highways.

[19] See the maps in Appendix A.2 for more details on how each of these classifications divides the Portuguese territory.

[20] Municipalities were grouped into 18 districts, based on the district system that dates back to 1835. Districts have been removed from the legal framework, however they are still used to this day for statistical purposes.

4.3 Robustness and Heterogeneity

4.3.1 Robustness

As to further ensure the robustness of the model, a set of exercises was computed in Table 4. The Columns in this table follow same specification as Columns (1) and (7) of the previous Table 3, but this time the sample is restricted. In Columns (1) and (2), district capitals are excluded from the sample. In Columns (3) and (4), all municipalities along the Atlantic are eliminated from the sample. Lastly, in Columns (5) and (6) only single establishment firms are accounted for.

District capitals are the main regional markets for consumer goods and services. This means that producers, which are not located in these regions, need to transport their goods all the way to these markets to be able to reach their costumers. Following this logic, one may hypothesize that producers who are more distant from these district capitals, are also more prone to be affected by higher transportation costs when trying to get their products to their costumers. Thus, if firms in district capitals are excluded from the sample, one may expect a significantly higher effect of the introduction of tolls on the other firms, which depend more on highways as a mean of transportation for their products. Looking at the results in table 4, the estimated coefficients are in line with this hypothesis. As expected, by excluding district capitals, the size of the coefficient becomes significantly bigger. This indicates that firms situated outside district capitals were more affected by the tolls.

The next exercise is to drop all municipalities along the coast from the sample. The estimated coefficients in Table 4 shows that the results are consistent with the baseline specification.

Lastly, for the final exercise only single establishments are considered. Some of the firms in the sample have more than one establishment, although they only represent 3,08% of the total sample. However, this exercise was important to make sure the results are consistent if only single establishment firms had been included in the study from the beginning. As shown in Table 4, results are consistent with the baseline specification.

4.3.2 Placebo Test

Additionally, a placebo exercise is built to simulate the difference-in-difference analysis for a point in time where the treatment had not been implemented yet. In order to do this, let us consider the pre-treatment period, 2006-2009, and split it into two: either divide it in the middle, 2006-2007 and 2008-2009, or divide it into 2006-2008 and 2009. Table 5 presents the results of the placebo regression. The first two columns show the results of the placebo regression if the pre-treatment period is split in the middle whereas the last two columns show the alternative split. Looking at the results, all interaction terms are statistically not significant. Hence, these findings, together with the previous testes made, provide reinforced evidence that the results obtained previously for the log of turnover are indeed caused by the introduction of tolls rather than some other unobserved factors of the SCUT regions.

4.3.3 Heterogeneity

To run a deeper analysis on the effect of the introduction of the tolls on firms' turnover, Table 6 descriminates firms by size and sector. Firm size is defined according to Eurostat classification: small and medium sized enterprises (SMEs) have 1-249 workers whereas large enterprises have 250 or more workers. Additionally, firms were sorted by sector following INE's (*Instituto Nacional de Estatistica*) recommendation.[21] Table 6 shows the results of this analysis. The results on Table 6 show that large firms were more affected than small and medium size enterprises. This is consistent with the idea that larger firms have a higher tendency to export their products to other countries or other municipalities within Portugal. As such, they're more susceptible to an increase in transportation costs.

Furthermore, the secondary sector seems to have been struck the hardest by the introduction of tolls when compared to the service sector. A plausible explanation for this result is that manufacturing firms tend to export their products more or in the least they're not necessarily near the

[21] Primary Sector was not included in the analysis as it had very few observations. Furthermore, construction was analyzed seperately from the secondary sector. For more details on how each firm was categorized to each sector see Table A.4 in the Appendix.

markets they serve. Whereas firms in the service sector tend to be closer to their market, thus they are less affected by an increase in transportation cost than the manufacturing sector.

4.4 Probability of Exiting and Probability of Moving

So far in the analysis, we've been looking at the effect of the introduction of tolls on firms' turnover. But another interesting question is whether this increase in transportation costs lead firms to move to another municipality or even exit the market. To try to answer this question, a set of regressions were computed shown in Table 7. Note that all regression on this table follow a Linear Probability Model (LPM). Similarly to Table 3 Column (1), (2) and (3) use regional year fixed effects: NUTS2, NUTS3 and district year fixed effects respectively. Columns (4), (5) and (6) add sector fixed effects to these specifications. Column (7) adds a set of municipal level controls. All specifications include municipal and year fixed effects. However, note that this time around, firm fixed effects were not included. This is due to the nature of the variables, which by definition have a very low variability. That is, their values vary utmost once from 0 to 1 when a firm changes municipality or exits the market. As such, these variables have very low individual within variation. Therefore, adding firm fixed effects might not be appropriate.[22]

Examining the results obtained for the probability of firms changing municipality, Table 7 shows that all estimated coefficients are statistically not significant. Furthermore, in regards to the probability of exiting, Columns (2), (3), (5) and (6) show statistically significant results. However, the size of these coefficients is very small. Therefore, there is no evidence that the introduction of tolls lead to firms changing municipality or exiting the market.

4.5 Other Outcomes

To have a better understanding of how firms were affected by the the unexpected increase in transportation costs, it is important to look at other firm-level outcomes. Tables 8 and 9 show the estimated effect of this shock on the following outcomes: exports (to the EU and the rest of the

[22]The author did however try to do the same exercise including firm fixed effects and similar results were obtained.

world), number of employees, labor productivity, average wage and inventories.

Looking at Columns (1) - (6) from Table 8, it seems that this treatment had a substantial effect on firms exports. In fact, firms subject to this shock saw their exports decrease by 5% at a 10% confidence level. Going one step further, Columns (3) - (6) separately analyze the exports that were destined to the EU market from the ones going to the rest of the world. One can see that, exports to the EU area were significantly affected whilst no significant effect was found for the ones directed to the non-EU market. More precisely, exports to the EU decreased by around 6% for firms in treated areas. Note that this decrease in exports coincides with the hypothesis previously made in regards to how the manufacturing sector, as well as, large firms were affected by the shock. If indeed, these two type of firms tend to export more, then it's only natural that these firms were more vulnerable to this shock, given that exports were heavily affected.

But sales to the outside market were not the only ones that were struck by this shock. According to the findings in Columns (7) - (8), the sales to the internal market suffered a significant decrease due to this policy. Treated regions saw their sales to this market decrease by 7% vis à vis comparison regions.

The results obtained for the sales to the EU and the internal market can be explained by the dependence of these two markets on road transportation. In regards to the EU market, note that Spain is one of the main trading partner of Portugal.[23] Spain's proximity to Portugal makes trade between these two countries more reliable on road transportation. In addition, Spain's relevance for Portuguese exports, makes Portuguese firms' more vulnerable to an increase in transportation costs to this market. This could possibly explain the decrease in exports to the EU market. As for the internal market, firm's which relied on the SCUT highways to transport their products to other municipalities, saw their sales decrease due to this increase in transportation costs. In sum, a plausible explanation for these results is that this policy mainly affected producers which rely on these roads to bring their products to other parts of the country (internal market) and to other EU countries (specially Spain).

[23] According toBanco de Portugal, in 2010, Portugal's exports to Spain accounted for 32% of the total exports made to the EU area.

Based on the results obtained in Table 9, the introduction of tolls had a significantly negative effect on the number of workers. At a 10% significance level, the number of employees of treated firms decreased by 1%. These results are consistent with the findings of Audretsch, Pereira dos Santos and Dohse (2018), who found a significantly negative impact on employment at the municipal-level. Although the point estimate on the impact of the introduction of tolls on average wages is negative, no claims can be made in regards to the impact of the treatment on this variable as its coefficient is not significantly different from zero at the 10% level.

In Column (9), the coefficient for labor productivity is not statistically significant. However, once one controls for time-varying municipal level characteristics, it becomes statistically significant at a 10% significant level. Under this specification it shows that the treatment decreased labor productivity by 3,8% for firms in the treated regions. As for the last two Columns, no evidence was found on the effect of the introduction of tolls on firms' inventories. This result may be attributed to large number of small and medium firms in the sample. A plausible explanation is that these type of firms may be less efficient in managing their inventories. This lack of efficiency may result in delayed adjustments to achieve optimal inventory stocking.[24]

5 Conclusion

Few studies make use of a natural experiment as a source of exogenous variation in transport infrastructure. This paper follows this approach by exploiting the introduction of tolls on Portuguese SCUT highways which was forced upon Portuguese authorities.

Results suggest that the introduction of tolls had a substantial impact on firms' performance in regions that previously had toll-free SCUT highways. As shown, this increase in transportation costs had a significant negative impact on firms' turnover. Furthermore, the firms in the secondary sector alongside large firms seem to have been struck the hardest by this shock. Exports also suffered a sizable decrease, specially the ones targeted to other EU countries. Moreover, sales to the internal market were also heavily affected by this policy. Lastly, the introduction of tolls lead

[24]In this sample, 80% of firms are SMEs (Small and Medium sized Enterprises).

to a decrease in the number of employees, average wage and labor productivity.

In sum, introducing tolls and increasing transportation costs for firms in these areas had a detrimental effect on firms' performance. This is shown by the sizable decrease in firms' turnover. Moreover, sales to more road dependent locations were struck the hardest. This might explain the significant decrease in exports to the EU partner countries, as well as, the decrease in sales to the internal market. In face of higher transportation costs, producers struggled to deliver their products to these destinations. In line with this hypothesis, firms in the secondary sector, as well as, large firms were more affected by this policy. These type of firms have a higher tendency to export to other countries and, at the same time, to other municipalities in Portugal. Therefore, they're more vulnerable to an increase in transportation costs to these markets.

In conclusion, even though this policy helped to achieve budgetary goals momentously, it also translated into substantial costs for Portuguese firms. It is possible that policy makers started realizing this since, in August 2016, these tolls were reduced by 15%.

6 Figures

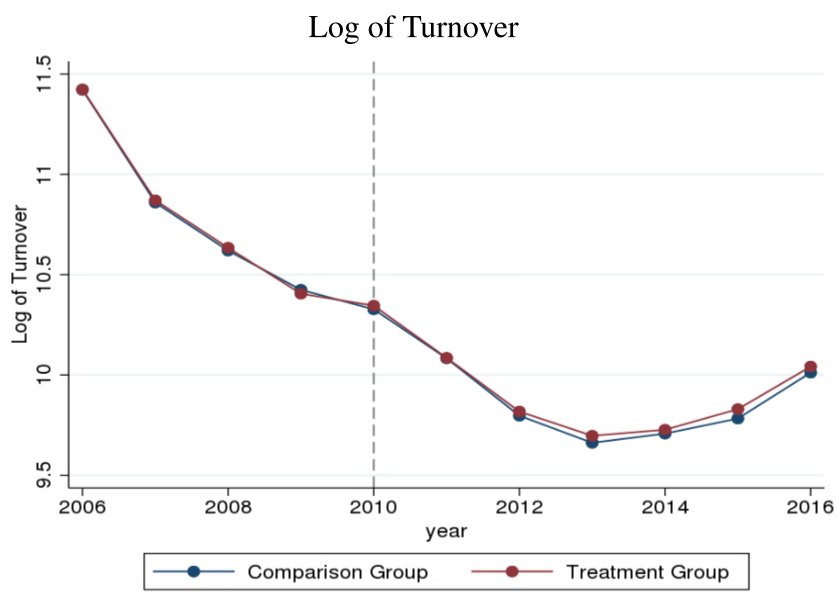
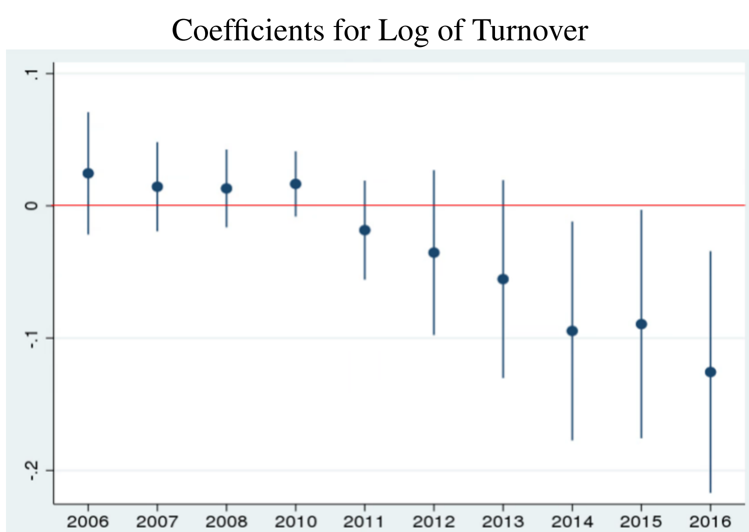


Figure 1: Evolution of Log of Turnover



Notes: This graph was computed using year fixed effects, municipal fixed effects and a NUTS2*year dummy. The 90% confidence levels are calculated using clustered standard errors at the municipal level. Results using the set of time-varying controls are very similar and are available upon request. These municipal time-varying controls include electricity consumption per capita, age dependency ratio, population density and expenses per capita.

Figure 2: Event Study

7 Tables

Variable	Obs.	Mean	Std. Dev.	Min	Max
Main Dependent Variable					
Log of Turnover	3.677.473	10,21193	4,116228	0	22,98802
Probabilities					
Exit	3.677.473	0,0319344	0,1758256	0	1
Moved	3.677.473	0,0182024	0,1336829	0	1
Other Outcomes					
Log Number of Workers	3.677.473	1,262944	0,9832968	0	10,11387
Log of Exports	3.677.473	1,503811	3,817034	0	22,02988
Log of Exports - EU Market	3.677.473	1,225637	3,462759	0	21,3901
Log of Exports - Extra EU Market	3.677.473	0,6440802	2,570737	0	21,44868
Log of Sales - Internal Market	3.677.473	9,984998	4,236277	-0,0512933	22,58125
Log of Average Wage	3.043.943	6,537879	3,78099	0	14,63995
Log of Labor Productivity	3.043.943	10,11218	2,404479	0	20,96442
Log of Inventories and Biological Assets	3.677.473	5,774278	5,374746	-1,203973	20,94546
Control Variables					
Electricity Consumption pc	3.677.473	4,881396	3,421607	1,526943	83,85919
Population Density	3.677.473	1718,366	2132,229	4,2	7492,4
Age Dependency Ratio	3.677.473	0,5338962	0,0952578	0,371478	1,107895
Expenses pc	3.677.473	0,5072029	0,2351439	0,0891436	2,639032

Table 1: Descriptive Statistics

Variable	Treatment Group	Control Group	Difference	Std. Errors
Electricity Consumption pc	5,241	4,878	0,363	(0,514)
Population Density	799,078	2054,233	-0,0013*	(686,653)
Age Dependency Ratio	0,474	0,522	-0,048**	(0,019)
Expenses pc	0,463	0,495	-0,032	(0,070)

Notes: Results on this table are based on the pre-treatment period 2006-2009. Standard errors are clustered at the municipal level. “pc” stand for “per capita”. Stars indicate significance levels of 10% (*), 5% (**), and 1%(***).

Table 2: Balance Test

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Log of Turnover				
$Treated \times PostPeriod$	$-0,0760^{*}$	$-0,100^{***}$	$-0,115^{***}$	$-0,0761^{*}$	$-0,101^{***}$	$-0,115^{***}$	$-0,0750^{*}$
	(0,0407)	(0,0286)	(0,0316)	(0,0406)	(0,0286)	(0,0315)	(0,0404)
R-squared	0,038	0,038	0,038	0,038	0,038	0,038	0,038
Firm FE	✓	✓	✓	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓
Nuts 2 × Year FE	✓			✓			✓
District ×Year FE		✓			✓		
Nuts 3 ×Year FE			✓			✓	
Sector FE				✓	✓	✓	
Controls							✓

Notes: N=3.677.473. Standard errors in parenthesis are clustered at the municipal level. The vector of socio- -demographic and economic controls includes electricity consumption per capita, age dependency ratio, population density and expenses per capita. Stars indicate significance levels of 10% (*), 5% (**) and 1%(***).

Table 3: Baseline Results

	Exclude District Capitals		Exclude Coast		Single Estab. Firms	
	(1)	(2)	(3)	(4)	(5)	(6)
			Log of Turnover			
$Treated \times PostPeriod$	$-0,126^{***}$	$-0,109^{***}$	$-0,0736^{*}$	$-0,0731^{*}$	-0.0758^{*}	-0.0750^{*}
	(0,0462)	(0,0420)	(0,0422)	(0,0393)	(0.0421)	(0.0417)
R-squared	0,041	0,041	0,038	0,038	0,038	0,038
N	2.589.616	2.589.616	1.913.944	1.913.944	3.564.083	3.564.083
Firm FE	✓	✓	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Nuts 2 × Year FE	✓	✓	✓	✓	✓	✓
Controls		✓		✓		✓

Standard errors in parenthesis are clustered at the municipal level. The vector of socio-demographic and economic controls includes electricity consumption per capita, age dependency ratio, population density and expenses per capita. Stars indicate significance levels of 10% (*), 5% (**) and 1%(***).

Table 4: Robustness Tests

	2008 placebo Shock		2009 placebo Shock	
	(1)	(2)	(3)	(4)
		Log of Turnover		
$Treated \times PostPeriod$	$-0,0187$	$-0,0189$	$-0,0255$	$-0,0221$
	(0,0201)	(0,0207)	(0,0230)	(0,0224)
R-squared	0,008	0,008	0,008	0,008
Firm FE	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Nuts 2 × Year FE	✓	✓	✓	✓
Controls		✓		✓

Notes: N=1.241.388. Standard errors in parenthesis are clustered at the municipal level. The vector of socio-demographic and economic controls includes electricity consumption per capita, age dependency ratio, population density and expenses per capita. Stars indicate significance levels of 10% (*), 5% (**), and 1%(***).

Table 5: Placebo Test

	SMEs		Large		Secondary Sector		Tertiary Sector	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Log of Turnover				
$Treated \times PostPeriod$	$-0,0498^{*}$	$-0,0505^{*}$	$-0,0658^{*}$	$-0,0667^{*}$	$-0,105^{**}$	$-0,0999^{**}$	$-0,0736^{*}$	$-0,0732^{*}$
	(0,0290)	(0,0259)	(0,0381)	(0,0346)	(0,0531)	(0,0498)	(0,0383)	(0,0380)
R-squared	0,015	0,015	0,035	0,037	0,046	0,046	0,036	0,036
N	3.035.671	3.035.671	8.272	8.272	438.631	438.631	2.681.294	2.681.294
Firm-FE	✓	✓	✓	✓	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Nuts 2 × Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Controls		✓		✓		✓		✓

Notes: N=1.241.388. Standard errors in parenthesis are clustered at the municipal level. The vector of socio-demographic and economic controls includes electricity consumption per capita, age dependency ratio, population density and expenses per capita. Stars indicate significance levels of 10% (*), 5% (**) and 1%(***).

Table 6: Heterogeneity Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Prob. of Changing Mun.			
$Treated \times PostPeriod$	0,00083	0,0017	0,0014	0,00083	0,0017	0,0014	0,00076
	(0,0027)	(0,0041)	(0,0039)	(0,0027)	(0,0041)	(0,0039)	(0,0029)
R-squared	0,004	0,005	0,005	0,004	0,005	0,005	0,004
				Prob. of Exiting			
$Treated \times PostPeriod$	$0,0019$	$0,0018^{*}$	$0,0018^{*}$	$0,0019$	$0,0018^{*}$	$0,0018^{*}$	$0,0017$
	(0,0013)	(0,0011)	(0,0011)	(0,0013)	(0,0011)	(0,0011)	(0,0012)
R-squared	0,003	0,004	0,004	0,004	0,004	0,004	0,003
Municipality FE	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓
Nuts 2 × Year FE	✓			✓			✓
Nuts 3 ×Year FE		✓			✓		
District ×Year FE			✓			✓	
Sector FE				✓	✓	✓	
Controls							✓

Notes: N=3.677.473. Standard errors in parenthesis are clustered at the municipal level. The vector of socio-demographic and economic controls includes electricity consumption per capita, age dependency ratio, population density and expenses per capita. Stars indicate significance levels of 10% (*), 5% (**), and 1%(***). Results shown above are calculated using a Linear Probability Model (LPM). The author tried to do the same exercise including irm fixed effects and similar results were obtained.

Table 7: Regression results for probability of exiting and probability of moving

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Log Exports		Log Exp. (EU Market)		Log Exp. (Extra EU Market)		Sales (Internal Market)	
$Treated \times PostPeriod$	$-0,0479^{*}$	$-0,0500^{*}$	$-0,0627^{**}$	$-0,0643^{**}$	0,0223	0,0205	$-0,0738^{*}$	$-0,0721^{*}$
	(0,0288)	(0,0276)	(0,0281)	(0,0256)	(0,0172)	(0,0175)	(0,0418)	(0,0406)
R-squared	0,003	0,003	0,003	0,003	0,005	0,005	0,036	0,036
N	3.677.473	3.677.473	3.677.473	3.677.473	3.677.473	3.677.473	3.677.495	3.677.495
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Nuts 2 × Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Controls		✓		✓		✓		✓

Notes: Standard errors in parenthesis are clustered at the municipal level. The vector of socio-demographic and economic controls includes electricity consumption per capita, age dependency ratio, population density and expenses per capita. Stars indicate significance levels of 10% (*), 5% (**) and 1%(***).

Table 8: Regression results for firm-level exports

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	Log Numb. Workers		Log Labor Productivity		Log Average Wage		Log Inventories	
$Treated \times PostPeriod$	$-0,0101^{*}$	$-0,0102^{*}$	-0,0377	$-0,0379^{*}$	-0,0250	-0,0260	-0,0063	-0,0035
	(0,00569)	(0,00548)	(0,0247)	(0,0220)	(0,0172)	(0,0171)	(0,0287)	(0,0271)
R-squared	0,023	0,023	0,011	0,012	0,005	0,005	0,025	0,025
N	3.677.473	3.677.473	3.043.943	3.043.943	3.043.943	3.043.943	3.677.473	3.677.473
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Nuts 2 × Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Controls		✓		✓		✓		✓

Notes: Standard errors in parenthesis are clustered at the municipal level. The vector of socio-demographic and economic controls includes electricity consumption per capita, age dependency ratio, population density and expenses per capita. Stars indicate significance levels of 10% (*), 5% (**), and 1%(***).

Table 9: Regression results for other firm-level outcomes

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A Appendix

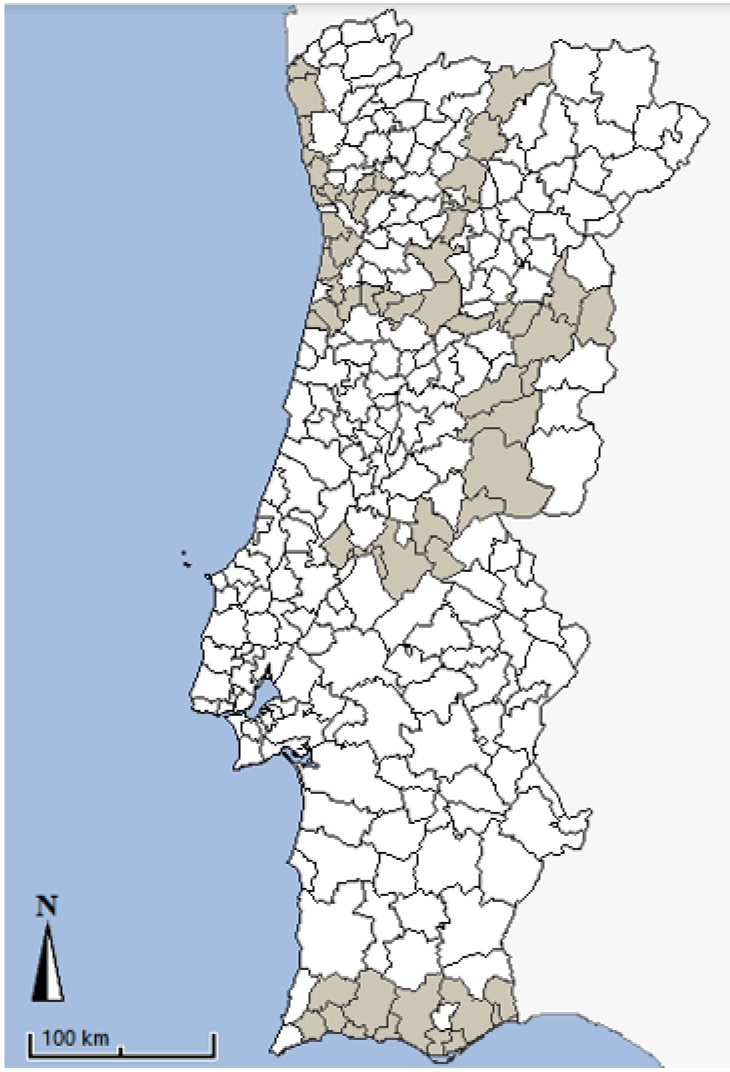
Variables	Description	Source
Main Dependent Variable		
Turnover	Total number of sales and services of a given firm	*BdP*
Treatment Variables		
Treated	Binary variable that takes the value 1 if a given municipality is crossed by a SCUT highway and 0 otherwise. (See Table A.2)	*ANSR*
PostPeriod	Binary variable that takes the value 1 for all periods after the treatment started and 0 otherwise. (See Table A.2)	
Probabilities		
Exit	Binary variable that takes the value 1 when a firms suspends or ceases activity and 0 otherwise.	*BdP*
Moved	Binary variable that equals 1 when a firm changes municipality and 0 otherwise.	*BdP*
Other Outcomes		
Number of Workers	Total number of (paid and unpaid) employees in a given firm.	*BdP*
Exports	Total sales and services of a given firm to the outside market.	*BdP*
Exports - EU Market	Total sales and services of a given firm to the EU-Market.	*BdP*
Exports - Extra EU Market	Total sales and service of a given firm to the rest of the world.	*BdP*
Average Wage	Ratio between total salary of employees and the number of employees.	*BdP*
Labor Productivity	Ratio between turnover and number of employees.	*BdP*
Inventories and Biological Assets	Raw and subsidiary materials and consumables; Advances from customers; Inventories (excepting Raw and subsidiary materials and consumables).	*BdP*
Municipal Control Variables		
Electricity Consumption pc	Total consumption of electricity in a given municipality divided by the number of inhabitantsof that municipality (Unit: Thousand of kWh/Inhabitants).	*DGEG*
Population Density	Number of inhabitants in a given municipality divided by the respective municipality area (Unit: $Inhabitants/km^2$).	*INE*
Age Dependency Ratio	Ratio of individuals usually not part of the labor force (age 0-14 and +65) and individuals part of the active population (age 15-64) (Unit: Percentage).	*INE*
Expenses pc	Total municipal expenses divided by the number of inhabitants of the respective municipality (Unit: Thousand of Euros/Inhabitants).	*DGAA*

Notes: "pc" stands for "per capita"; ANSR (*Autoridade Nacional de Segurança Rodoviária*); DGEG *(Direção Geral de Energia e Geologia);* BdP (*Banco de Portugal - Central Balance Sheet*); INE *(Instituto Nacional de Estatística);* DGAL *(Direção Geral das Autarquias Locais).*

Table A.1: Variable Description

SCUT Highway	Municipalities Affected
Tolls introduced on the 15^{th} October 2010	
SCUT Grande Porto - 79 Km	
A4: AE Transmontana	Matosinhos, Maia.
A41: CREP - Circular Regional Exterior do Porto	Matosinhos, Valongo, Santa Maria da Feira, Espinho.
A42: AE Douro Litoral	Valongo, Paços de Ferreira, Paredes, Lousada.
SCUT Litoral Norte -113 Km	
A28	Matosinhos, Vila do Conde, Póvoa de Varzim, Esposende, Viana do Castelo, Caminha.
SCUT Costa da Prata – 110 Km	
A29	Estarreja, Ovar, Espinho, Vila Nova de Gaia.
Tolls introduced on the 8^{th} December 2011	
SCUT Algarve – 133 Km	
A22	Lagos, Monchique, Portimão, Lagoa, Silves, Albufeira, Loulé, Faro, Olhão, Tavira, Castro Marim, Vila Real de Sto.António.
SCUT Beira Interior – 217 Km	
A23	Torres Novas, Entroncamento, Constância, Abrantes, Mação, Gavião, Vila Velha de Rodão,Vila Nova da Barquinha,Castelo Branco, Fundão, Belmonte, Covilhã, Guarda.
SCUT Interior Norte – 162 Km	
A24	Viseu, Castro Daire, Lamego, Peso da Régua, Vila Real, Vila Pouca de Aguiar, Chaves.
SCUT Beiras Litoral e Alta – 173 Km	
A25	Ílhavo, Aveiro, Albergaria-a-Velha, Sever do Vouga, Oliveira de Frades, Vouzela, Viseu,Mangualde, Fornos de Algodres, Celorico da Beira, Guarda, Pinhel, Almeida.

Table A.2: Municipalities Affected by the Introduction of Tolls in the SCUT Highways



Note: Darkened regions represent treated municipalities whereas light regions depict municipalities in the control group. Graph retrieved from Marktest.

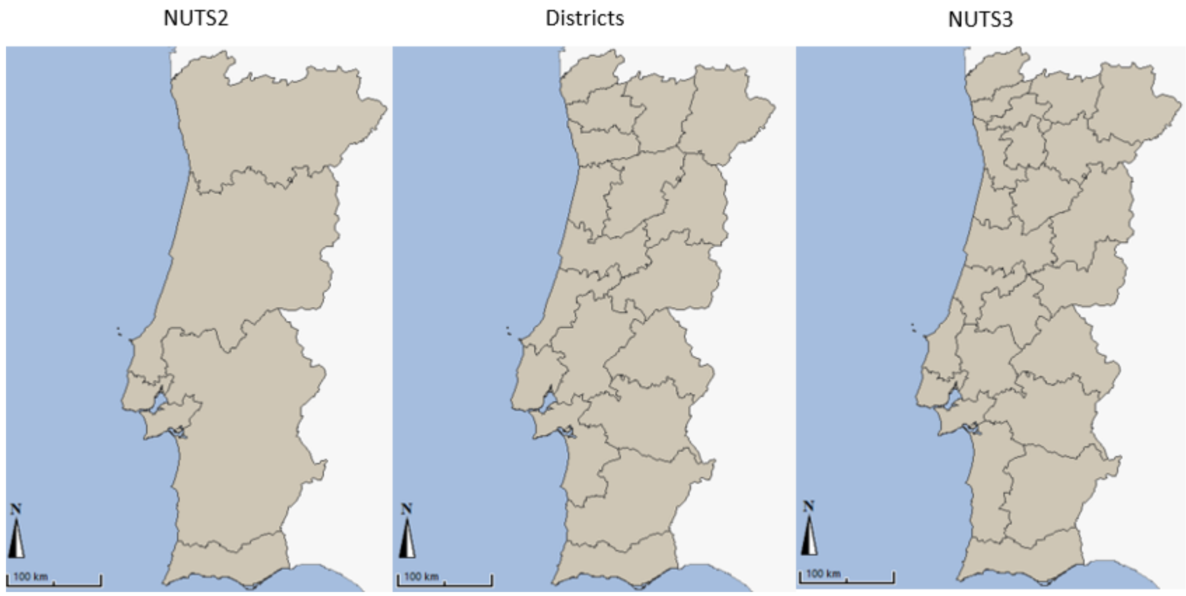
Figure A.1: Geographical Distribution of Affected Municipalities

Interaction Term	Log of Turnover
$Treated_i \cdot Year_{2006}$	0,0244
	(0,0280)
$Treated_i \cdot Year_{2007}$	0,0146
	(0,0204)
$Treated_i \cdot Year_{2008}$	0,0132
	(0,0178)
$Treated_i \cdot Year_{2010}$	0,0165
	(0,0149)
$Treated_i \cdot Year_{2011}$	-0,0183
	(0,0227)
$Treated_i \cdot Year_{2012}$	-0,0354
	(0,0377)
$Treated_i \cdot Year_{2013}$	-0,0553
	(0,0453)
$Treated_i \cdot Year_{2014}$	$-0,0945^{*}$
	(0,0501)
$Treated_i \cdot Year_{2015}$	$-0,0894^{*}$
	(0,0523)
$Treated_i \cdot Year_{2016}$	$-0,126^{**}$
	(0,0553)
N	3.677.473
R-squared	0,038

Notes: Standard errors are clustered at the municipal level.

Stars indicate significance levels of 10% (*), 5% (**), and 1%(***)

Table A.3: Event Study Results



Note: Graphs retrieved from Marktest.

Figure A.2: Dividing Portugal into regions

Firm sector definition according to *Instituto Nacional de Estatistica* (INE)

Código	Designação		Método de cálculo
1	Setor primário		CAE - 0111 a 0322
2	Setor secundário		CAE - 0510 a 4399
3	Setor terciário	Serviços de natureza social	CAE - 8411 a 9499 e 9601 a 9900
4		Serviços de natureza económica	CAE - 4511 a 8299 e 9511 a 9529

Note: In the database provided by Banco de Portugal, firms' economic acivity was classified according to CAE Rev.3. This table provided by INE shows the corresponding sector to each firm's economic activity classification.

Table A.4: Definition of Size and Sector