UNIVERSITY OF NAPLES FEDERICO II

DOCTORAL THESIS

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3 Essays in Public Economics

Author:
Annalisa Tirozzi

Supervisor:
Prof. Edoardo Di Porto

A thesis submitted for the degree of Doctor of Philosophy

in the

Department of Economics and Statistics

Declaration of Authorship

I, Annalisa Tirozzi, declare that this thesis titled, "3 Essays in Public Economics" and the work presented in it are my own. I confirm that:

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Abstract

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3 Essays in Public Economics

by Annalisa Tirozzi

The present research endeavors to shed light onto the issues of the property tax and informal labour. First, literature review evaluates some of the different results on the effects of the property tax, looking at the Italian experience. After having discussed why Italy represents a good experimental setting, empirical contributions are collected on local firms' investments, property values and households' consumption. Moreover, they are reviewed findings related to the political economy of residential property taxation with respect to the incentives of local authorities, tax avoidance and voters' reaction. Second, the empirical evaluation on the effects of the property tax on business, after a reform approved in Italy in 2016. This reform approves the exclusion of a type of heavy equipment, in Italian called "imbullonati", from the business property tax base. The objective of the analysis is to evaluate firms' response in terms of resource allocation decisions. Results show that, after the policy implementation, firms which previously used this type of equipment augment their level of capital: they invest more in equipment. The augmented level of capital, due to the policy implementation, induces an increase in value added and profits. Third, it is investigated the informality in Italian Labour Market driven by the intense use of non-standard jobs, as part-time contracts. Using administrative data released by the Italian Social Security Institute (INPS) combined with data of firms' financial statements and inspections data, I construct an irregular job rate taking advantage from machine-learning technique and accruals model. My microeconomic indicator of irregular job is consistent with the indicator of irregular job provided by ISTAT. Correlation is positive, equal to about 90% (in terms of R2), and statistically significant.

Keywords: *literature review, immovable property taxation, business tax base, difference-in-differences, part-time, informality, prediction, accruals.*

Acknowledgements

I would like to thank my supervisor Prof. Edoardo Di Porto for his encouragement after my graduate studies and for extensive advice, guidance and patience throughout my PhD journey.

I gratefully acknowledge Prof. Maria Gabriella Graziano and Prof. Marco Pagano, the heads of PhD program, for support and opportunities provided.

A special thank goes to Simone Chinetti, for help, patience, friendship, with me when I need unconditionally. What I have learned during these years is also result of his generosity.

Last, the most important, I thank my family: my sister, for life always by my side and my mum. Everything I do is possible only because my mum is with me. She is the best of me.

Contents

List of Figures

List of Tables

List of Abbreviations

BHE	Bolted Heavy Equipments
CV	Cross Validation
DID	Difference in differences
DSP	Domestic Stability Pact - Patto di Stabilità
Fuzzy DID	Fuzzy difference in differences
GDP	Gross Domestic Product - Prodotto Interno Lordo
ICI	Imposta Comunale sugli Immobili
ILO	International Labour Office
IMU	Imposta Municipale Unica
IMU Prin	IMU - primary residences
IMU Sec	IMU - secondary dwellings
INAIL	Istituto Nazionale per l'assicurazione sugli infortuni sul lavoro
INL	Ispettorato Nazionale del Lavoro
INPS	Italian Social Security Institute - Istituto Nazionale di Previdenza Sociale
IRAP	Imposta Regionale sulle Attivtà Produttive
ISTAT	Istituto Nazionale di Statistica
IV	Instrumental Variable
LASSO	Least Absolute Shrinkage And Selection
LATE	Local Average Treatment Effect
LSDV	Least square dummy variable
MEF	Ministry of Economics and Finance - Ministero Economia e Finanza
OECD	Organisation for Economic Co-operation and Development
OMI	Osservatorio del Mercato Immobiliare
RSS	Residual sum of squares
SLL	Sistema Locale Lavoro
SMEs	Small and medium enterprises - Piccole e medie imprese
SHIW	Survey of Household Income and Wealth
TIN	Tax Identification Number
Wald CIC	Changes-in-changes Wald ratio
Wald DID	Wald ratio
Wald TC	Time Corrected Wald ratio
2SLS	Two-Stage Least Squares

Chapter 1

The issues of the property tax and the shadow labour market

In this first chapter, I present an overview of the main results and contributions of this dissertation. The objective of the first two chapters is to discuss the issue of the property tax. Property tax is one of the main sources of fiscal revenues for local governments in many countries and it is widely applied to a large fraction of both residential and business capital (Norregaard, 2013). The starting point is tax competition introduced by Tiebout, 1956 hypothesis: individuals choose not only the perfect mix of public good, but also the perfect mix of taxes they are willing to pay for financing the level of public good they want to receive in exchange. Inter-jurisdictional competition is seen as the way for achieving the efficient provision of local public good.[1] In this context, property tax has always been considered particularly well-suited from an efficient point of view for local governments purposes. The *traditional* view was introduced by Simon, 1943 and Netzer et al., 1966 and it concludes that the property tax is fully shifted forward to consumers in the form of higher housing prices.[2] Given a wide range of options, individuals will not be willing to pay more in property tax than what they receive from it in benefits. Under these assumptions, the "perfect capitalization" converts the property tax into a *benefit tax*, at least in the long run equilibrium, as a payment for local public services received (Hamilton, 1976).[3] The conclusion of the model is that the local property tax can be considered as a non-distortionary "benefit" tax. In contrast with the *benefit view*, the *capital* tax view (or the *new* view) by Mieszkowski, 1972 suggests how property tax differentials entail an inefficient allocation of capital across jurisdictions, from the high-tax jurisdiction to the low-tax jurisdiction. In an economy with

[1] For a comprehensive review of the related literature, see Epple and Nechyba, 2004.

[2] Under the assumption of local jurisdictions homogeneous in house values with a binding zoning constraints, enough jurisdictions to accomodate all desired housing/government service, and a minimum house value for each community, individuals would never accept to pay a home with a value greater than the minimum house value established by the zoning constraint.

[3] Author extended his model with heterogeneous house values. In addition, in the model communities are considered heterogeneous with respect to housing consumption and demands for public services.

national fixed capital stock and two types of local jurisdictions with "high" tax rates and "low" tax rates, property tax rates drive out of the high-tax jurisdiction to the low-tax jurisdiction, and vice-versa. The distorsive mechanism is more likely to hold for business capital than residential, being business capital more mobile than residential (Nechyba, 2001).

Despite established and deep attention, the estimation of the impact of local property tax is still a largely debated issues in the public finance literature. This is because the effects of this tax are difficult to estimate empirically, in a clear and robust way. Indeed, property taxation can affect different agents (households, firms, local governments, etc.) in the economy, and as a consequence, its overall economic effect strictly depends on the degree of the impact on the various outcomes. In this sense, spill-overs effect refer to the impact of changes in the taxation of a jurisdiction on the outcome of a neighbouring jurisdiction. If such spill-overs exist, it is then important to take them into account in order to obtain consistent estimate of the impact of the property tax. A branch of public finance literature relies on quasi-natural experiments. The key strategy to obtain a consistent estimate is to overcome the challenge of estimating the unobserved characteristics by relying on variation that is orthogonal to them. In this sense, an important issue for empirical researchers is to find good experimental settings. Italy is a good laboratory in this sense: the continuous reforms occurred during years give the possibility for quasi-natural experiments at municipal level. The second chapter of this dissertation is a literature review in which they are collected different papers where researchers take advantage from the Italian setting and the numerous reforms had during years, to analyze the effects of the property tax from different points of views. Researchers have had the chance to estimate the impact of the property tax not only on business activities, but also on households' choices in terms of consumption and tax avoidance, local governments and urbanisation, local property values and electoral incentives.

A crucial assumption of the *capital* tax view is the mobility of capital, and in particular this mobility is suggested to be higher if we look at business capital. At firm level, empirical literature investigates the effects of the property tax on firms' decisions. This branch of literature relies on discontinuities at state borders. Duranton, Gobillon, and Overman, 2011 stress the three main econometric issues faced by researchers in this sense: unobserved firm location heterogeneity, unobserved time-varying site-specific effects and the endogeneity of local taxation. Authors develop an econometric technique, "spatial differencing", with panel data to overcome heterogeneity problem and a combination of spatial differencing and instrumenting to overcome unobserved time-varying site characteristics and the endogeneity of local taxation. Their results suggest that property revaluations (which determine the tax base) occur in case of building expansion and magnify the effects of an increase in

property tax, acting as a major break in firms' expansion in that municipality, affecting negatively employment growth. Relying on the same technique of border discontinuity, Belotti, Di Porto, and Santoni, 2020 find a negative effect of the property tax on equipment, employment and value added. So, empirical evidences suggest distortionary effects of this tax. In line with these contributions, the third chapter of this dissertation is an empirical analysis of the effects of the property tax on business. Differently from previous contributions, I take advantage from a difference-in-differences design, where I look at differences in firms' tax base, driven by the ownership or not of a type of heavy equipment used by firms, which are ruled out from the business property tax base in 2016. Results show that, after the policy implementation, firms which previously used this type of equipment augment their level of capital: they invest more in equipment. Moreover, the augmented level of capital, due to the policy implementation, induce an increase in value added. In this third chapter, I test empirically the existence of the distortionary effects of the local property tax on business. I document that the distorsive effect exists on the part of capital subject to investments, equipment, in general the part of capital more volatile than the land. In contrast with the view that the property tax is most desirable from an efficient point of view, the value of the property reflects the value of the land (unimproved), land is immobile and represents the tax base, the price appreciation is independent of personal effort, but it is determined only by demand and supply forces (Bastani and Waldenström, 2020), what I show in the third chapter of this dissertation is that when the property tax is applied to land and other components of business capital, the efficiency, when we consider components different from the land, does not hold anymore, and the property tax acts exactly as a tax on capital. My innovation is given by the fact that I have the possibility to directly check the distorsive mechanism using the removing of the capital part from the business property tax base. I look at what happens when that part which creates distorsions is removed, without looking at differences in tax rates between jurisdictions.

The last chapter is related to the issue of informality in labour market. By definition, formal workers are those conforming with tax and labour laws, such as minimum wage directives, pension and health insurance, workplace standards of safety, etc. In contrast, an irregular worker is one whose job position is not declared, without any kind of labour protection and regulation. Informal workers are labour force employed in "semi-illegal" jobs (called also "grey" workers), where workers' careers are partially hidden. The main actors in informality can be: informal workers employed by firms, informal self-employed, or informal production by firms. When the cost of hiring someone "officially" is tremendously high, agents' response is to choose the cheaper alternative, the "unofficial" labour market. Burden of tax, social security contributions on wages as well as regulations are told to be the main determinants of the increase of the "cost" of hiring someone officially. Implemented

for specific reasons, regulations can also represent a good chance for firms and individuals to choose informal work (Loayza and Rigolini, 2006). A well known case of perverse effect of regulations on informality is given by flexible jobs. Born as an instrument against shadow labour, flexible jobs can have the perverse effect of increasing informality, representing a chance for firms to "save" on labour costs, especially if individuals are willing to work more. I investigate informality in Italian Labour Market driven by the intense use of non-standard jobs, as part-time contracts. Italy represents a good and interesting setting, due to the highest levels of evasion and underground work, and the numerous interventions against shadow economy implemented by Governments. Using administrative data released by the Italian Social Security Institute (INPS) combined with data of firms' financial statements and inspections data, I construct an irregular job rate taking advantage from machine-learning technique and accruals model. What emerges from Italian setting between 2008-2017 is a greater tendency to use flexible jobs, reducing period and schedule. What I show in this chapter is that, combining different sources of data and methods it is possible to characterize potential irregular units, given the narrow amount of information available and observed, making also the inspection procedure more efficient. In my analysis, I consider informality in the form of informal workers employed by firms, from social security perspective. My microeconomic indicator of irregular job is consistent with the indicator of irregular job provided by ISTAT. Correlation is positive, equal to about 90% (in terms of R2), and statistically significant. Irregular firms have in mean highest values of part-time contracts, with highest levels in mean of contracts with a percentage of part-time under 50% and between 50 and 60%, while the lowest values in mean are for contracts with a percentage of part-time over 90%. Irregular firms take advantage from part-time contracts to hide full-time workers. In this sense, the propensity to have in mean part-time contracts with a percentage of part-time which is not to much high is in line with the hypotheses of informality: they are declared as a 50% part-time, saving on contributions, but workers schedule is higher.

Chapter 2

The economic effects of immovable property taxation: a review of the Italian experience.

Abstract

In this paper we review the results in the recent literature on the effects of immovable property taxation reforms occurred in Italy in the last decades. We first sum up the recent history of property taxation reforms and discuss why Italy represents a good experimental laboratory to identify their effects on various economic outcomes. Empirical contributions regard the impact of the ICI, introduced in 1993, and of the IMU, introduced in 2012, on local firms' investments, property values and households' consumption. We also review the findings related to the political economy of residential property taxation with respect to the incentives of local authorities, tax avoidance and voters' reaction.

2.1 Introduction

In the wake of the global economic downturn triggered by the financial crisis of 2007-08 and the sovereign debt crisis in Southern European countries, many observers and scholars have advocated property taxes as a fiscal remedy to public deficits (Panizza and Presbitero, 2014).[1] However, the macroeconomic literature has found mixed results on the impact of property taxes on GDP growth in developed countries (Kneller, Bleaney, and Gemmell, 1999; Widmalm, 2001; Arnold et al., 2011; Xing, 2012). The reason behind the non-conclusive results stems from the fact that the property taxation can affect different agents (households, firms, local governments, etc.) in the economy; as a consequence, its overall economic effect strictly depends on the degree of the impact on the various outcomes. Furthermore, governments tend to raise immovable property taxes especially during economic downturns, in order to meet their budgetary needs and fiscal consolidation objectives.[2] In such cases, cyclical fluctuations of the aggregate economy and the potential concurrent changes of other taxes, may confound the precise identification of the impact of immovable property tax reforms.[3] It is therefore difficult to establish a robust and univocal empirical estimate of the impact of property taxation on a country's macroeconomy.

The more recent literature has recognised these limitations and has focused on the effects of property taxation from a microeconomic perspective, trying to isolate the different channels through which property taxation can impact real outcomes. This paper aims at reviewing this type of contributions with a focus on the evidence drawn from Italy. The recent Italian experiences in terms of property tax reforms represent a good laboratory for the micro-econometric estimation of the impact of property taxation for different reasons: 1) different reforms occurred in Italy in the last decades, especially with regard to the transition from the *Imposta Comunale sugli Immobili* (ICI, hereafter) to the *Imposta Municipale Unica* (IMU, hereafter) in 2012; 2) property taxation is highly decentralised in Italy, providing large cross-sectional variation within the country, especially at municipality level.

Property tax is one of the main sources of fiscal revenues for local governments in many countries and it is widely applied to a large fraction of both residential and business capital (Norregaard, 2013); in this respect, Italy is not an exception.Indeed,

[1] This is a joint work with Edoardo Di Porto and Tommaso Oliviero, published on *Economia Pubblica* (2021).

[2] The readers may refer to Arachi et al., 2012 for a detailed discussion on the Italian 2012 experience.

[3] The readers may refer to Oliviero et al., 2019 for a discussion of the macroeconomic literature on property taxation and on the issues related to the identification of its impact.

Italian municipalities' current revenues are mainly composed by three sources: revenues from taxes on property or income etc., transfers from higher-level governments and other non-tax revenues. On average, in period 2008-2016, property tax revenues represented about 42% of total fiscal revenues, and about 15% of total revenues.[4]

The economic literature argues that local property tax exerts distortionary effects on different margins, such as house prices or employment or the use of capital at local level (Mieszkowski and Zodrow, 1989; Zodrow, 2001). Seminal contributions of the literature dates back to more than 50 years (e.g. Netzer et al., 1966); for a comprehensive review of the effect of local taxation on resource allocation, we remind the reader to Bartik (1991), while for a more recent reference on empirical local public finance, we remind the reader to Revelli (2015). Despite this established and deep attention, the estimation of the impact of immovable property tax is still a largely debated issues in the public finance literature. In this paper, we will review the contributions in this literature that focus on the Italian experiences.

Finally, as discussed by Messina and Savegnano, 2014 property tax is more transparent than other taxes: transparency should induce less avoidance and could be more salient to local tax-payers; furthermore property tax has important distributive impacts, and consequently reforms of the property taxation may have non-negligible political economy implications.At the same time, it has been argued that property taxation is highly unpopular (*The Hated Property Tax: Salience, Tax Rates, and Tax Revolts*). For these reasons property taxation reforms in Italy have been explored in relation to their political economy consequences; a final section of the paper is devoted to a review of the contributions to this strand of the literature.

The rest of the paper is organized as follows: the section 2 highlights the recent history of immovable property taxation in Italy; section 3 describes the methodological issues in studying the effects of the property tax and discusses why the Italian case is particularly interesting from the perspective of public economists; the section 4 reviews the recent contributions in the literature about the economic impact of property tax reforms in Italy; the section 5 concludes.

2.2 The recent history of property tax in Italy

In the last decades, Italy has gradually aligned the level of immovable property tax revenue over GDP to the OECD average. Figure 3.1 plots the time series of immovable property tax revenues in Italy from 1990 to 2018 and compares it with the average of OECD countries. The average level of property tax revenues over GDP in the last decades is around 1% for OECD countries. As clearly showed by the figure Italy

[4]Source of data: AIDA-PA, Bureaus Van Dijk. Statistics are from authors' calculations.

witnesses two main changes related to two property tax reforms: 1) in 1993 Italy, introduced for the first time a taxation on immovable property tax the ICI, passing to a level of about 0.85% of property tax revenues over GDP. The figure shows that in 2008, there has been a significant drop in tax revenues over GDP to 0.6%; this has been related to a tax reform which reduced the property tax on primary residences; 2) in 2012 the IMU tax system replaced the ICI; as a consequence, Italy passed to a level of immovable property tax revenues over GDP of about 1.5%, reaching a level significantly above the OECD average. In the two following sub-sections we will describe in more details the main content of the tax systems, ICI and IMU; in the subsequent section we will discuss why the Italian case is of particular interest with respect to the methodological challenges by the public economics literature.

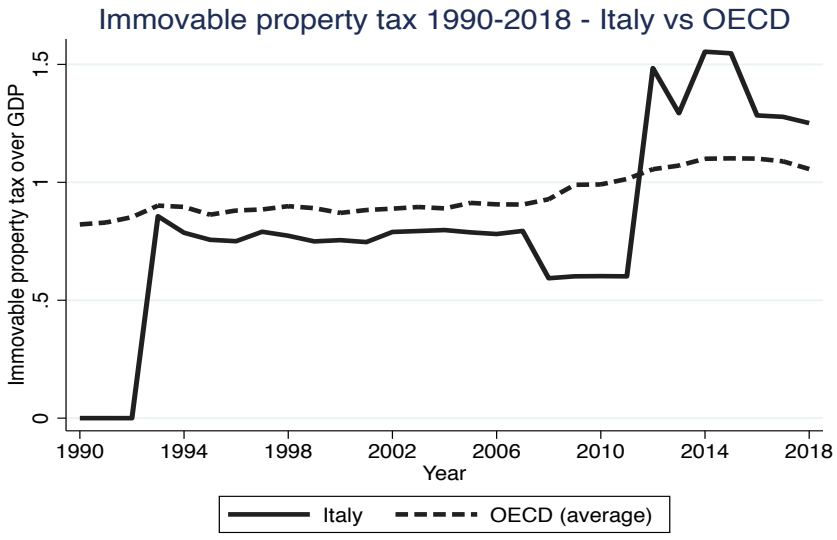


FIGURE 2.1: *The figure plots the ratio between Total Immovable Property Tax Revenues over GDP from 1984 to 2017. (source: OECD)*

2.2.1 1993 - ICI

The ICI system has been introduced in 1993.[5] It consists of the taxation on properties (residential, commercial, industrial buildings, agricultural and residential land) and has been paid by their owners or possessors. Tax revenues are collected by the municipalities where the property stands. The tax base is represented by the cadastral value of the property revalued by 5% and multiplied by a factor which depends on the nature of the property (for instance, the multiplier is 100 for residential properties, while it is 50 for hotels).[6] The tax duty is obtained by multiplying the tax

[5] Decree Law 30/12/1992, n.504.

[6] The rationale for the multiplier equal to 100 for residences is a discount rate of 1% according to a simple perpetuity formula.

base to the tax rate set by each municipality. The national statutory tax rate has been initially set at 0.4% and could be modified up to 0.7%, in case of documented extraordinary municipal balance needs. As highlighted by Pellegrino, 2007, from 1993 to 1997, the ICI is disciplined by the central government and very few municipalities set a tax rate at the maximum level of 0.7%. Starting from 1997, the central government allows each municipality to self-discipline the property tax system within some boundaries prescribed by the national law.[7]. Under the 1997 law regime, each municipality can in fact differentiate properties depending on their use (for instance if used as primary or secondary residence). A deduction of 180.000 liras (93.5 euros about) applies to tax duties related to primary residences, which is defined as the property where the owner or the possessor has its residence. The 1997 law also allows each municipality to decide upon the deduction.

As highlighted by Pellegrino, 2007 two main issues arises regarding the ICI regime. First, from 1997, the average tax rates on primary and secondary residences steadily increased over time; second, the cadastral value of properties remained fixed over time and did not update according to the changes of the market values. This increased the property tax bill for the Italian households over time and created relevant differences in the tax liabilities among properties of similar market values.

Following the national elections in 2008, the newly elected government introduced a tax exemption of the taxation on primary residences. This fiscal reform was approved at the end of July 2008 and followed a reform in 2007 that increased the amount of deductions for primary residences. The timing is crucial as it is been exploited by Di Porto, Martino, and Ohlsson, 2021 to study the effect of the reform on tax avoidance as we will review in section 4.

2.2.2 2012 - IMU

From middle 2011, Italy has been hit by a tremendous sovereign debt crisis. This crisis lead to the birth of a coalition government in November which lead to the approval of a fiscal consolidation reform contained in the "Manovra Salva Italia".[8] Arachi et al. (2012) report the main tax measures included in the 2012-2014 fiscal package and show that the largest incidence of the tax measures regards the introduction of a new immovable property taxation regime (IMU) with the abolishment of the previous regime (ICI).

The IMU system introduces three main innovations with respect to the previous regime: 1) the main dwelling, irrespective of the category, is re-included in the tax base; 2) the tax base increases: the tax base is represented by the cadastral value of the property revalued by 5% and multiplied by a factor larger than in the ICI system

[7] Decree Law 15/12/1997, n.446.
[8] Literally translated: "Save Italy Reform".

(for example the factor was equal to 160 instead of 100 for residential properties and 60 instead of 50 for hotels); 3) a differentiated tax system for primary and other immovable properties: the basic tax rate is set equal to 0.4% of the tax base for primary residences and to 0.76% for the other properties. Each municipality is allowed to modify the tax rate on primary residences within a +/-0.2 percentage points band and the other properties' tax rate within a +/-0.3 percentage points band. Similarly to the ICI system, the local authority has to deliberate on the approved tax rates by the end of October, otherwise the statutory rates apply; moreover, the government sets the basic deduction of 200 euros on the tax paid on the main dwelling plus additional 50 euros per household member less than 26 (up to a max deduction of 400 euros).[9]

2.3 Methodological issues

This paper reviews the empirical evidence on the impact of property taxation in Italy with a focus on papers that implement a micro-econometric approach. Given that property tax rates are local in Italy, the baseline reduced form specification used by empiricists is of the following type:

$$y_{iat} = \beta_1 T_{at} + \beta_2 X_{iat} + \alpha_i + \delta_a + \psi_{zt} + \theta_{zt} + \epsilon_{it}, \tag{2.1}$$

where y_{iat} is a dependent variable related to taxpayer i realised decision on a specific outcome in location a at time t, T_{at} is the tax rate in jurisdiction a at time t, X_{iat} are time varying observed characteristics for taxpayer i, α_i and δ_a are time invariant unobserved effects respectively for taxpayer i or jurisdiction a. Importantly, to obtain a robust estimation of the relation of property taxes on economic outcomes in a spatial environment, it is crucial to take into consideration unobserved factors that at time t can affect individuals i or groups of individuals within a jurisdiction or even an entire jurisdiction a. In this respect, in equation (2.1) we distinguish between unspecified unobserved factors, which we label with ψ_{zt}, and specific unobserved factors that are due to spill-overs across jurisdictions, which we label with θ_{zt}. Spill-overs effect refer to the impact of changes in the taxation of a jurisdiction on the outcome of a neighbouring jurisdiction (for instance due to the mobility of tax-payers across jurisdictions); if such spill-overs exist, it is then important to take them into account in order to obtain consistent estimate of the impact of property taxes. This is a very general form for a linear regression. In the rest of the paper we reformulate this very general formulation in each specific empirical setting.

[9] Municipalities are allowed to modify also the level of the deductions, but, similarly to the evidence regarding the ICI system, this tool has been rarely used.

Duranton, Gobillon, and Overman, 2011 analysed the impact of business property tax on firms' performance providing a discussion on why previous empirical works have found no significant effects of taxes on firms' location decisions and the issues that may affect the consistency of the coefficients in equation 2.1. First, a location choice issue may arise from the fact that there should be several site's characteristics affecting the taxpayer's choices on where to localise its activities (choosing a plant for production or just buying an house to live) that are unobservable by the analyst, and likely correlated with both taxpayer's characteristics and local taxation. Second, a reverse causality may arise due to the likely correlation between taxpayer's decisions and many aspects of the tax system itself. Third, a relevant source of bias is likely given by the presence of taxpayer specific unobserved heterogeneity. The use of panel data allows to overcome heterogeneity problem, in addition a combination of spatial differencing and instrumenting appears the best solution in order to overcome unobserved time-varying site characteristics and the endogeneity of local taxation.

The recent empirical literature on property tax addresses these issues mostly relying on quasi-experiments: the key strategy to obtain a consistent estimates of the coefficients in equation 2.1 is to overcome the challenge of estimating the unobserved characteristics by relying on variation that is arguably orthogonal to them. The continuous reforms of the Italian property tax system have provided a flourishing terrain to set natural experiments and to exploit this estimation strategy.

2.4 Review of the literature: evidence from Italy

In this section we will divide the contributions in studies that exploit different dimensions and timing of the reforms that regard the immovable property taxation in Italy. We first focus on papers concerns the impact of the ICI system on different dimensions: urbanization, tax avoidance, business. Secondly, we focus on more recent papers that exploit the IMU reform in 2012 as a quasi-experimental setting by summarizing the results of paper that look at the impact on property values and on household's consumption. The third part is devoted to the political economy of property tax and its implications.

2.4.1 The impact of immovable property tax on urbanization

From its introduction, ICI represented the main tax revenue for Italian municipalities and one of the main budget revenues together with the transfers from the central government. The ability of increasing the revenues from ICI is however limited. In the previous paragraph we highlighted how municipal authorities are able, within pre-specified boundaries, to increase the revenues by setting an higher tax rate. In

fact, given that the tax base is represented by the cadastral value of properties which is not updated regularly at market value, the easiest tool to raise revenues is by increasing the tax rates. Alternatively, as highlighted by Ermini, Fiorillo, and Santolini, 2013, Italian municipalities may increase the tax base by increasing the total number of constructions. In the presence of the domestic stability pact (DSP) in 1999, which imposes stronger limits to the levels of deficit of local authorities, the increase in the total number of constructions represents a tool to increase revenues, and the fiscal capacity of the municipality, without impacting on the level of debt and on the level of the ICI tax rates (Pellegrino, 2007). To test for this hypothesis, the authors relate the variation in ICI revenues to the propensity of the municipality to issue building permits. Specifically, in the empirical analysis they collect data on Italian municipalities from 1999 to 2006 and estimate the following version of the benchmark econometric model:

$$y_{at} = \beta_1 \bar{T}_{at} + \beta_2 X_{at} + \psi_t + \epsilon_{it} \tag{2.2}$$

where y_{at} is the number of building permits released by a local council a at year t,[10] $\bar{T}_{at}$, differently from equation (2.1), is not measured by the local tax rate in municipality a at time t but by the logarithm of the amount of ICI revenue per capita, X_{at} is a vector of control variables which include other sources of local revenues (for example the revenues from taxes on waste and on the occupation of public spaces, the transfers from the government), local council geographical and socio-economic variables that can impact the demand and the amount of land consumption (such as total population, income etc.), and ψ_t are time fixed effect. Their estimates of the coefficient of interest β_1 show a significant positive correlation between the revenues from ICI and building permits. From this result, which cannot be unequivocally interpreted with a causal statement, the authors conclude that local property taxes are not used by local authorities to regulate the use of land but, on the contrary, it is used to increase their tax revenue with no regards to a possible overconsumption of land and environment. This "side effect" of Italian property tax is also confirmed by Bimonte and Stabile, 2015: they exploit the variation for a long time series (1980-2007) in order to study the relation between the growth rate of building permits and changes in the housing market and demographic characteristics in Italy and if this relation is affected by the introduction of ICI in 1993. They find that from the '90s, local municipalities adopted less tight urban policies to offset their budgetary needs; this mechanism is even stronger starting from the late '90s when the fiscal decentralisation and the DSP imposed stringent conditions on the fiscal and financial capacities of Italian municipalities. The common conclusion reached by

[10] The number of permits released at local level is used as a proxy for the consumption of land. The authors acknowledge that this indicator does not allow to retrieve the economic destination of land consumption

Ermini, Fiorillo, and Santolini, 2013 and Bimonte and Stabile, 2015 is that not only the introduction of the property tax did not slow down the supply side of the housing market, but, combined with the fiscal decentralization and the fiscal discipline rules, it even increased the land utilisation with possible negative long-run effects on the environment related to the urban sprawl phenomenon. Consistently, Ermini and Santolini, 2016 show how property tax rates differentials between cities' core and suburbs in urban areas had a significant impact on the expansion of Italian urbanised areas measured by population density. In particular, urban areas become more compact when the property tax rate of the hinterland rises relatively to the core municipality; this last result highlights that tax differentials between the core and hinterland on the level of the property tax may have side effect in terms of spatial expansion.

2.4.2 The impact of property tax on local business activity

Local property taxation in Italy concerns residential and business properties. Business tax (IRAP) is at regional level; this kind of tax was used to be the same at national level, but during the 2009 some regions increased the tax rate in order to adjust their fiscal budget. The following subsection concerns the impact of local property taxation on firms performance.

Belotti, Di Porto, and Santoni, 2020 estimate the effect of local non-residential property taxation on firms performance for the period 2001-2010, using AIDA dataset, provided by Bureau Van Dijk. Authors try to investigate and test the effect of the local taxation on employment, but also they evaluate the effect on firms sales and TFP. For the local property tax, data are taken from the Ministry of Economy and Finances. By exploiting firm level panel data in which firms are geo-localized, authors expect non-residential property tax to affect not only employment but also a negative effect across other dimensions. The econometric strategy is the following:

$$y_{it} = \beta_1 r_{at} + \beta_2 a_{it} + \beta_3 a_{it}^2 + \alpha_1 + \delta_a + \psi_{zt} + \theta_{zt} + \epsilon_{it} \tag{2.3}$$

where y_{it} is the log outcome of firm i at time t, r_{at} is the tax rate in municipality a, a_{it} and a_{it}^2 second order polynomial of the firm age, α_i is a firm fixed-effect which captures the impact of the unobservable time-invariant firm characteristics, ψ_{zt} source of time-varying heterogeneity for location z, θ_{zt} time-varying effect for location z, ϵ_{it} is the idiosyncratic error. β_1 captures the net effect of the municipal tax rate.

In the model implemented it is likely the tax rate of a municipality to be correlated with time-varying effect for location z. In this case the use of the instrumental variable is not successufull: spatial differentiation overcomes this problem. Following Duranton, Gobillon, and Overman, 2011, for each time t it is taken the difference

between each reference firm and any neighbouring firm located at a distance less than d from the reference one. In this way only neighbouring firms located across municipalities are considered to correctly identitfy the effects of taxation. In this case the novelty is given by the instrumental strategy based on the politcal alignment of municipal government with the central one, distinguishing if this alignment is with the right-wing or the left wing. Authors provide evidence that tax is not capitalised into prices, but a negative effect can be seen on employment, productivity and sales. An increase in the property tax rate leads to substantial reductions in firms employment (i.e., a growth slow-down effect) and no evidence of selection due to property taxation.[11] Robustness checks are implemented considering the firm size: large firms are excluded in order to rule out multi-plant firms, firms located in specific Italian regions (Campania, Abruzzo, Lazio, Molise and Sicilia), which imposed in 2008 a greater tax rate for the business tax, are not considered in the sample. The last robustness check is geographical, using the sub-sample of firms in the Northern regions. This choice is justified because the most of the manufacturing firms are located in the North of Italy.

2.4.3 The impact of the property taxes on property values and households' consumption

In this subsection we focus on contributions that analysed the impact of the introduction of the IMU. In the previous paragraph we highlighted that one peculiarity of the tax was that each municipality could set the tax rates on the primary residences (Imu Prin, thereafter) and on secondary dwellings (Imu Sec, thereafter). Oliviero and Scognamiglio, 2019 show that there is substantial cross-sectional heterogeneity among Italian municipalities in relation to both the Imu Prin and the Imu Sec and exploit this variation to estimate the impact of the property tax on property values. In particular, by using data on average property values for each municipality,[12] at each semester from 2010 to 2013, they estimate the following version of the benchmark equation 2.1:

$$y_{at} = \beta_1 T_a * Post_t + \delta_a + \psi_t + \epsilon_{it}, \tag{2.4}$$

[11] Local taxation represents a cost that can be reduced by moving production facilities to a new location characterized by a lower tax rate. However, if a firm choose to relocate, then it will face the cost of moving its assets to the new location. Clearly, if relocation costs are higher than local taxation costs regardless of the location, a firm will linger in its original location suffering what Duranton, Gobillon, and Overman (2011) define as slow-down effect; while if it relocates this will cause the so-called "selection" effect. Indeed, movers are likely to be the most efficient firms and will tend to relocate in low tax rate jurisdictions.

[12] The data are provided by the OMI (Osservatorio del Mercato Immobiliare - Agenzia delle Entrate). For a detailed description of the source of the dataset and of the evolution of the Italian housing market in recent years, we remind the readers to the *Statistiche Catastali, 2006-2018* by the OMI and to the *Immobili in Italia, 2011-2018* by the MEF (Ministry of Economics and Finance).

where y_{at} is either the log of house price per square meter or the log of rent per square meter in municipality a at time t, T_a is a measure of property tax intensity for each municipality a and is a linear combination of the property tax rate on primary residences (Imu Prin) and on other residences (Imu Sec) in 2012, $Post_t$ is a dummy that takes value equal of 1 after the introduction of the IMU system (2012) and zero in the two years that preceded it (2010 and 2011), δ_a captures unobserved time-invariant characteristic at municipality level and ψ_t absorbs any shock common to all municipalities that may affect the outcome of interest. To account for the endogeneity problems arising from the estimation of the impact of the property tax rates, the authors combine the difference-in-difference estimation strategy in equation 2.4 with an instrumental variable approach based on the timing of the municipal elections. As showed by Alesina and Paradisi, 2017, municipalities that did not have elections in 2013 set higher tax rates on primary residences than the others.[13] The authors show that the timing of elections is as good as randomly assigned with respect to their outcome of interest and instrument the variable T_a with the occurrence or not of municipal elections in 2013. The LATE (local average treatment effect) estimate shows that a 0.1 percentage points increase in the tax rate induced about 4% reduction in municipal average property values in the year subsequent to the reform. While the effect is large, the authors show that the population of compliers shows low levels of quality of local governments and this justify a reasonably large degree of property tax capitalisation.

The result of this paper confirms the theoretical hypothesis that property taxes are capitalized into property values; in other words, property taxes impact the demand for housing and finally, depending on the steepness of the supply curve, affects the equilibrium prices. The distortionary effect of the IMU on the demand for properties is only one side of the empirical findings on the effect of this tax reform. Surico and Trezzi, 2015 study the income effect of the IMU on the consumption of the Italian households; they estimate the following version of the benchmark equation at individual level:

$$y_i = \beta_1 T_i + \beta_2 X_i + \epsilon_i \tag{2.5}$$

where y_i indicates the change in consumption expenditure (either in non-durable or durable goods) of household i between 2010 and 2012, T_i is the amount of Imu tax paid on either the main or the secondary dwelling or both in 2012, the set of controls X_i includes the self-reported change in house price between 2010 and 2012,

[13] The hypothesis of the authors is that municipalities that had elections in 2013 set lower tax rates than the others for political economy reasons. In particular, the incumbent municipal council, to increase the chances of being re-elected, decided one year before the voting to set lower tax rates on primary residences only. This is related to the fact that in Italy the homeownership rate, especially in small municipalities, is very high and a relatively lower tax rate may have increased their consensus for a big constituency.

households demographics (age, homeownership status, educational attainment of the household head, family size etc.), regional dummies, property characteristics and a set of dummy variables capturing expectations about future income and about future local house prices. They show that the tax paid on the primary residences had a significant negative impact on the consumption of durable goods. This income effect is strongly related to a reaction of homeowners with a mortgage and likely to be liquidity constrained.

This paper confirms that also the property tax can have distortionary impact on the behaviour of economic agents when it is combined with market frictions that prevent fully insurance against negative income shocks.

2.4.4 Property tax avoidance

In this subsection the attention is on the impact of tax reforms on tax avoidance.

The Italian reform of 2008 abolished property taxation on the principal residences and increased it on the secondary ones. Di Porto, Martino, and Ohlsson, 2021 estimate the causal effect of the property reform on inter vivos trasnsfers, providing evidence of property tax avoidance. The analysis is based on the idea that Italian families, taking advantage from the new reform, started to redistribute property among their members, in order to avoid taxes on secondary properties. The result is that, without any costs because of a very low taxation on property gifts, child of a particular family acquires the property of the residence, that becomes his/her principal residence and, as a consequence, he/she does not have to pay tax. After 2008 tax reform the probability that high-wealth donors made an inter-vivos property gift increased by 3% and the size transferred by 4 meters squared relative to less wealthy donors increased. In this case the natural experiment is drawn defining as treatment group taxpayers affected by the reform (high wealth donors), compared with the unaffected (less wealthy donors) as control group.

Information on donors and recipients are taken from the Survey on Household Income and Wealth (SHIW) provided by the Bank of Italy, from 1998-2002. Using a difference-in difference approach, the econometric strategy is the following:

$$y_{it} = \beta_1 HOPD_i + \beta_2 Post2008_t + \beta_3 Post2008_t * HOPD_i + X_{it}^d + X_{it}^r + \epsilon_{it} \qquad (2.6)$$

where y_{it} is the dependent variable that specifies if a property was ever given inter vivos or the number of the square meters given inter vivos. This two outcomes capture respectively the extensive and the intensive margin. $HOPD_i$ is an indicator for high parental occupation donors, $Post2008_t$ indicates the post reform period, $Post2008_t * HOPD_i$ is the interaction term that marks observations with high

parental occupation donors after reform. A set of year indicators are used in order to capture time invariant or cross-sectional invariant factors. Authors are able to compute the amount of tax avoidance due to inter-vivos transfer. It is estimated to be around 78 millions, 4% of the annual tax revenue from principal residences. The crucial effect in their analysis, induced by the avoidance behaviour, on the tax base erosion is driven by intra-families transfers. An additional evidence concerns how donation affects families' behaviours in terms of income, consumption and savings. It is defined an experiment where the treatment is receiving a house as a property gift. In this case, because the treatment cannot be assumed as random, in order to distinguish treatment and control group, under specific assumptions, authors implement a fuzzy DID design, where the ratio between the DID of the outcome and the DID of the treatment is a consistent estimator of the LATE. In terms of income coming from the property, the intra-family transfer should increase the spending capacity of the recipients; in terms of household's wealth, it is reasonable to assume that receiving a house increases the value of real estate and this can be seen linked with an increase in the detention of financial assets.

2.4.5 The political economy of property taxation

Property taxation is not popular among taxpayers and consequently it is unpopular also among local politicians (i.e. mayors of municipalities); indeed, mayors may tend to manipulate local property taxes more than other taxes because it is salient among payers who naturally represent their (potential) voters in future elections. Bordignon, Grembi, and Santino, 2017 analysed the effect of the introduction of a less salient tax through the Italian reform of 1999. Italian municipalities were allowed to partially substitute revenues related to property taxation with less transparent ones. They estimate how mayors, who have to face re-electoral concerns, react to the possibility of using a less transparent tax compared with mayors who face term limit. They construct a panel of 7,583 municipalities and consider the municipal electoral rounds in the period 1995-2005; each mayor is classified as eligible or not for the next election. Using a difference-in difference approach, they estimate the following econometric model:

$$Y_{it} = a_i + \gamma_t + \beta Elegible_{it} + \delta Elegible_{it} * After1999 + X'_{mt}\tau + \epsilon_{it} \tag{2.7}$$

where Y_{it} is the outcome of interest (either total tax revenues or property tax rate or deductions on the resident tax or business property tax rate) for municipality i at time t, *Elegible* is a dummy variable equal to 1 if a mayor faces reelections, zero otherwise, a_i are municipalities fixed effects, γ_t are yearly fixed effects, $After1999$ is a dummy variable which takes value 1 for year 1999 (1999 included), δ is the parameter of interest. Results are in line with the political agency model: mayors

who are in their first term tend to use less intensively more salient tax, like the property tax on residential buildings, with respect to mayors who face the end of their mandate.

As highlighted in the section 2.2, in 2011 the IMU replaced the ICI. Using the timing of the introduction of the fiscal reform, Alesina and Paradisi, 2017 estimate the causal effect of having close municipal elections on the decision regarding the IMU tax rates by the incumbent local politician. Starting from the idea that close electoral incentives can imply different reactions by local politicians, it is reasonable to think that governments could try to strategically manipulate fiscal policy tools in order to gain consensus among voters. Exploiting the fact that the timing of municipal elections in Italy was orthogonal to the decision by the central government of introducing the IMU, the authors estimate the impact of having close elections in 2013 on the IMU tax rates set by municipalities in 2012. In particular they estimate the following model:

$$Y_{a,p} = \beta Elec_{a,p} + \gamma X_{a,p} + \lambda_p + \epsilon_{a,p} \tag{2.8}$$

where Y_a is the outcome of interest (either the IMU tax rate on primary or secondary residences set in 2012) for each municipality a, $Elec_a$ is a dummy variable that takes value of 1 if elections are planned to take place in 2013 and zero otherwise, $X_{a,p}$ are control variables at municipality or province level, and λ_p are province fixed-effects.

Results show how having closer elections affect the IMU tax rates set in 2012; the authors highlight that the effect is particularly evident in the Southern Italian regions; this is consistent with the literature on the effect of civicness on control of local politicians: lower civicness is presumably associated with less control of local politicians who can strategically manipulate policies to their advantage.

A second experiment is designed considering only municipalities that did not vote in 2012, taking advantage of the randomness of the number of years lasting to next elections in each municipality. The model estimated is the following:

$$Y_{p,i} = \beta NTE_{p,i} + \gamma X_{p,i} + \lambda_p + \epsilon_{p,i} \tag{2.9}$$

where NTE counts the number of years lasting to next elections for municipalities that do not elect in 2012. Authors provide significant evidence of a strategic manipulation by governments through a choice of a lower tax rate if a new election is close. Moreover, it is possible to identify a strategic interaction between tax and public spending determination. Fiscal interaction is one of the main result of yardstick competition: citizens make comparative performance evaluation across government in order to better evaluate the quality of their politicians' decisions. Bordignon, Cerniglia, and Revelli, 2003 test the presence of yardstick competition in Lombardia, a large region in Italy. They build a dataset on local property taxation

in a sample of Lombardian municipalities. Their purpose is to inspect, using the information available in the sample, if mayors who should not be concerned with election outcomes behave differently in their tax setting decisions with respect to the other mayors, using information on the local choices of property tax rate.

Bocci, Ferretti, and Lattarulo, 2019 use spatial model to detect the determinants of fiscal policies and inspect the presence of yardstick competition, but differently from Bordignon, Cerniglia, and Revelli, 2003, they conduct their experiment considering all the Italian municipalities. Fiscal policies adopted on property tax in Italy in 2014, with respect to taxation on both residential and business properties are evaluated. Authors construct an index which indicates the percentage of the municipal total tax revenue due to the fiscal policy on real property. The index measures the additional burden on inhabitants and firms produced by the property tax policy. They the relation between the imitative behaviour and the municipality size in order to evaluate if the latter influences the spatial interdependence. Through spatial model it is explained how not only balance sheet variables, but also political and socio-economic aspects, and the behaviour of neighbouring municipalities affect policy decisions. Moreover there is no evidence of the presence of yardstick competition. Finally results show that budgetary constraints and Internal Stability Pact can force policies to higher fiscal effort.

Padovano and Petrarca, 2014 build upon the literature concerning on the yardstick competition. The innovation of their analysis is looking at different indicators of popularity and several specifications of inter-jurisdictional comparison. The first contribution to the literature is given by the estimation of the potential correlation between the popularity of the mayors and their fiscal decisions consistently with yardstick competition theory. The second contribution is given by the dataset used, including all the Italian municipalities for the whole period when the mayors could set the local property tax rate (1995-2007). The third contribution is given by the institutional setting: in Italy mayors directly decide the proportional tax rate to finance municipal expenditure and voters directly elect their mayors. Italian framework allows to make a inter-jurisdictional comparison of fiscal performance, where elected mayors are directly accountable for voters. The estimated econometric model is the following:

$$P_{it} = \beta_0 X_{it} + \beta_1 TaxDifference_{it} + v_{it} \tag{2.10}$$

where the dependent variable P_{it} measures the electoral popularity of the mayor as the local win margin in jurisdiction i at time t. X_{it} represents electoral, political, economic, and fiscal determinants of the mayor P_{it}. The variable of interest is the residential property tax rate difference which is calculated as the difference between the tax rate in the jurisdiction i and the average tax rate in the neighbouring

jurisdictions.
Results of the vote popularity equation confirm how differences in fiscal performances among jurisdictions can influence the probability of mayors of being re-elected. With respect to the spatial tax setting equation, results show significant strategic interactions among the fiscal decisions of neighbouring municipalities: mayors tend to take into account their neighbours' decisions when they face a fiscal decision.

Finally, applying a microsimulation model Pellegrino, Piacenza, and Turati, 2011 study the distributive impact of housing taxation on taxpayers. The model uses as input data Survey on Household Income and Wealth (SHIW) provided by the Bank of Italy, as a representative sample of Italian population, considering information on households income and wealth. The authors evaluate the distributive impact of the 2008 reform, which abolished the ICI on the main residence; they find that households who benefit the most by such reforms are the ones at the top of the income distribution. This has potentially strong political economy consequences, that are explored by Pellegrino and Turati, 2011: they estimate the distribution consequences of a budget-balanced tax reform that reduces the income tax while increasing the property tax on the main dwelling. They find that, under reasonable calibration of the model, the share of winners from such a tax change could be larger than losers, and conclude that a political majority supporting this reform is potentially attainable.

2.5 Final remarks

In this paper we have attempted to review all the empirical contributions related to the economic impact of immovable property tax in Italy. This kind of impact is difficult to estimate, as the theory suggests, because of the endogeneity problem that may arise and the possibility of many sources of bias given by unobserved heterogeneity. Italy represents a good set of natural experiments: the continuous fiscal reforms during the years give the possibility to construct quasi-natural experiments to be exploited for identification. We have showed how researchers have estimated the impact of property tax on business activities, households' choices in terms of consumption and tax avoidance, local governments and urbanisation, local property values and incentives by politicians. The aim of this paper has been to collect all evidences regarding the Italian experience and to provide to the readers, both academics and policy makers, a comprehensive framework to study all the potential economic impacts of immovable property taxation.

Chapter 3

Is the property tax a capital tax?

Abstract

This chapter studies the impact of the local property tax on business by exploiting a tax reform approved in Italy at the end of 2015, when heavy equipment are excluded from the business property tax base. Difference-in-differences estimates document that property tax reform affects capital investment: firms that previously employ heavy equipment increase their capital more than other firms. Increasing capital determines effects on firms' production: with fuzzy difference-in-differences I show that for treated firms the augmented level of capital entails an increase in value added and profits in the post-period.

3.1 Introduction

Property tax is a form of capital taxation,[1] applied to residential and business capital. Both theoretical and empirical literature discuss the issue of the property taxation. In contrast with the *benefit* view (Hamilton, 1976) of the property tax as non-distortionary "benefit" tax fully capitalized into property values,[2] theory also supports the *capital* tax view, which implies distortionary effects of the property taxation in allocation of capital, including housing capital and the level of local public services (Mieszkowski, 1972; Zodrow and Mieszkowski, 1983; Zodrow and Mieszkowski, 1986). The property tax acts as a tax on capital, and it cannot be seen as an efficient tax (Zodrow, 2001). As a tax on capital, and being capital mobile, especially business capital, the distorsive mechanism of the property tax is more likely to hold for business capital than residential (Nechyba, 2001). In line with the *capital* tax view, empirical literature has provided evidences of the distorsive effects of the local property tax on resource allocation choices.[3] The link between local taxation and resource allocation is analyzed looking at firm location decisions, due to the different tax rates set by jurisdictions, to assess the inefficiency of the local property tax on business capital.[4] The main econometric issues faced by researchers in the empirical evaluation of the property taxation effects are: unobserved firm location heterogeneity, unobserved time-varying site-specific effects and the endogeneity of the local taxation. In order to overcome them, Duranton, Gobillon, and Overman, 2011 develope "spatial differencing",[5] and find the negative impact of the local property tax for English firms on employment growth and no effect on entry, documenting that property revaluations (which determine the tax base) occur in case of building expansion and magnify the effects of an increase in property tax. These revaluations

[1] Capital taxation: property tax, net wealth tax, inheritance/donation tax, capital gains tax.

[2] The *benefit* view is an extension of the Tiebout, 1956 hypothesis: independent local governments offer a wide variety of expenditure and tax policies, and perfectly mobile consumers reveal their preferences for local public good. Because public good is financed by taxes paid, consumers with their location choices reveal their preferences not only in terms of public good provisions, but also in the level of taxes. The *benefit* view predicts that individuals, given a wide range of options, will not be willing to pay more in property tax than what they receive from it in benefits. Consequently, the property tax and the public services it finances are capitalized into property values. Competition starts when regions taxes are kept low enough to induce individuals to stay in that region instead of choosing another, given the level of public good provided.

[3] For a comprehensive review of the effect of local taxation on resource allocation, see (Bartik, 1991). For a more recent reference in the literature on its impact on local public finance, (Revelli, 2015). Seminal contributions of the literature dates back to more than 50 years, see (Netzer et al., 1966).

[4] The *capital* tax view predicts that higher levels of property taxation implies inefficient land use and a misallocation of capital to low tax jurisdictions.

[5] Duranton, Gobillon, and Overman, 2011 lay out how spatial differencing, combined with time differencing and instrumentation, can overcome endogeneity issues due to tax setting to unobserved local economic shocks. Firms in different local jurisdictions are subject to different tax rates, but are otherwise affected similarly by unobserved local factors. Spatial differencing technique allows to control for any local shock that spills over to both firms and which maybe correlated with tax policy.

can act as a major break on local employment growth by limiting the expansion of establishments in that municipality or by forcing them to move away in others. In Italy Belotti, Di Porto, and Santoni, 2020, using "spatial differencing" too, evidence the negative effect of the local property tax on business taking advantage from the exogenous variation in local property tax rates caused by the political alignment of local and central governments. Local property tax on business has a sizeable negative impact on equipment, employment, and value added. In contrast with Duranton, Gobillon, and Overman, 2011, the effect is seen on equipment, a part of tangible fixed assets more volatile than buildings. Moreover, a stronger distortionary mechanism is suggested when "heavy equipment" are included in the business tax base. The inclusion of heavy equipment in the business property tax base induces firms to depress investments and downsize.

In this chapter, I investigate the effect of the local property tax on business taking advantage from the Italian institutional setting to exploit the effect of a change of the business property tax base and I evaluate the distorsive mechanism suggested by Belotti, Di Porto, and Santoni, 2020 due to heavy equipment inclusion in the business property tax base. I look at firms' response in capital investment after the exclusion of heavy equipment from the business property tax base. At the end of 2015, Italian government approves the exclusion of a type of heavy equipment, the so called *imbullonati* (hereafter, *BHE*, bolted heavy equipment) from the business property tax base.[6] Until 2015, a firm that employ *BHE* within production process must include them in the business property tax base for the local property taxation, in addition to the other properties (lands and buildings). So that, *BHE* have differentiated the business property tax base between firms during years. At the end of 2015, the Domestic Stability Pact (hereafter, DSP) of 2016 rules out *BHE* from the business property tax base. The 2016 reform arrives following an intense debate on the legitimacy of *BHE* taxation. As intermediate input for economic activities and not an increase of business properties, taxing *BHE* is considered as "unfair" by Italian managers. Starting from 2012, debates about the tax are frequent. Already in 2014, after the change of the Italian Prime Minister, the *BHE* removal is programmed as one of the necessary goals of the new government. Nonetheless complaints, at the end of 2014 the DSP of 2015 confirms the tax. Then in 2015, finally, Italian managers obtain to abolish it. The reform is approved at the end of December 2015 and it is effective starting from the the beginning of 2016. So that, it is likely firms have made changes in anticipation of the reform implementation. Moreover, municipalities heavy affected by the fiscal loss consequently the reform, ask and receive a monetary refund by Italian government equal to the exact fiscal amount related to the *BHE* taxation, confirming in this way its great impact also at municipal level, as local financial

[6] *BHE* are necessary input for a specific economic activity, "fixed" to the soil with bolts, with the possibility of being moved, relocated or even sold.

revenue.

I address the following research question: "How much a change in the local property tax on business affects firms' resource allocation decisions?". Differently from previous empirical contributions, I use a difference-in-differences design instead of "spatial differencing", overcoming in this way the possible sources of bias. In addition, I do not take advantage from differences in tax rates between jurisdictions, but on the difference in firms' tax base, driven by the ownership or not of *BHE* by firms, in different municipalities as well as in the same municipality. I use AIDA dataset, provided by Bureau Van Dijk, which collects balance statements of Italian corporate firms, for the sample period 2008-2017. I leverage the change in the total of equipment, in which *BHE* are accounted, as the source of the variation induced exogenous by the 2016 reform. My empirical approach is divided in two parts. In the first part, I combine a difference across firms that employ *BHE* versus not, with difference pre vs post, induced by the timing of the reform. Using a difference-in-differences approach, I look at the exogenous variation in the level of equipment for treated firms, compared with all the others not affected by the policy. In this way, I estimate the immediate and direct effect of the local property tax on firms' capital. Results show that after the *BHE* taxation removal, firms that employ *BHE* within production process invest more in capital, increasing their equipment, with an anticipation effect of the policy starting from 2014. My results document that the *BHE* removal causes an increase in equipment of 115,130 euros, about 43 percent of the median level of equipment in the pre-reform period (2008-2013). In the second part of my analysis, I use the greater variation of equipment for treated firms (firms that employ *BHE* within production process) as the source of variation to implement a Fuzzy difference-in-differences, allowing for heterogeneous treatment effects, in the spirit of De Chaisemartin and d'Haultfoeuille, 2018. Between 2014-2017, treated firms faces a greater increase of the treatment rate (the level of equipment), while for control firms the treatment rate remains stable. Following De Chaisemartin and d'Haultfoeuille, 2018, the Wald DID estimator accounts for the treatment effect heterogeneity across groups and time periods, robust to negative-weighting issues. The time-corrected Wald ratio accounts for the effect of time on the outcome in the treatment group. Results show that a 1 standard deviation increase of equipment for treated firms in the post-period (2014-2017), leads to an increase in value added and profits . In contrast with previous empirical contributions, my results do not imply effects in terms of employment (new hires by firms) but on the contribution of the existing inputs, capital and labour. As discussed by Diamond and Mirrlees, 1971, business property, as an intermediate input, should not be taxed in order to avoid distortions in production. In this sense, removing local property tax on *BHE* represents removing tax on an intermediate input. So that, the increase in value added,

through the augmented level of capital, implies that firms raise the value of products, making their labour force more productive.

The rest of the chapter is organised with Sections 2 where I discuss the institutional setting in which the reform is applied; Section 4 describes data; Section 5 explains the econometric approach; Section 6 concludes.

3.2 Institutional setting

3.2.1 Business property tax

In Italy the property tax is the IMU (Imposta municipale unica) introduced in 2011, which replaced the previous property tax called ICI (Imposta comunale sugli immobili), introduced in 1993. Property taxation is not actually a transaction with a specified price which could consist the tax base. Since no market transaction takes place, the benefit of the properties cannot be observed for tax purposes, but must instead be estimated or "imputed". The main prerequisite in order to apply the tax is the *ownership* of the property such as residential, commercial, industrial buildings, agricultural and residential land. It is at municipal level: revenues are collected by each municipality where the property stands and it has to be paid by owners. The property tax base is computed considering the cadastral value of the real estate revaluated of 5% and multiplied by a factor different for each category of the property. The base is given by the estimated value of the property, without regard to the real taxable capacity of the taxpayer.[7]

Business properties are considered by the Italian Law as "special properties", included in category D and E of the real estate register. The tax base is given by the cadastral value of business properties multiplying by the factor of 2% (if the category is D) and 3% (if the category is E). A firm must register all the properties owned for local property tax purposes. Originally, when IMU replaces ICI, for the year 2012, a share of the revenue is attributed to the State, equal to half the amount calculated by applying the standard tax rate of 0.76%. Since 2013, the portion of the

[7] In most cases property tax is calculated on the value of each piece of property separately, as examples in Italy, France, Portugal, Ireland and Greece, or it is given by the real estate property value as a whole, for example in Germany. In some countries the name of the property tax is different, depending on the nature of the properties (residential or non-residential; buildings or lands). In France there is the "Property tax" for buildings and premises, the "Land tax" applied for lands, and, until 2010, the "Tax on Professional Premises" on the non-residential buildings and premises (the tax base is 50% of the assessed rental value). In Germany there is the "Property tax", applied on Former Federal Area, in New Laender, and Agricultural and Forestry undertakings (tax rates change depending on the type of land). In Greece the property tax is applied on urban properties (State Property Tax, Local Property Tax, Special Property Tax), and there is the so called "Special Property Impost" on the urban property specifically connected with electric power systems, but not on the electric power system itself. In Spain there is the IBI (Impuesto sobre bienes inmuebles), which is applied on the cadastral value of the properties (as the same as in Italy), and in Great Britain there is the Uniform Business rate, applied to business properties.

IMU tax reserved to the State is abolished and the revenue from the IMU deriving from business properties is attributed to municipalities, calculated at a standard rate of 0.76%. Regard business properties, municipalities retain only the power to increase the standard rate of 0.76% by up to 0.3 percentage points until 1.06%, and to dispose of the additional revenue.

During years, local property tax on business has been deeply discussed in Italy.[8] Confartigianato (Italian Business Association) in 2018 observes that between years 2010 and 2017 the local property tax levy on business has had an increase of 11,5 billion (in 7 years it is more than doubled). It is calculated that the local taxation on business properties (buildings, technical rooms, soil, offices, etc) is around 9 millions, half point of GDP. The analysis of cadastral statistics shows, in terms of distribution of the taxable properties that business properties account for 59.0% of the total taxable amount.[9] Half (54.8%) of the cadastral income accounts for small firms, owners of 70.7% of the properties. In particular, the real estate tax burden weighs more heavily on the creation of value of micro-firms that record an income of 20.9 euros for every 1,000 euros of value added, a value of 37.0% higher than the 15.2 recorded by medium-large companies. Table 3.1 reports the evolution of tax levy between 2012-2018 for the IMU, comparing residential and business properties. The total tax levy for IMU in 2018 is equal to 19,8 billions, it is decreased significantly compared to 2012 (- 4,9 billions). A significant decrease of tax levy for IMU is seen starting from 2016 for business properties, first year in which it is effective the *BHE* taxation removal.

The real estate levy represents an important item of municipal income. A comparison between standard needs and historical expenditure in municipalities of regions with ordinary statute highlights that 30.7% of the expenditure is managed in inefficient municipalities that offer fewer services, recording, however, an historical expenditure that is 18.7% higher than the standard requirement. The inefficiency of municipal expenditure translates into higher taxation: the levy for a micro-small firm located in inefficient municipalities - and therefore benefiting from a lower level of services - is 4.8% higher with respect to a similar one operating in efficient municipalities (Confindustria, 2015).

[8] According to PWC and Bank, 2020 (annual study from PWC and the World Bank Group) Italian firms pay more taxes than the other European countries, being penalized in global competition. For the World Bank, Italian total fiscal burden (Total tax and contribution rate) is equal to 59,1%, compared to a global burden of 40,5% and an European burden of 38,9%.

[9] C/1 Shops and workshops for 21.7%, D/8 Buildings built or adapted for the special needs of a commercial activity for 18.2%, D/7 Buildings built or adapted for the special needs of a industrial activity for 17.8%, D/1 Mills for 15.2%, A/10 Offices and private studios for 14.1%, D/2 Hotels and pensions for 7.8% and C/3 Laboratories for the arts and trades for 5.2%.

3.2.2 The *BHE* taxation

Italian managers have always criticized the excessive tax burden on firms, particularly high especially if it is compared with the other countries. The general view is that taxing business properties is "unfair": business properties are intermediate input for production process and not an accumulation of business assets, so the payment of the local property tax appears with no reasons, hurting business activities.

Until 2015, tax burden for some Italian firms is impacted by the *BHE* taxation. A firm that employ *BHE* within production process must register these heavy equipment to the real estate register (in addition to the other properties), and their specific cadastral value contributes to the total business property tax base. With regard to *BHE* taxation, debates have been intense. Including *BHE* in the business property tax base arises from an interpretation of the law, proposed in 2008 and confirmed in 2012: if equipment or similar are "fixed" to the soil, they have to be considered as a stable unit of that real estate (stable also in terms of time), so it is suitable to characterize and affect the real estate appraisal of that real estate.[10] From 2012, Italian firms have asked for a revision of the law and for the *BHE* taxation removal, but expectations are disregarded. In 2013, there is again the request of the *BHE* taxation removal, but at the end of the year the DSP of 2014 confirms the taxation. A signal starts to be seen in 2014, when there is the change of the Italian Prime Minister.[11] The new government announces the *BHE* removal as one of its necessary goals. At the end of 2014, the DSP of 2015 confirms again the taxation. The vice-Minister for the Economy discusses in interviews about the *BHE* and the continuous request by Italian managers to be taken into consideration. The vice-Minister, in November 2014, guarantees that the *BHE* removal will be part of the purposes for the 2015. After these claims, expectations during 2015 are high and in September of the same year, the Prime Minister, during television interviews, officially announces the *BHE* taxation removal. Indeed, at the end of 2015, the DSP of 2016 rules out *BHE* from the business property tax base.

The *BHE* taxation removal represents a consistent saving for firms, which can be seen also in terms of tax revenues for municipalities. Table 3.2 reports the percentage change in the IMU on business properties classified by economic sector codes. The *BHE* IMU exemption results in a tax reduction approximately equal to 350 million euros on annual basis. In all the economic sectors there is a substantial reduction in tax burden: sectors that has benefited most from the reduction is the "Supply of energy" (-56.6%) and "Supply of water" (-16.92%), then Manufacturing (-7.23%) and to follow all the others.

[10] First confirmed by Corte di Cassazione and later the Territorial Agency confirms the interpretation of the law and the suitability of *BHE* to be part of the business tax base.

[11] Matteo Renzi replaces Enrico Letta.

Given this general and consistent tax reduction, it can be argued if municipalities, as a consequence of the fiscal loss due to *BHE* taxation removal, increase tax rate or other taxes to face the less tax revenues.[12] Between 2015-2018, municipalities are not allowed to increase tax rates for municipal taxes. Indeed, the DSP of 2016 blocks the possibility for mayors to approve increases of tax rates. So that, during the years considered in this analysis firms could not face an increase in IMU tax rate or in other forms of municipal taxation. At the same time, the *BHE* taxation removal implies a refund for Italian municipalities heavily affected by the fiscal loss, in terms of financial revenues. Indeed, it is approved a refund for 3,695 municipalities,[13] in order to not impact their financial statements and their revenues, already programmed considering the *BHE* taxation.

3.2.3 Incentives for firms in 2014

Based on the timeline of the 2016 reform approval, it is possible an anticipation effect of the policy starting from 2014. For this reason, I am going to conduct my empirical analysis taking into account the beginning of firms' response from 2014. In this subsection, I discuss other kind of incentives approved in 2014, which can be supposed reasonably to affect my results in terms of capital investments. I explain how these incentives cannot be considered as confounded factors for my results.

The *BHE* taxation removal arrives not only after numerous requests, but also after years of slow down in firms' investments. Low levels of revenues and strong difficulties to have access to credit have represented for Italian firms a brake for investments (Unioncamere, 2013). These difficulties hold for small/medium firms (OCSE, 2014), but also for big firms. In 2013 big firms face a drop of their revenues, with a contraction of employment, investment and productivity.[14] One of the consequences is the increase of the average age of firms' equipment, passing from 11,8 years in 2004 to 18,8 years in 2013. In this sense, firms in the years until 2014 are not investing in capital and do not have any kind of stimulus in this direction. As a period of downfall of investments, Italian government in 2014 promotes different incentives. Regarding firms' capital, there are the so called "Superammortamento - Iperammortamento" and the "Sabatini Law".

"Superammortamento - Iperammortamento" consists of an increase of the price of acquisition of new instrumental assets, which affects the amortization deduction

[12] In Italy at municipal level in addition to IMU there is another property tax called TASI (tax on indivisible services). It includes not only the possession, but also the detention of real estate and agricultural land is excluded. The DSP of 2016 eliminated the TASI tax on the main homes of both the owner and the owner, excluding luxury ones. A tax which, from an economic point of view, is in fact included in those of a patrimonial nature.

[13] *Decree Law 29/12/2016 n.21.*

[14] Investments in 2012 register a loss of 4,5% billions, and of 14,4 billions with respect to 2004 (-40,6%).

only from a tax point of view, resulting in a higher amortization deduction. Relative to *BHE*, this incentive in 2014 is not possible: until *BHE* are included in the business property tax base, so they are considered as business properties, they could not be part of this solution. In this sense, in 2014 it cannot represent a real incentive for firms that employ *BHE* within production process to invest more in *BHE*.

The "Sabatini Law"[15] allows for financing small and medium enterprises (SMEs) for the capital goods purchase. Companies operating in all the economic sector codes are included, also agriculture and fisheries. Eligible expenditures cover the purchase or acquisition in leasing of machinery, equipment, capital goods and business equipment as well as hardware, software and digital technologies. It could be reasonably argued that the "Sabatini Law" impacts the effectiveness of the *BHE* taxation removal, because *BHE* can be included in the eligible expenditures. Despite the "Sabatini Law" represents a good incentive for firms, as declared by Italian managers and reported in Invitalia, 2019, the "Sabatini Law" alone does not push firms to invest more in capital. Moreover, managers declare that at least the "Sabatini Law" represents a good instrument, when firms apply or have the possibility to apply for, to financing investments already programmed, so not induced by the "Sabatini Law" itself. Managers' point of view is that this incentive alone cannot cause a decision in terms of investments, but in some cases can only be one of the way to financing it. Moreover, Invitalia, 2019 reports that the "Sabatini Law", has a lower take up, compared to the other incentives approved, in particular the "Superammortamento - Iperammortamento", which covers the highest levels.

3.3 Data and Descriptive Statistics

I use the yearly dataset AIDA, provided by Bureau Van Dijk, which contains financial statements delivered by a subset of Italian firms (corporate firms) to Chamber of Commerce. I consider the time series of 10 years from 2008 to 2017. I only select firms in activity, dropping out all the ones closed or wound up.[16]

Financial statements do not report the exact amount of *BHE* owned by firms. The only information available is the book value total of equipment, in which *BHE* are accounted if firms employ them within production process.

The book value total of equipment is one of the components of Tangible Fixed Assets, made up as follows: *Lands and Buildings*, *Equipment*, *Machinery*, *Other machinery*. Since I can only observe the book value total of equipment, firms for which it is not reported the exact value of equipment are not included in my analytic sample.

[15] *Decree Law n. 69/2013.*

[16] Negative or missing values of value added are replaced with labour costs. Values of all the variables of interest are winsorized at the 1th and the 99th percentile.

Moreover, they are excluded all the observations with negative values of equipment, remaining with a balanced panel of 170,230 observations.[17]

Table 3.3 reports descriptive statistics of equipment for the different economic sector codes at 2-digits (NACE rev 2) available in my sample.

BHE are those components, essentially with the nature of equipment, which perform specific functions within a given production process. Treatment and Control groups are built discussing if firms employ or not *BHE* within production process. This distinction takes place looking at economic sector codes. For Manufacturing *BHE* are equipment related to the production, used inside the building, as blast furnaces, chimneys, conveyor trolleys, etc. For Energy production *BHE* are photovoltaic panels fixed to the soil, or wind turbines. For the industry of Entertainment (Art/sport) *BHE* are attractions like: Ferris wheels, roller-coaster, rides, water-slides, the chairlifts, the cabins.

I assume that Manufacturing, Energy, Art/sport are economic sector codes with a more intense employment of *BHE* within production process. All the others are assumed to have a less or not employment of *BHE* within production process. Manufacturing ranges from 2-digits NACE10 to NACE33; Energy 2-digits NACE35; Art/sport 2-digits NACE93. Firms which belong to one of these three economic sector codes compose the Treatment group. In addition, I select more in depth treated firms, choosing that ones which are also located in municipalities refunded for the fiscal loss due to *BHE* taxation removal. Control group is made up of firms which belong to all the other economic sector codes different from Manufacturing, Energy, Art/sport, which are assumed to have a less or not employment of *BHE* within production process.

Table 3.4 reports descriptive statistics of economic sector codes that employ *BHE* within production process. Energy has the highest value in median of equipment and the highest value in mean. The highest number of observations is given by Manufacturing, also because Manufacturing is mostly intense and developed in Italy.

Figure 3.1 compares the value in mean of equipment for economic sector codes that employ *BHE* within production process, looking at their geographic distribution: North Centre and South of Italy. Energy has the highest values, compared with Manufacturing and Art/sport, and the highest values in Centre of Italy. Manufacturing presents similar values in North, Centre and South regions. Differently, Art/sport is significantly higher in values of equipment in Centre of Italy, with respect to North and South.

[17] Firms can edit a shorter version of their financial statements, only including the value of Tangible Fixed Assets, without the specific elements, if they are in situations defined by the Italian Law.

3.4 Econometric approach

As explained in the previous section, Treatment group is made up of those firms which belong to one of the following three economic sector codes: Manufacturing, Energy, Art/sport which are assumed with a more intense employment of *BHE* within production process. Control group is made up of firms which belong to all the other economic sector codes different from Manufacturing, Energy, Art/sport, which are assumed to have a less or not employment of *BHE* within production process.

The ideal experimental setting to estimate the direct effect of the *BHE* taxation removal would be observing the response of the level *BHE* for firms that employ *BHE*, due to the policy. Financial statements do not report the exact amount of *BHE* owned by firms. The only information available is the book value total of equipment, in which *BHE* are accounted if firms employ them within production process. Given the lack of the exact amount of *BHE* or their presence within firms' assets, I am going to exploit the book value of equipment as a proxy for the level of *BHE* owned by a firm. In order to assess the direct impact of the policy, the identification leverages the variation of equipment.

The impact of the 2016 reform depends on whether it primarily affects equipment for firms that employ *BHE*, while for firms that do not employ *BHE* equipment must remain stable. I rely on a difference-in-differences approach, comparing treated group before/after the treatment with the untreated group. This approach takes into account all the possible unobserved characteristics that might be correlated with dependent variables of interest, and alternative explanations of the results. The extent to which firms are affected by the reform depends on the inclusion of *BHE* in the book value total of equipment. Significant variations in equipment for firms that employ *BHE* (treated) are imputed to the variation of *BHE* included in equipment, compared with a level of equipment for firms that do not employ *BHE* (control) which remains stable because it does not include *BHE*. Figure 3.2 shows the series of average equipment for Treatment and Control group. The level of equipment for treated firms faces an increase in average starting from 2014. The comparison of the two groups suggests an increase of equipment for firms that employ *BHE* due to the anticipation effect of the policy.

The key assumption behind the DID strategy is the pre-trends assumption, meaning that the trend in the outcome variable for both treated and control groups during the pre-treatment periods are the same. Regard my analysis it must be true that firms, before the year of the event (the year of the reform approval) do not vary their level of equipment, but significant changes must be seen only after the reform, in order to correctly address this variation as an effect of the policy.

I estimate a difference-in-differences regression comparing pre-reform years 2008-2013 with the post-reform years 2014-2017, the benchmark year is 2013. Fixed effects capture time-invariant heterogeneity across firms, year fixed effects control for year-specific shocks common to all firms. Standard errors are clustered at firm level to avoid potential serial correlation across periods Bertrand, Duflo, and Mullainathan, 2004:

$$Y_{i,t} = \gamma_i + \lambda_t + \sum_{k=2008}^{2017} \beta_k^T \mathbb{1}(k = t) \times T_i + \epsilon_{i,t} \tag{3.1}$$

$Y_{i,t}$ is the outcome variable equipment for firm i at time t, λ_t captures time fixed effects, γ_i is firm fixed effects, the coefficient of interest β_k estimates how the treatment T_i affects the outcome of interest in year k, for the post-reform years 2014-2017, but also the pre-reform years 2008-2013, in order to investigate the anticipation of the reform. The anticipation of the reform implementation leads to an increase in the level of equipment for treated firms in year t compared to year 2013, when the effect is normalized to 0. In 2014 the average effect is 21,523 euros; in 2015 76,661 euros; in 2016 119,053 euros; and in 2017 202,028 euros. Pre-trends provide suggestive evidence of the exogeneity of T_i (see Table 3.5).

In addition, I estimate a more compact version of the eq 3.1, as follows:

$$Y_{i,t} = \lambda_t + \gamma_i + \beta^T Post_t \times T_i + \epsilon_{i,t} \tag{3.2}$$

$Y_{i,t}$ is the outcome variable, the level of equipment for firm i at time t, λ_t are time fixed effects, γ_i are firms fixed effects, $Post_t$ is a dummy variable which takes value of 1 in years 2014-2017, β^T is the coefficient of interest which captures the average effect of 1-year increase of T_i in the post-reform years, standard errors are clustered at firm level. The estimated increase of equipment is 115,130 euros, about 43 percent of the median level of equipment in the pre-reform period (2008-2013) (see Table 3.6).

3.4.1 Placebo tests

In order to check the validity of the identifying assumption, I run placebo test. From eq 4.2, I use pre-reform period (2008-2013) and I artificially assign the date in which the reform becomes effective in 2013, 2012, 2011, 2010, and 2009. Table 3.7 reports placebo estimates. I test the effect of treatment T_i on equipment. Results are not statistically significant for all the years considered.

3.4.2 Fuzzy DID

In the previous section, it is discussed the effect of the 2016 Italian reform on firms' capital. The *BHE* taxation removal determines higher capital investments for firms

that employ *BHE*.

In this part of the analysis, I investigate how the higher capital affects other firms' outcomes. The treatment is the higher capital (equipment), due to the *BHE* taxation removal. I argue that firms that experienced a higher increase in equipment, as a result of the *BHE* taxation removal, would experience positive effects on other firm's dimensions. I further investigate how the higher capital affects firms' employees, salaries, profits, and value added. Moreover, I check if higher capital implies investments in other capital components, as a result of a substitution effect.

Between 2014-2017, it is observed that the share of *treated* units increases more in a group (firms that employ *BHE*) and remains stable in the control group (firms that do not employ *BHE*). This kind of setting is called by De Chaisemartin and d'Haultfoeuille, 2018 fuzzy DID. Authors demonstrate that under specific assumptions on treatment effects, the ratio between the DID of the Y (the outcome variable) and the DID of the treatment, the so called Wald estimator (hereafter, Wald DID) identifies the Local Average Treatment Effect (LATE).[18] The assumptions needed to be the Wald DID a consistent estimator for the LATE are the homogeneity assumptions: 1) the effect of the treatment should not vary over time; 2) when the treatment increases both in the treatment and in the control group, treatment effects should be equal in these two groups.

De Chaisemartin and d'Haultfoeuille, 2018 also propose two alternative estimates of the same Wald DID which do not rely on any treatment effect assumption. These estimators can be used specifically when the share of treated units is stable in the control group, accounting for the treatment effect heterogeneity across groups and time periods, robust to negative-weighting issues. The first one is the time-corrected Wald ratio (hereafter, Wald TC), which accounts for the effect of time on the outcome in the treatment group, relying on common trends assumptions within subgroups of units sharing the same treatment at the first date. The second one is

[18]The impact of a treatment can be evaluated through an instrumental variable (IV) regression using the interaction of time and group as an instrument for treatment.Angrist and Imbens, 1995 have already shown that IV coefficients can be interpreted as LATE in a model allowing for heterogeneous treatment effects, and this strategy is referred as an IV-DID. This type of approach has been implemented by Duflo, 2001 in order to estimate the impact of educational attainment on wages, using INPRES program. Author constructs two "supergroups" of districts, by regressing the number of primary schools constructed on the number of school-age children in each district. She defines treatment districts as those with a positive residual in that regression. So, she uses a Wald-DID with her two groups of districts and cohorts to estimate returns to education. She estimates a 2SLS regression of wages on cohort dummies, district dummies, and years of schooling, using the interaction of cohort 1 and schools constructed in one's district of birth as the instrument for years of schooling. De Chaisemartin and d'Haultfoeuille, 2018 show how in Duflo, 2001 2SLS regression with fixed effects estimates a weighted sum of switchers' returns to education across districts, with potentially many negative weights. In this setting, returns to schooling might differ across districts. They are considered three supergroups of districts depending on whether their years of schooling increased, remained stable, or decreased between cohorts 0 and 1. This approach enables to obtain point estimates of returns to schooling, without assuming that returns are homogeneous between districts or over time. Controls are only districts with a stable distribution of education.

the changes-in-changes Wald ratio (hereafter, Wald CIC), which accounts for the effect of time on the outcome through the quantile-quantile transform and generalizes the changes-in-changes estimator introduced by Athey and Imbens, 2006 to fuzzy design. It relies on the assumption that a control and a treatment group unit with the same outcome and the same treatment at the first date will also have the same outcome at the second date.[19]

In my setting, the homogeneity assumptions are unrealistic. The share of treated units is stable in control group. As demonstrated in the previous section, the share of treated units increases more only for firms that employ *BHE*, while for control firms, firms that do not employ *BHE*, the share of treated units is stable. So that, I investigate the causal effect allowing for a model with heterogeneous treatment effects. I compare units whose treatment status changes in post-reform period to untreated stable units, units remained untreated in the same period. I define treatment units using a variable equal to 1 (resp. 0, -1) for firm $i \times$ years t observations such that equipment increases (resp. remains stable, decreases) in years 2014-2017 in that firm. I cluster the bootstrap at the firms level, to allow for firm-level correlation over time. Control units are those firms for which equipment remains stable.[20]

I report results from the Wald DID and from the Wald TC and Wald CIC, to compare results and assess their robustness to different hypotheses. Table 3.8 reports results from the analysis on employees, salaries, profits, and value added. The higher capital (equipment), due to the *BHE* taxation removal, for treated firms (firms that employ *BHE*) boosts the other firms' dimensions. The coefficients estimated by the Wald TC are larger than the Wald DID, meaning that the Wald TC estimates correctly the additional effect of time on the outcome variable in the treatment group, so the homogeneity assumptions do not hold. Moreover, the Wald CIC lies in between the Wald DID and Wald TC for all the outcomes considered, meaning that in comparison, the Wald TC captures better the heterogeneity due to the time with respect to the Wald CIC.

A correct economic interpretation of the Wald TC can be obtained dividing the coefficient by the mean value of the outcome in the pre-period and multiplying it by 100 for the percentage. A 1 standard deviation (hereafter, σ) increase of T_i, which is the average change in equipment for firms that employ *BHE*, between 2014-2017, leads to an increase of employees of 359, of salaries of 2.020, of profits of 1.840 and of value added of 144,713.

Table 3.9 reports results from the analysis on other components of Tangible Fixed Assets: lands and buildings, machinery and other machinery. The higher capital (equipment), due to the *BHE* taxation removal, for treated firms (firms that employ *BHE*) boosts the other components of Tangible Fixed Assets. Again, the coefficients

[19] Appendix A explains in details assumptions of the three estimators.

[20] I use the *fuzzydid* command, developed by the authors, available in STATA repository.

of interest is the Wald TC. A 1 σ increase of T_i, which is the average change in equipment for firms that employ *BHE*, between 2014-2017, leads to an increase of lands and buildings of 2.290, of machinery of 3234, and of other machinery of 2403.

3.4.3 Placebo tests

In order to check the validity of my results, I run two placebo tests. I compute placebo Wald DID and Wald TC to assess if results found are plausible in my setting. First, instead of using post-period 2014-2017, my placebo estimators compare the evolution of the outcome variables between treated and control firms in the pre-reform period (2008-2013). The higher capital (equipment) is the treatment and its increase is imputed as a result of the *BHE* taxation removal. The share of *treated* units increases more in firms that employ *BHE* between 2014-2017, while for control firms treated units remain stable. My placebo compares the evolution of outcomes between treated and control firms in pre-period, in order to correct impute the effect of the treatment, the higher capital, to the 2016 reform, so only in the post-period when the increase of equipment happens.

Table 3.10 reports placebo results. Only for salaries, placebo is statistically significant, meaning that results found in the previous section, considering post-reform years, are not reliable. For employees, value added and profits estimates are not statistically significant.

In order to investigate more the validity of my results, I run a second placebo. I compute placebo Wald DID and Wald TC in the post-period (2014-2017), ruling out treated firms (firms that employ *BHE*), using only control firms (firms that do not employ *BHE*) and randomly dividing treatment and control group.

Table 3.11 reports placebo results. Placebo estimates for profits and value added are not statistically significant, for both Wald TC and Wald DID. For employees, the Wald TC is not statistically significant, but it is significant the Wald DID, meaning that the Wald estimator captures a significant effect if I consider only control firms. The effect on employees cannot be consider valid in my setting.

Table 3.12 reports placebo results for the other components of Tangible Fixed Assets. Again, my placebo estimators compare the evolution of the outcome variables between treated and control firms in the pre-reform period (2008-2013). Only for the book value Other machinery placebo estimates are not statistically significant, confirming the validity of results of Wald TC found previously.

So that, I run a second placebo Wald DID and Wald TC in the post-period (2014-2017) for the outcome variable Other machinery, ruling out treated firms (firms that employ *BHE*), using only control firms (firms that do not employ *BHE*) and randomly dividing treatment and control group. Placebo estimates are statistically significant and do not confirm the reliability of the results, see table 3.13.

3.5 Discussion of the results

While considered a "non-distortionary" tax, most desirable from an efficient point of view with respect to other taxes, "neutrality" of the property tax is a controversial issue for empirical research. My results highlight that changes in the business property tax base can significantly improve firms' capital investments, with positive effects also on other firms' dimensions.

To identify the effects of the business property tax on firms' outcomes, I take advantage of an Italian reform approved at the end of 2015, which rules out a type of heavy equipment, *BHE*, from the business property tax base. I document two main results. First, firms that employ *BHE* in production process (treated firms) improve their investments in equipment. Second, the augmented level of capital, induced by the *BHE* taxation removal, for treated firms, determines an increase in value added and profits.

These findings contribute to the debate on the "non-neutrality" of the property tax. Belotti, Di Porto, and Santoni, 2020 provide evidence that in those tax systems where the business property tax base is set taking into account firms' equipment, a reasonably more elastic asset than buildings, an increase in business property tax rate is likely to depress firm investments only through equipment. Splitting Tangible Fixed Assets into equipment and lands-buildings, authors' results confirm that business property tax has no effect on fixed costs (lands and buildings), whereas for equipment and machinery there is a negative effect with a semi-elasticity of -1.312. The negative effect on capital, due to the increase of the business property tax rate, is seen to be driven by a reduction in equipment, and not on buildings. In line with these results, my analysis confirms that the property tax on business affects firms' capital through equipment. When the taxation on *BHE* is removed, firms that employ *BHE* invest more in equipment, with an estimated increase of about 43%. All these evidences suggest that the neutrality of the property tax is reasonable looking at the land,[21] and more generally to that part of capital which is fixed.

My analysis has also the prerogative to use the greater investment in equipment, due to the 2016 reform implementation, as the source of the variation to investigate other firms' dimensions. Positive effects on value added and profits for firms that employ *BHE* confirms that a property tax on intermediate input creates distortions in production process.[22]

These findings have also implications in public policy. I show that the composition of the business property tax base has an impact on firms' investments decisions.

[21] The value of the property reflects the value of the land (unimproved), land is immobile and represents the tax base, the price appreciation is independent of personal effort, but it is determined only by demand and supply forces (Bastani and Waldenström, 2020).

[22] Business property, as an intermediate input, should not be taxed in order to avoid distortions in production (Diamond and Mirrlees, 1971).

From a public policy implication perspective, there are two policy takeaway. One pertains the efficiency of the reform. Removing property tax on *BHE* suggests that taxing capital equipment does not incentive firms' investments. Despite equipment are taxed as real properties, they are a kind of asset more elastic than land and buildings. The neutrality of the property tax in this case does not apply. So, the reform in terms of efficiency has worked, pushing firms' capital investments. The second lesson relates to governments' taxation choices. If governments want to tax business properties, they should take into account that the efficiency of the property tax is more likely to be possible for land than for other components of business capital, otherwise the property tax will act exactly as a tax on capital. In terms of tax rates, although exact compensation is paid to the municipalities after the reform, it is reasonable that tax rates are increased on a less mobile business property tax base or other taxes at municipal level are raised. It is not possible for me to check this situation, because in the same year of the *BHE* reform it is also approved the ban for mayors to increase municipal tax rates. The ban has been removed in 2019, and what it is observed is that all the Italian municipalities increased their tax rates up to the limit allowed.

3.6 Conclusion

In this chapter, I test empirically the existence of the distortionary effects of the local property tax on business capital. If the distorsive effect is possible to arise, and business capital is more likely to be affected, one of the research question for empirical literature is: "How much local property tax on business affects firms' resource allocation decisions?". I take advantage of the *BHE* removal from the business property tax base, approved in Italy at the end of 2015. I document two main results: the effect of the local property tax on firms' capital investments and how the greater investment in capital investment determines an effect on firms' dimensions as value added and profits. With a difference-in-differences design, I estimate the immediate and direct effect of the local property tax on business capital and I document that firms that employ *BHE* in production process invest more in capital, augmenting their level of equipment, in response to the policy shock. Using a Fuzzy difference-in-difference design, allowing for heterogeneous treatment effects in the spirit of De Chaisemartin and d'Haultfoeuille, 2018, I show that the augmented level of capital, identified as the source of the variation for firms previously impacted by the *BHE* taxation removal, leads to an increase in the value added and profits for treated firms during the post-reform period.

3.7 Figures and Tables

TABLE 3.1: Real estates tax levy 2012-2018 - IMU

	2012	2013	2014	2015	2016	2017	2018
Residential properties	4,07	0,47	0,09	0,10	0,08	0,08	0,07
Business properties	20,60	20,10	20,23	20,23	19,35	19,22	18,65
Total	24,67	20,56	20,32	20,33	19,43	19,29	18,72

Notes: table reports the evolution of tax levy between 2012-2018 for the IMU, comparing residential and business properties. The total tax levy for IMU in 2018 is equal to 19,8 billions, it is decreased significantly compared to 2012 (- 4,9 billions). A significant decrease of tax levy for IMU is seen starting from 2016 for business properties, first year in which it is effective the *BHE* taxation removal. Values are expressed in billions euros. *Source:* Italian Revenue Agency, 2019

TABLE 3.2: IMU Tax revenue - Business properties

	2015	2016	% var.
Agriculture	51,453	48,450	-5.84
Commerce	348,089	341,338	-1.94
Mining	5,831	5,468	-6.22
Manufacturing	864,880	802,369	-7.23
Energy	332,219	144,169	-56.60
Water	35,384	29,396	-16.92
Constructions	141,652	131,879	-6.90
Private Services	1,764,9	1,699,3	-3.72
Public Services	68,445	66,246	-3.21
Others	203,803	196,921	-3.38

Notes: Table shows the percentage change in the IMU on properties classified in category D, by economic sector codes, between 2015 and 2016. The *BHE* IMU exemption resulted in a tax reduction of approximately 350 million euros on an annual basis. The analysis of IMU payments is restricted solely to the payments under the jurisdiction of the State. Computations cannot be punctually replicated also for IMU payments under municipalities, since results would be influenced by any changes in the tax rates. On the contrary, the payments due to the State are always made at the same tax rate. Values are expressed in thousands euros. *Source:* Italian Revenue Agency, 2017

TABLE 3.3: Equipment by economic sector codes 2-digits

	Mean	SD	Median	Obs
Agriculture	2,158	3,099	789,4	1,820
Mining	2,453	3,392	1,125	610
Manufacturing	1,954	2,961	726,5	90,040
Energy	7,400	5,356	11,990	1,040
Water	3,233	4,427	823,7	3870
Construction	606,0	1,836	50,2	10,660
Sales	483,3	1,606	55,9	24,190
Transport	1,039	2,734	47,8	8,490
Hotel/restaurant	1,077	2,098	264,4	2,970
Communication	535,4	1,918	5,5	5,620
Finance	115,5	649,5	0	1,150
Real estate	880,9	2,682	10,8	1,430
Professionals	560,1	1,991	8,3	6,420
Services	555,1	1,848	18,4	4,700
Public administration	83,2	66	78,2	10
Education	60,5	229,3	544.0	420
Health	550	1,427	71,4	4,940
Art/sport	833,3	2,095	31,5	930
Other	955	2,269	159,6	920
Total	1,449			170,230

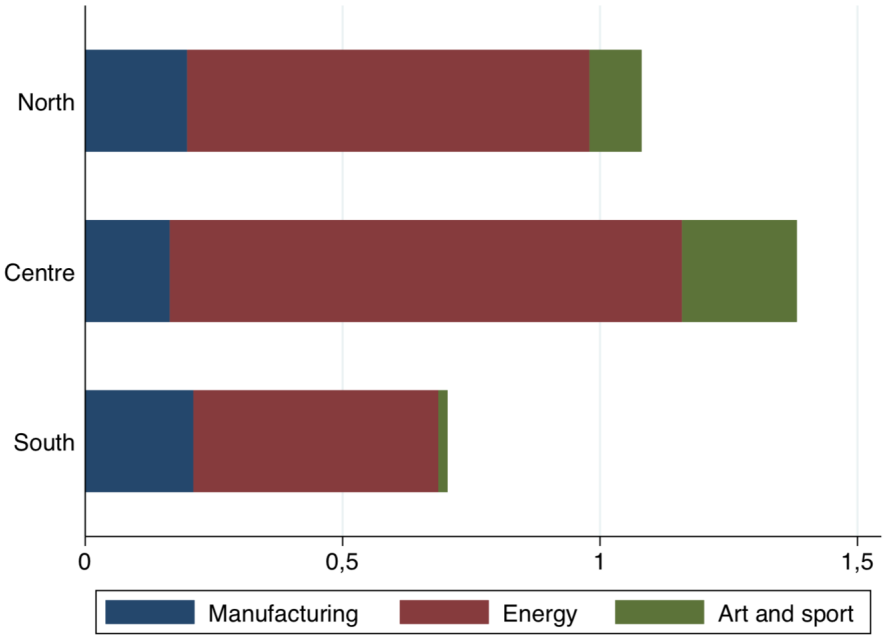
Notes: Values are expressed in thousands euros.

TABLE 3.4: Equipment by *BHE* economic sector codes at 2-digits

	Mean	SD	Median	Obs
Manufacturing	1,953	2,958	726,2	89,330
Energy	7,400	5,356	11,990	1,040
Art/sport	1,104	2,374	42,5	500
Total	2,010			90,870

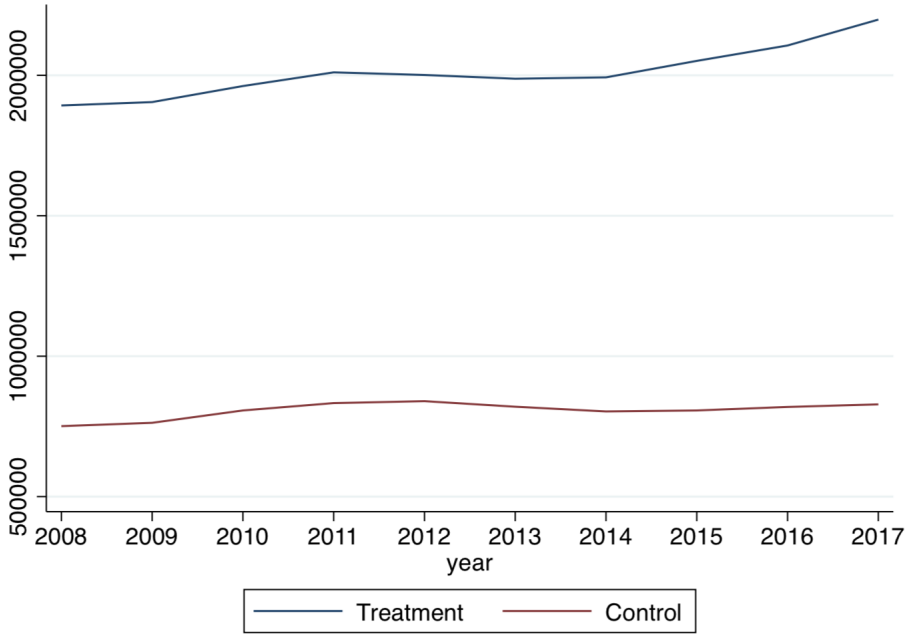
Notes: Values are expressed in thousands euros.

FIGURE 3.1: Equipment by *BHE* economic sector codes at 2-digits and macro regions



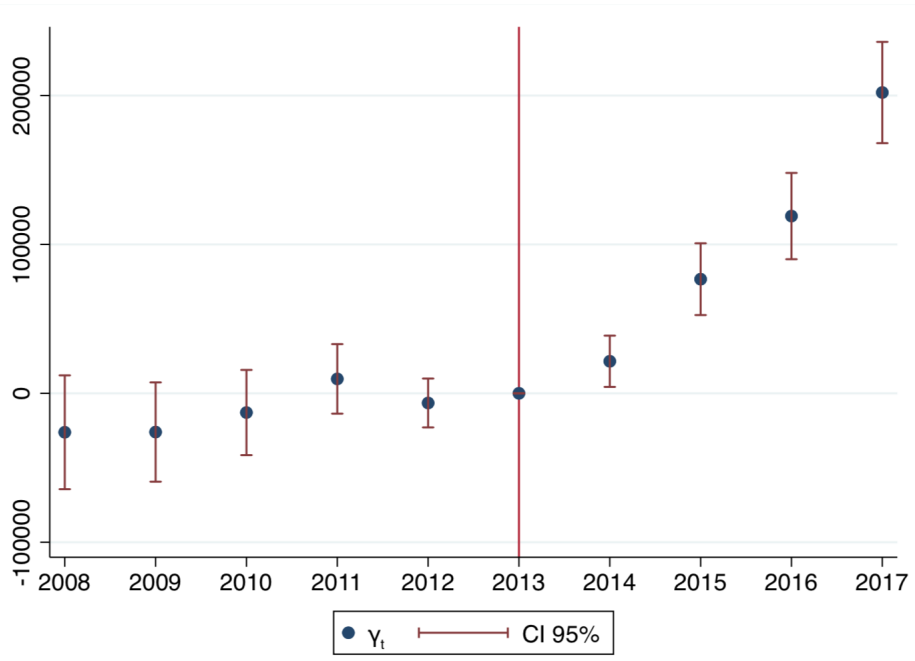
Notes: The figure compares the value in mean of equipment looking at firms' geographic distribution: North Centre and South of Italy. Values are expressed in millions euros.

FIGURE 3.2: Equipment for Treatment and Control group



Notes: figure shows the series of average equipment for Treatment and Control group. Equipment for treated firms faces an increase in average starting from 2014. The comparison of the two groups suggests an increase of equipment for firms *BHE* users linked due to the anticipation effect of the policy.

FIGURE 3.3: Equipment



Notes: figure shows Equipment response to a 1-year increase in T_i. I estimate a difference-in-differences regression comparing pre-reform years 2008-2017 with the post-reform years 2014-2017, the single reference year is 2013. Fixed effects capture time-invariant heterogeneity across firms, year fixed effects control for year-specific shocks common to all firms. Standard errors are clustered at the firm level.

TABLE 3.5: Pre-trend Analysis

	Equipment (1)
$T_i \times \mathbb{1}$(Year = 2008)	-26,161
	(23242)
$T_i \times \mathbb{1}$(Year = 2009)	-26,015
	(20275)
$T_i \times \mathbb{1}$(Year = 2010)	-12,912
	(17398)
$T_i \times \mathbb{1}$(Year = 2011)	9,685
	(14201)
$T_i \times \mathbb{1}$(Year = 2012)	-6,480
	(9982)
$T_i \times \mathbb{1}$(Year = 2014)	21,523**
	(10467)
$T_i \times \mathbb{1}$(Year = 2015)	76,662***
	(14659)
$T_i \times \mathbb{1}$(Year = 2016)	119,053***
	(17618)
$T_i \times \mathbb{1}$(Year = 2017)	202,029***
	(20676)
Year FE	Yes
Firms FE	Yes
Median outcome pre-2014	268,062
Adjusted R^2	0.905
Observations	170,230

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE 3.6: Estimation results

	Equipment (1)
Treat * Post	115,130***
	(17514)
Constant	1,360,4***
	(8751)
Year FE	Yes
Firms FE	Yes
Median outcome pre-2014	268,062
Adjusted R^2	0.905
Observations	170,230

Notes: I estimate a difference-in-differences regression. Fixed effects capture time-invariant heterogeneity across firms, year fixed effects control for year-specific shocks common to all firms. Standard errors in parentheses are clustered at the firm level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE 3.7: Placebo results

	Equipment (1)	Equipment (2)	Equipment (3)	Equipment (4)	Equipment (5)
Treat * Post 2012	12,377				
	(15217)				
Treat * Post 2011		10,610			
		(15171)			
Treat * Post 2010			22,764		
			(15642)		
Treat * Post 2009				23,661	
				(16215)	
Treat * Post 2008					19,016
					(17202)
Year FE	Yes	Yes	Yes	Yes	Yes
Firms FE	Yes	Yes	Yes	Yes	Yes
Median outcome pre-2014	268,062	268,062	268,062	268,062	268,062
Adjusted R^2	0.931	0.931	0.931	0.931	0.931
Observations	102,138	102,138	102,138	102,138	102,138

Notes: I use pre-reform period and I artificially assign the reform in 2013, 2012, 2011, 2010, and 2009. Standard errors in parentheses are clustered at the firm level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 3.8: Estimation results

	Employees	Salaries	Profits	Value added
	(1)	(2)	(3)	(4)
Wald DID	328	1,670	1,360	122,533
	(93)	(2064)	(3578)	(34899)
Wald TC	359	2,020	1,840	144,713
	(124)	(2579)	(4628)	(40223)
Wald CIC	267	7,075	3,713	121,169
	(53)	(1329)	(4259)	(37810)
Mean outcome pre-2014	134.1	3,187,9	574,275	70,754
Mean T_i	1,493,8	1,493,8	1,493,8	1,493,8
Std. Dev. T_i	2,820,8	2,820,8	2,820,8	2,820,8
Observations	68,092	68,092	36,340	68,092

Notes: table reports the effects of a 1 standard deviation increase in equipment, when the reform is passed, for firms that employ *BHE*, between 2014-2017. I cluster the bootstrap at the firms level, to allow for firm-level correlation over time.

TABLE 3.9: Estimation results

	Lands and Buildings	Machinery	Other machinery
	(1)	(2)	(3)
Wald DID	2,100	2,794	2,042
	(3074)	(4337)	(3980)
Wald TC	2,290	3,234	2,403
	(3827)	(5545)	(5160)
Wald CIC	2,070	1,927	1,660
	(2943)	(2606)	(2605)
Mean outcome pre-2014	3976968	295183.3	286372.5
Mean T_i	1,493,8	1,493,8	1,493,8
Std. Dev. T_i	2,820,8	2,820,8	2,820,8
Observations	36,348	36,348	36,348

Notes: table reports the effects of a 1 standard deviation increase in equipment, when the reform is passed, for firms that employ *BHE*, between 2014-2017. I cluster the bootstrap at the firms level, to allow for firm-level correlation over time.

TABLE 3.10: Placebo results

	Employees	Salaries	Profits	Value added
	(1)	(2)	(3)	(4)
Wald DID	224	2,070	-2,517	77,690
	(260)	(2794)	(4762)	(50132)
Wald TC	182	2,500	-4,785	82,887
	(383)	(3665)	(68128)	(63497)
Mean outcome pre-2014	134.1	3,187,9	574,275	70,754
Mean T_i	1,493,8	1,493,8	1,493,8	1,493,8
Std. Dev. T_i	2,820,8	2,820,8	2,820,8	2,820,8
Observations	54,522	54,522	54,522	54,522

Notes: placebo test estimates the Wald estimators looking at the pre-period 2008-2013. My placebo estimators compare the evolution of outcome variables from 2008-2013 between treated firms and the control firms. I cluster the bootstrap at the firms level, to allow for firm-level correlation over time.

TABLE 3.11: Placebo results

	Employees (1)	Profits (2)	Value added (3)
Wald DID	107.1	920,652	10,846
	(46.68)	(68040)	(12285)
Wald TC	53.3	3,558	23,787
	(218.34)	(2243)	(18144)
Mean outcome pre-2014	134.1	574,275	70,754
Mean T_i	1,493,8	1,493,8	1,493,8
Std. Dev. T_i	2,820,8	2,820,8	2,820,8
Observations	23,576	31,744	31,744

Notes: I compute Wald estimators in the post-period, ruling out treated firms, and randomly assigning treatment and control to all the others. I cluster the bootstrap at the firms level, to allow for firm-level correlation over time.

TABLE 3.12: Placebo results

	Lands and buildings (1)	Machinery (2)	Other machinery (3)
Wald DID	2,760	2,592	390,065
	(4347)	(6126)	(436653)
Wald TC	3,180	2,131	-15313.65
	(5794)	(8203)	(580437.9)
Mean outcome pre-2014	3,976,9	295,183	286,372
Mean T_i	1,493,8	1,493,8	1,493,8
Std. Dev. T_i	2,820,8	2,820,8	2,820,8
Observations	54,522	54,522	54,522

Notes: placebo test estimates the Wald estimators looking at the pre-period 2008-2013. My placebo estimators compare the evolution of outcome variables from 2008-2013 between treated firms and the control firms. I cluster the bootstrap at the firms level, to allow for firm-level correlation over time.

TABLE 3.13: Placebo results

	Other machinery (1)
Wald DID	611,129
	(134360)
Wald TC	1,037,4
	(337912.1)
Mean outcome pre-2014	286372.5
Mean T_i	1,493,8
Std. Dev. T_i	2,820,8
Observations	23,576

Notes: I compute Wald estimators in the post-period, ruling out treated firms, and randomly assigning treatment and control to all the others. I cluster the bootstrap at the firms level, to allow for firm-level correlation over time.

Chapter 4

Searching for informal work using administrative data

Abstract

This chapter investigates informality in Italian Labour Market driven by the intense use of non-standard jobs, as part-time contracts. Using administrative data released by the Italian Social Security Institute (INPS) combined with data of firms' financial statements and inspections data, I construct an irregular job rate taking advantage from machine-learning technique and accruals model. My microeconomic indicator of irregular job is consistent with the indicator of irregular job provided by ISTAT. Correlation is positive, equal to about 90% (in terms of R2), and statistically significant.

4.1 Introduction

Fighting tax evasion, the shadow economy and informal (illegal) employment are important policy goals in OECD countries.[1] Policymakers aim to decrease the attractiveness of the shadow economy working, reducing the impact of some of its main causes, as high taxes, social security contributions and heavy regulation. Flexible jobs (or non-standard jobs) are born with the objective of being a deterrent for irregular workers, thanks to a more efficient and less heavy regulation.[2] At the same time, these contracts can represent a good chance for "informality". Informality arises when workers are employed in "semi-illegal" irregular jobs. There is not a common definition of informal work: it depends on the policy concern that motivates the analysis and data availability (Feld and Schneider, 2010).[3] Differently from "black" workers, for "grey" workers there is the possibility of looking at some information. Informal workers are partially regularly hired, so a partial information on their careers is available. Given the narrow amount of information available on shadow labour, it is important to better identify the potential irregularity hidden behind the regular contract observed, making in this way also the inspection procedure more efficient. How optimally allocate inspectors is a decision problem, and knowing which establishment or individual is more likely to have violations would be equivalent to knowing which ones should be inspected (Glaeser et al., 2016).[4] As one of the European countries with the greatest amount of undeclared workers, in order to improve regular hires, through some labour changes, there has been in Italy the incentive to use non-standard jobs.[5] After the 2008 crisis and a consequently contraction of labour demand, a great evidence of the Italian labour market is a substantial reduction of the duration of contracts: they are becoming shorter in the duration per year and in the worked hours per day. This evidence is due to a greater use of part-time, which number passes from 2 milion and half to 3 milion and half.

[1] This study uses anonymous data from the Italian Institute of Social Security (INPS). Data access was provided as part of the VISITINPS Initiative. The views expressed here belong solely to the author and do not necessarily reflect those of the INPS.

[2] Examples are: Germany's mini-jobs, UK's zero-hours contracts, "Titre de service" in Netherlands and "Cheque de employ" in France.

[3] Many approaches refer to social security contributions, or employment status, or employment contract. Definitions take into account various situations, when labour regulations are not applied, not enforced or not complied with for any reason.

[4] Glaeser et al., 2016 use prediction tournaments to improve city operations. Comparing algorithms' performance *out-of-sample*, authors show that using the winning ones increases significantly inspections efficacy, better identifying restaurants to inspect in Boston. Estimates show a 30% to 50% improvement in the number of violations found per inspection.

[5] As examples, in 2014 there is the so called *Riforma Poletti* through which the temporary contract is drastically liberalised; in 2015, with the Jobs Act it is introduced a type of contract "contratto a tutele crescenti" as a substitute of the general permanent contract; in addition another type of contract "Contratto di collaborazione a progetto" is abolished; in 2017 voucher is abolished, and reintroduced in 2019. Voucher are introduced in 2003, used from 2008 and extended to all the economic sector codes between 2012 and 2013.

Moreover, between 2014-2017 there is a huge increase of temporary contracts, most of them associated to a part-time solution instead of a full-time one (INPS, 2019). It happens that many of these part-time contracts are "involuntary", driven by the impossibility of a full-time job. Indeed, Eurostat data suggest that, between all the European countries, Italy is the second one for number of part-time workers, due to the lack of access to a full-time job (see figure 3.1). Compared with permanent full-time contracts, non-standard jobs as temporary and part-time, are significantly more likely to be informal (ILO, 2018).[6] One might wonder if, in response to the difficulties to find a full-time job and the desire of firms to save on tax burden, many of these part-time contracts could hide informal situations. This chapter addresses the following research question: "Are firms with an excessive prevalence of part-time contracts involved in informality?". In order to answer this question, I construct an informality job rate. The approach I use in order to investigate informality is made up of a combination of different sources of data and analysis methods. I use administrative data from the Italian Social Security Institute (*Istituto Nazionale di Previdenza Sociale* hereafter, INPS) for firms' employment information, CERVED data (for non-agricultural firms) for firms' financial statements, data of INPS inspections, meaning that for each firm defined as irregular I can also check if that firm has been already inspected. Moreover, I compare my results with Italian irregular job rate, using data from the Italian National Statistics Agency (hereafter, ISTAT). All this sources of data are processed taking advantage from machine-learning techniques. I use LASSO (Least Absolute Shrinkage And Selection, Tibshirani, 1996) to generate firm specific prediction models for the share of part-time workers over the total number of employees.[7] I merge INPS and CERVED dataset, having in this way for each firm each year detailed information about employees and financial statements variables. I collapse INPS data in order to create three different variables: permanent, temporary and seasonal part-time contracts. For each of them, I use LASSO in order to choose only covariates whose estimates are not zero, from a group of 17 covariates, from the financial statements. LASSO selects only financial statement variables which impact more on the share of part-time workers. Based on the model selection, I predict the share of part-time workers. Firms with an excess of part-time contracts are considered as "informal" units. I define as informal units the ones for which the real value

[6] International Labour Office. Two billion workers, representing 61.2% of the world's employed population, are in informal employment. In Europe and Central Asia, a quarter (25.1%) of the employed population engages in informal employment. ILO, 2018 evaluates informality as 70% of all employment in developing and emerging countries, and about 18% in developed countries. Schneider and Enste, 2000 calculate that informal sector accounts for 10 to 20 percent of GDP in most OECD countries, 20% to 30% in Southern European OECD countries and in Central European transition economies. For a comprehensive review of all the possible characteristics of informality across countries see Hazans, 2011.

[7] LASSO works as a covariate-selection method: it excludes the covariates whose estimated coefficients are zero and includes the covariates whose estimates are not zero. It does the *model selection*, choosing the one with the best performance *out-of-sample*.

falls above the upper limit of the confidence interval of the predicted value. Each time the real value is higher than the upper limit, that value is considered as irregular. In this way, it is possible to define firms' score, given the number of times this firm is find irregular, based on the number of years observed. Scores range from 0 to 100% of irregularity. A score at 100% means that for each year available, that firm is also observed irregular: it has a greater tendency to anomalies. In addition, I take advantage from accruals model and measure of credit constraint in order to check the level of reliability of these firms. I prove the reliability of firms, not only looking at their workforce, but also at the quality of their financial statements. My microeconomic indicator of irregular job is consistent with the indicator of irregular job provided by ISTAT. Correlation is positive, equal to about 90% (in terms of R2), and statistically significant. Southern regions present the highest values of irregularity such as Campania, Calabria and Sicily, while the lowest values are concentrated in Northen regions, such as Valle d'Aosta and Trentino Alto Adige. Results show that irregular firms present negative results in terms of profitability and investments. In terms of contracts, irregular firms have in mean highest values of part-time contracts, with highest levels in mean of contracts with a percentage of part-time under 50% and between 50 and 60%, while the lowest values in mean are for contracts with a percentage of part-time over 90%. Taking advantage from part-time contracts to hide full-time workers, the propensity to have in mean part-time contracts with a percentage of part-time which is not to much high is in line with the hypotheses of informality: they are declared as a 50% part-time, saving on contributions, but workers schedule is higher.

The dilemma of shadow labour in politics as in economics is largely debated and still ongoing. When the cost of hiring someone "officially" is tremendously high, agents' response is to choose the cheaper alternative, the "unofficial" labour market. Burden of tax, social security contributions on wages as well as regulations are told to be the main determinants of the increase of the "cost" of hiring someone officially. Implemented for specific reasons, regulations can also represent a good chance for firms and individuals to choose informal work (Loayza and Rigolini, 2006). I show in this chapter that, combining different sources of data and methods, it is possible to characterize potential irregular units, also improving in this way inspection procedure. In my analysis, I consider informality from social security perspective, but obviously the area of informality can be extended. Hence, promoting a more intense use of different sources of data, as well as different methods of analysis contributes to enhancing efforts to fight tax evasion.

The rest of the chapter is organised with two sections where I review the literature related to machine-learning and accruals model, a section where I present the institutional setting, so the context which makes this kind of analysis for Italy particularly well suited, a section where a describe data, and the other sections where

step by step I explain how I define irregular firms. The last section concludes.

4.2 Machine-learning and Econometrics

In this section, I briefly review some of the empirical contributions in which machine-learning techniques are applied.

Machine-learning is focused on pure *prediction*. Its main goal is to find functions that work well *out-of-sample*. The family of machine-learning consists of: 1) supervised learning= regression, when we have both outcome y and regressors x; 2) unsupervised learning, we have no outcome y and only several x. With regression methods (supervised learning for continuous y) it is considered a linear regression model with a large number of regressors p. These methods have the objective of reducing the model complexity. It provides a powerful way of making quality predictions. In addition to the most common tools developed by researchers, machine-learning has the ability to discover complex structure not specified in advance, manages to fit complex and very flexible functional forms to the data without simply over fitting, finds functions that work well *out-of-sample* (Mullainathan and Spiess, 2017). Economic literature has found numerous and different ways to take advantage of machine-learning prediction capacity. Antulov-Fantulin, Lagravinese, and Resce, 2021, predict the bankruptcy of Italian municipalities in the period 2009-2016. Using institutional data, instead of historical financial data for each municipality, along with the socio-demographic and economic context, the predictability is analyzed through the performance of the statistical and machine learning models. Results suggest that it is possible to make *out-of-sample* predictions with a high true positive rate and low false-positive rate. The model shows that some non-financial features (e.g. geographical area) are more important than many financial features to predict the default of municipalities. Rockoff et al., 2011 predict effectiveness of new math teachers in New York City. Authors collect information on a number of nontraditional predictors of effectiveness, including teaching-specific content knowledge, cognitive ability, personality traits, feelings of self-efficacy, and scores on a commercially available teacher selection instrument. Only a few of these predictors have statistically significant relationships with student and teacher outcomes in terms of value added. McBride and Nichols, 2015 target households at risk of poverty in developing countries, highlighting that effective poverty targeting tools should minimize *out-of-sample* errors and machine-learning can improve the accuracy of poverty targeting tools. Moritz and Zimmermann, 2016 adapt methods from machine learning to show how past returns of US firms have significant predictive power over their future stock prices. Benatia and Villemeur, 2019 study the incentives for market manipulations arising from reneging opportunities in sequential markets under

imperfect commitment and market power. Authors leverage machine-learning to use model's predictions for identifying manipulations and assessing its welfare impacts.

The impact of a policy depends on who benefits from it. Some individuals may have a higher payoff and the effect may be zero on some groups, also because some may be less likely to put into practice the incentivised behaviour. Predicting who is more likely to belong to these groups is a prediction policy problem (Kleinberg et al., 2015). Andini et al., 2018, provides an application of machine-learning targeting to a massive tax-rebate introduced in Italy in 2014. They consider the hypothetical situation in which its only purpose was to increase consumption, set in an ex-ante situation in which theory and previous evidence suggest which group should be targeted to reach this purpose, but this group cannot be directly observed and needs to be predicted. Authors use supervised machine-learning methods to carry out this prediction and check whether it would have improved the impact on consumption.

Machine-learning can manage unconventional data, for example satellites images, online posts, reviews or comments provided by people. It is also useful in preprocessing and imputing traditional data. As examples, Henderson, Storeygard, and Weil, 2012, show how luminosity at night correlates with economic output; Blumenstock, Cadamuro, and On, 2015 use cell-phone data to measure wealth, allowing them to quantify poverty in Rwanda at individual level. Glaeser et al., 2018 use images from Google Street View to measure block-level income in New York City and Boston; Kang et al., 2013 use restaurant reviews on Yelp.com to predict the outcome of hygiene inspections; Antweiler and Frank, 2004 classify text on online financial message boards as bullish, bearish, or neither.

Another application of machine-learning involves estimation problems. In the instrumental variables application, the first stage is the first step of estimation, but it can also be seen as a prediction task: only the predictors $\hat{x}$ enter the second stage, the coefficient of the first stage are a means of these fitted values (Mullainathan and Spiess, 2017). Many papers introduce regularization into the first stage of instrumental variable analysis in a high-dimensional setting, including the LASSO (Belloni et al., 2012) and ridge regression (Carrasco, 2012; Belloni et al., 2016). Chernozhukov et al., 2018 take care of high-dimensional controls in treatment effect estimation by solving two simultaneous prediction problems, one in the outcome and one in the treatment equation. Athey and Imbens, 2016 map out treatment effects heterogeneity, through sample-splitting, and obtain valid (conditional) inference on treatment effects that are estimated using decision trees.

4.3 Earnings quality and accounting fraud

In this section, I review the main contributions related to the branch of empirical literature devoted to the link between abnormal accruals and accounting fraud.

Depending on the context-specific, common proxies for earnings quality used by researchers are: persistence, accruals, smoothness, timeliness, loss avoidance, investor responsiveness, and external indicators such as restatements and SEC enforcement releases, and these proxies can vary with respect to the specific decision-context. Literature on earnings quality is divided in two branches: one is related to the determinants of the earnings quality proxy, the other is about the consequences of earnings quality proxy.

The general equation for earnings quality is:

$$\textit{Reported Earnings} = \textit{Function of (X)} + \textit{error term}$$

Fundamental earning process (X) : the output of the firm's production function which depends on operating cycle, macro-business condition, investment opportunity set, managerial skill, and other features of the firm; *error term*: the ability of the accounting system to measure the firm's fundamental earnings process. Accruals models: 1) control for the accruals that are related to the firm's fundamental earning process; 2) distinguish normal accruals from the components that represent the discretion. A strand of research area is related to the determinants and consequences of the so called *abnormal accruals*, derived from the accruals models. Residuals from the model are used as a measure of "abnormal" accruals. Jones, 1991 identifies accruals as a function of revenues growth and depreciation is a function of PPE, scaling all the variables by total assets. Dechow, Sloan, and Sweeney, 1995 adjust Jones' model to exclude growth in credit sales in years identified as a manipulation. Dechow and Dichev, 2002 model accruals as a function of past, present and future cash flows. For a comprehensive review of all the proxies, determinants and consequences of earnings quality provided by researchers see Dechow, Ge, and Schrand, 2010. Accruals measures are associated with a part of literature which is involved in *accounting frauds*. Accounting fraud is the intentional manipulation of financial statements to create a false appearance of corporate financial health. A company can falsify its financial statement by overstating its revenues, not recording expenses, and misstating assets and liabilities. For accounting fraud to take place, a firm must deliberately falsify financial records. A company can commit an accounting fraud if overstates its revenue, to cover up that the company is actually operating at a loss and not generating enough revenue. If the company overstates its revenues, it would drive up the firm's share price. Another type of accounting fraud takes place when company does not record its expenses, or when overstates its assets or understates its liabilities. This type of fraud misrepresents a company's short-term liquidity. When

intentional misreporting is frequent, the consequence is that financial and real economic activities cannot be properly evaluated. This is also true for the evaluation of a policy: the presence of accounting frauds con distort the real effects of that policy on who benefits from it. Literature on fraudulent accounting mechanisms starts with Dechow, Sloan, and Sweeney, 1996, putting the attention on the "reasons" why companies engage in accounting frauds: when a business is stagnant, companies are more likely to intentionally falsifying information. Statistical models have been developed with the objective of detect the occurrence of manipulation of financial information. One of the issues is to better identify financial information which are likely to be correlated with a potential accounting fraud, considering a huge set of variables. Song, Oshiro, and Shuto, 2016 introduced a total of six variables into the model based on some theoretical assumptions. Perols and Lougee, 2011 and Perols et al., 2017, use broadest possible swath of corporate information as explanatory variables. Additional variables are: financial indicators constructed from corporate financial information and corporate governance. Dechow et al., 2011 use as explanatory variables of fraudulent accounting: accruals quality, financial performance, non-financial measures, off-balance-sheet activities, market-based measures, theoretically related to the occurrence of accounting fraud. Another branch of literature refers accounting frauds to practical knowledge in the accounting field. Researchers put the attention on the so called "discretionary accounting accruals". Discretionary accounting accruals are linked to management's profit adjustment behaviour and are found to be strongly correlated with fraud situations. Healy and Wahlen, 1999 review all the detection practices used by researchers during years in order to inspect financial frauds, starting from extensive use of auditing to more sophisticated and less expensive and time consuming than auditing methods, such as data mining methods, with a particular focus on computational intelligence-based technique. West and Bhattacharya, 2016 provide a comprehensive review of financial fraud detection research using such data mining methods, with a particular focus on computational intelligence (CI)-based techniques. Authors present a comprehensive classification as well as analysis of fraud detection literature based on key aspects such as detection algorithm used, fraud type investigated, and performance of the detection methods for specific financial fraud types. The empirical earnings quality literature which focuses on the connections between abnormal accruals and accounting frauds tends to put the attention on the "reasons" why companies engage in accounting frauds. Kedia and Philippon, 2009 for the first time look at the effect of earnings management on the allocation of resources. In their analysis, authors show how bad managers who want to hide their poor quality must not only manage their earnings, but also hire and invest like good managers. When the misreporting is detected, firms shed labour and capital and productivity improves. In equilibrium bad managers hire and invest excessively, distorting the allocation of

resources among firms.

4.4 Institutional setting

In Italy the value added of the shadow or underground economy is worth about 12,1% (211 billion) of GDP. Figure 4.2 shows the yearly irregular job rate, computed as the percentage of units of undeclared employees over total work units, for period 2005-2017. It shows a substantial increase during years 2008-2015 of undeclared work, and a slight break in years 2015-2017. Between all the components of the underground economy, the impact of under declaration and irregular job is higher with respect to the unlawful activities (see figure 4.3), respectively evaluated 176 billion and 19 billion in 2017 (ISTAT, 2019).

The dynamic of employment in Italy seems to be particularly intense after 2008 crisis. Following a contraction of labour demand, it starts a phase of great recovery of the labour input. What emerges from Italian setting between 2008-2017 is a greater tendency to use flexible jobs, reducing period and schedule.

It seems that a great part of this growing employment, starting from 2008, is given by part-time contracts. In phase of weakness for the labour market, the use of part-time contracts can represent the answer of the business environment in order to react to the crisis. The stylised fact is a clear reduction of workers' time schedule. Moreover, another evidence of the Italian setting is the growing incidence of "involuntary" part-time on the total of part-time contracts. FDV, 2018 calculates that the so called "disadvantage area", the area made up of non-voluntary temporary employees and part-time workers (between 15 and 64 years), is in continuous growth with a value in the first semester of 2018 of more than 4 millions. Involuntary part-time (in absence of a full-time job) is increased in 2017, and in 2018 it is equal to more than 2 million (more than 1 million with respect to 2007, equal to +138,8%). The weight of involuntary part-time on the total of part-time contracts in 2007 is 38,2, in 2015 is 64,3%, in 2018 is 63,9% (see figure 4.4). The existence of "involuntary" part-time could represent a good chance to take advantage of full-time jobs not fully registered. The second evidence is that, not only a growing use of part-time contracts, but a growing incidence of "involuntary" part-time: despite many employees are willing to work full-time, they are forced to accept a part-time job in absence of something else. The absence of a job clearly generates inequalities, but also between employees there are strong differences, in terms of job insecurity and disadvantage. Uncertainty and weakness of labour market can be seen in this dynamic of non-standard jobs, with contracts not long-lasting, and an intense use of part-time, instead of full-time. These situations, could represent a good chance for undeclared work, in the form of semi-illegal jobs. One of the in-depth analysis of the MEF, 2019

computes the "informal base" as a difference between how much is declared for tax purposes and how much is declared by the same people in a research interview provided by Istat[8] in order to empirically investigate the "grey" phenomenon. Results show strong differences between "grey" and "black" workers' features: differences in gender are stronger for "black" labour (the probability for a woman is higher), than for "grey" labour, education impacts more in the probability of being a "black" worker than of being a "grey" worker, the probability of "grey" increases with age. Figure 4.6 reports computations of the "informal tax base". This analysis confirms the idea that informality phenomenon is not so distance from reality.

4.5 Data

I use different sources of data in order to get the dataset and variables used for the analysis.

Matched employer-employee records: I consider the universe of non-agricultural firms for which they are reported detailed information about employees covered by Social Security, filling the *Uniemens* modules. I use yearly data for the period 2005-2017. For each worker-firm record, information available is: type of contract (permanent, temporary or seasonal; part-time or full-time), beginning and end date of the contract, alongside the underlying motivation (e.g. layoff, quit), wage, broad occupation group. I collapse number of employees for each firm, creating four variables: temporary, permanent, seasonal and the total number of employees. Temporary contracts are distinguished if they are full-time or part-time; permanent and seasonal if they are part-time contracts. In addition, for part-time contracts I have the possibility to check the percentage of part-time, meaning that it is possible to see the exact measure of part-time for each contract (50%, 80%,..). In Italian Labour Legislation there is the distinction in three categories of part-time: horizontal (subject works less hours all the week), vertical (subject works less day of the week full time) and mixed (a mix of horizontal and vertical).[9] The percentage of part-time is available only for the type of part-time defined as horizontal.[10] Thanks to all these information, it is possible for me to identify employees for their exact type of contract, as follows: temporary part-time, permanent part-time, and seasonal part-time

[8] Silc Istat.

[9] Until 2015, employers must use different part-time contracts for the three different possibilities. After 2015 Jobs Acts, employers do not have to use different contracts for different part-time. Part-time contract is only one, and they must specify in the contract number of hours or days, or both of the part-time.

[10] It is possible to have employees who during the same year transform their contract. I define with a dummy variable which takes value of 1 if the contract during the year is transformed, in order to distinguish how many of my "informal" workers are ones whose contract was modified during the year.

workers. Firms are identified by a unique Tax Identification Number (TIN) and associated to a Contribution Identification Number. It is possible for a subset of firms more than one Contribution Identification Number. Sometimes, it happens that for more Contribution Identification numbers, they are associated different economic sector codes. I consider for my analysis the most used (the most repeated one) economic sector code.

CERVED data: using TIN, I match worker-firm record with CERVED data. In this way, I have for each firm the exact information about employees and financial statements. I consider the sample period of 2005-2017.[11]

Inspections data: thanks to the INPS archive, I can use data of inspections for the years 2002-2014. For each inspected firm, it is reported: beginning and end date of the inspection, the number of inspection for each year for each firm (it is possible for a single firm to receive more than one inspection), the result of the inspection (black workers or not, total omissions in workers' contracts). The 2014 is the last year available for INPS archive, because in 2015, with the Jobs Act, there is the birth of a new agency, the INL (Ispettorato Nazionale del Lavoro).[12]

ISTAT data: index of Italian irregular employees by economic sector codes and regions for period 2005-2017, based on the Labour Force Survey. I compare my irregular units, defined using INPS data, with the irregular job rate computed by ISTAT. It is used the rate of undeclared work, as the % of units of undeclared work over total units of work. ISTAT defines as ULA (Units of full-time work) all the labour units, for all the job positions covered by employed. ULA are computed as the share of total number of worked hours over the average number of worked hours full-time. The irregular ULA are defined as all the work units without regulation, and so that not directly observed.

4.6 Model selection-LASSO

I use LASSO (Tibshirani, 1996) to select the model with the best prediction of my outcome variable of interest. Using INPS data, I distinguish four different contract situations: temporary full-time, temporary part-time, permanent part-time and seasonal part-time. Combining INPS and CERVED dataset, I have for each firm, each year the number of employees and the financial statements information. I use LASSO to select the financial statements variables which impact more on the share of part-time and temporary full-time contracts. So that, I compute LASSO for three

[11] Values of the variable Roe are winsorized if Roe is less than 20 and greater than 100. Values of the variable Roa are winsorized if Roa is less than 20 and greater than 30.

[12] Before the reform of 2015, the inspection activity was carried out by three different subjects: Ministero, for labour regulation; INPS, for social previdence and INAIL, for job security. In order to simplify procedures and coordinate the activity of the three subjects, in 2015 it was approved the creation of the new agency, the INL.

different y, in order to select the covariates that have an effect on the three different types of part-time job. I run two different LASSO solutions: adaptive and plugin.[13]

Temporary full-time: the dependent variable is the share of temporary full-time over the total number of employees for each firm, each year for the sample period 2005-2017. Table 4.1 shows LASSO results. From a total of 17 covariates, the adaptive LASSO selects only 10, the Plugin LASSO selects only 1 covariate. The two LASSO performs quietly similar in terms of *out-of-sample* prediction performance. The Plugin LASSO selects less covariates than the Adaptive, so I will prefer this second model given by credits for prediction.

Temporary part-time: the dependent variable is the share of temporary part-time over the total number of employees for each firm, each year for the sample period 2005-2017. Table 4.2 shows LASSO results. From a total of 17 covariates, the adaptive LASSO selects only 9, the Plugin LASSO selects only 2 covariates. The two LASSO performs quietly similar in terms of *out-of-sample* prediction performance. The Plugin LASSO selects less covariates than the Adaptive, so I will prefer this second model given by credits and labour cost for prediction.

Permanent part-time: the dependent variable is the share of permanent part-time over the total number of employees for each firm, each year for the sample period 2005-2017. Table 4.3 shows LASSO results. From a total of 17 covariates, the adaptive LASSO selects only 9 covariates, the Plugin LASSO selects only 2 covariates. Again, the two LASSO performs quietly similar in terms of *out-of-sample* prediction performance, and the covariates selected by the Plugin LASSO are the same selected for the share of temporary part-time contracts, credits and labour cost.

Seasonal part-time: the dependent variable is the share of seasonal part-time over the total number of employees for each firm, each year for the sample period 2005-2017. Table 4.4 shows LASSO results. From a total of 17 covariates, the Adaptive LASSO selects 8 covariates, the Plugin LASSO, only 1, labour cost. The *out-of-sample* prediction performance in this last case is similar for Adaptive LASSO than Plugin. I will use the model with one covariate selected, labour cost.

4.7 Accruals

Using Cerved data, the general equation for the computation of accruals is the following:

[13] See Appendix D for more details about LASSO procedure.

$$\begin{aligned}\Delta Credits_{i,t} = \beta_1 \Delta Revenues_{i,t} + \beta_2 \Delta Revenues_{i,t} \times size_{i,t} + \\ + \beta_3 \Delta Revenues_{i,t} \times age_{i,t} + \beta_4 \Delta Revenues_{i,t} \times age_{i,t}^2 + \\ + \beta_5 \Delta Revenues_{i,t} \times grr_{i,t} + \epsilon_{i,t}\end{aligned} \tag{4.1}$$

In this version, accruals are not different for each industry, but I only include dummies into the model, where the outcome variable of interest is $DeltaCredits_{i,t}$ (credits variation) for each firm i in each year t of my sample periods. In my equation credits variation depends on $DeltaRevenues_{i,t}$ (revenues variation) for each firm i at time t, and a series of interactions between revenues variation and age, change in median revenues (grr variable), specifying with a dummy variable if median revenues is positive or negative, and $\epsilon_{i,t}$ is the error term (see Table 4.5).

4.8 Prediction

Based on the model selection in the previous section using LASSO, the third step of the analysis consists of estimating a least square dummy variable model (LSDV) for fixed effects using the only covariates selected by LASSO, and I also include dummy variables to take into account fixed effects. Because as dependent variable I have a ratio, and what I want is that prediction values are positive, because I am looking at number of employees, I consider the logarithm of the ratio.

Equation 4.2 is referred to temporary full-time, and reads as the follows:

$$\begin{aligned}Logratio_{i,t} = \zeta Credits_{i,t} + \delta_2 S_2 + ... \delta_n S_n + \\ + \delta_2 P_2 + ... \delta_n P_n + \epsilon_{i,t}\end{aligned} \tag{4.2}$$

where the dependent variable $Share_{i,t}$ is the log of the ratio of temporary full-time workers for each firm i at time t, $Labourcost_{i,t}$ and $Credits_{i,t}$ are the independent variables, $n-1$ dummy variables are used in order to capture industry fixed effects, $\epsilon_{i,t}$ is the error term. Dummy variables for industry is defined at 4-digits ateco code.

Equation 4.3 is referred to temporary part-time, and reads as the follows:

$$\begin{aligned}Logratio_{i,t} = \zeta Credits_{i,t} + \gamma Labourcost_{i,t} + \delta_2 S_2 + ... \delta_n S_n + \\ + \delta_2 P_2 + ... \delta_n P_n + \epsilon_{i,t}\end{aligned} \tag{4.3}$$

where the dependent variable $Share_{i,t}$ is the log of the ratio of temporary part-time workers for each firm i at time t, $Labourcost_{i,t}$ and $Credits_{i,t}$ are the independent variables, $n-1$ dummy variables are used in order to capture industry fixed effects, $\epsilon_{i,t}$ is the error term. Dummy variables for industry is defined at 4-digits ateco code.

Equation 4.4 is referred to permanent part-time, and reads as the follows:

$$Logratio_{i,t} = \zeta Credits_{i,t} + \gamma Labourcost_{i,t} + \delta_2 S_2 + ...\delta_n S_n + \\ + \delta_2 P_2 + ...\delta_n P_n + \epsilon_{i,t} \tag{4.4}$$

where the dependent variable $Share_{i,t}$ is the the log of the ratio of permanent part-time workers for each firm i at time t, $Labourcost_{i,t}$ and $Credits_{i,t}$ are the independent variables, $n-1$ dummy variables are used in order to capture fixed effects for industry, $\epsilon_{i,t}$ is the error term. Dummy variables for industry is defined at 4-digits ateco code.

Equation 4.5 is referred to seasonal part-time, and reads as the follows:

$$Logratio_{i,t} = \gamma Labourcost_{i,t} + \delta_2 S_2 + ...\delta_n S_n + \delta_2 P_2 + ...\delta_n P_n + \epsilon_{i,t} \tag{4.5}$$

where the dependent variable $Share_{i,t}$ is the log of the ratio of seasonal part-time workers for each firm i at time t, $Labourcost_{i,t}$ is the independent variable, $n-1$ dummy variables are used in order to capture industry fixed effects, $\epsilon_{i,t}$ is the error term. Dummy variables for industry is defined at 4-digits ateco code.

Firms' score: once computed the predicted values, I also compute the confidence interval of the prediction. I discriminate between statistical error and another type of error, which should be associated with an informal situation. I define as informal units the ones for which the real value falls above the upper limit of the confidence interval of the predicted value. Each time the real value is higher than the upper limit, that value is considered as irregular. In this way, it is possible to define firms' score, given the number of times this firm is find irregular, based on the number of years observed. Scores range from 0 to 100% of irregularity. A score at 100% means that for each year available, that firm is also observed irregular. It has a greater tendency to anomalies.

4.9 INPS Inspections

INPS inspections advocate to control for all the contracts for which it is compulsory the payments of social security contributions. Inspectors of "Social Security" have the power to ensure the compliance of the social security legislation. These inspectors have access to enterprises workplaces, examine enterprises, compulsory books, acquire declarations of workers and employers, and they can start a caution in case of irregularities found during inspections. A labour inspection visit can be generated from the three different situations: 1) **request of intervention:** it is a complaint against a specific employer, reported from one or more workers, regarding unlawful

or irregular treatment received by workers during their working activities; 2) **the office communication:** consisting of transmission by another administrative institute or by the judicial police; 3) **the autonomous initiative:** such as the planned labour inspection visit. According to a specific planning or operational guidelines, it is decided to inspect a specific entrepreneur. This last situation can take place also based on statistics studies and monitoring activities carried out previously by territorial supervisory bodies. The **autonomous initiative** better reflects the essence of labour inspections, thanks to the "*surprise effect*" that provides a higher effectiveness of the investigation.[14] The method I propose in order to define irregular firms is in line with this third method. Inspections can be planned according to the score of irregularity assigned to firms, based on observed data. Combining different sources of data and methods it is possible to characterize potential irregular units, making also the inspection procedure more efficient. Firms can be inspected based on precise analysis, and at the same time the activity is not driven by initiative from workers or entrepreneurs. The "*surprise effect*" which provides a higher effectiveness of the investigation is preserved and also the inspection activity will be more precise.

INPS inspections dataset reports the date of the beginning and the date of the end of the inspection, the identification code of the inspected firm and the type of irregularity discovered (black worker, all omitted, some omitted).

Figure 4.7 shows the yearly trend of INPS inspections from 2002-2014. Clearly, it seems that the inspected activity is reducing. Less firms inspected, less irregularities are discovered. This means that firms during years have faced a lower probability of being inspected, so irregular firms should have more incentive to not comply.

I merge my informal dataset with inspections dataset, in order to check whether firms I define as irregular, have also received an inspection by INPS, having in this way an additional information about firms' level of reliability.

4.10 Descriptive analysis

In the previous sections, I explain how I generate my dataset of informal units and firms' score of irregularity. With LASSO procedure, I select the covariates which impact more on the share of part-time contracts, (permanent, temporary and seasonal). I calculate predicted values, based on the LASSO model selection, and I distinguish if real values are higher than the upper limit of the confidence interval of the predicted value. Moreover, I calculate accruals residuals, having in this way an additional information about the level of reliability of firms.

In table 4.5 reports descriptive statistics (mean and standard deviation) for some of the main variables of the financial statements for irregular firms. I select firms

[14] For a more developed discussion about labour inspection in Italy see Fasani, 2011

distinguishing the percentage of irregularity: less than 10%, between 10 and 50% and more than 50%, which represent the highest score of irregularity. Firms with highest score of irregularity present negative value in terms of Roi, lowest levels of revenues, credits, and liquid assets. Figure 4.8 show mean of part-time contracts (horizontal) looking at the percentage of part-time, comparing the group of regular and irregular firms. Irregular firms have in mean highest values of part-time contracts, with highest levels in mean of contracts with a percentage of part-time under 50% and between 50 and 60%, while the lowest values in mean are for contracts with a percentage of part-time over 90%. Irregular firms take advantage from part-time contracts to hide full-time workers. In this sense, the propensity to have in mean part-time contracts with a percentage of part-time which is not to much high is in line with the hypotheses of informality: they are declared as a 50% part-time, saving on contributions, but workers schedule is higher. It can be argued that firms with a higher number of full-time workers prefer to use part-time workers. Figure 4.9 compares in mean part-time (horizontal) contracts and full-time contracts, for both regular and irregular firms. Regular and irregular firms present in mean similar levels of full-time contracts, but irregular firms have in mean consistent higher number of part-time contracts. Irregular firms have higher levels of 50% or less part-time in terms of percentage, with in mean a level of full time workers similar to regular workers. The only clear difference is in the mean of part-time contracts, which is effectively higher. Figure 4.10 compares the mean of part-time contracts in percentage, for the percentage of irregularity above and below 50%. Firms with the highest score of irregularity confirm the tendency to use not only more part-time contracts, but specifically contracts with a percentage of part-time that is not higher than 60%.

A not reliable financial statement, impaired loans or difficulties to have access to credit market can represent important drivers for firms to push firms to save on costs in irregular ways. For these reasons, I check the reliability of my results, looking at accruals and credit constraint for irregular firms. Table 4.7, I report descriptive statistics of the variable accruals, computed as residuals of Δ Credits for firms. I distinguish the three main economic sector codes: Manufacturing, Constructions and Services.[15] Services has the highest number of observations, compared with Manufacturing and Constructions. Mean values of accruals for Constructions and Services are negative, while for Manufacturing mean value is positive (48.9). The highest value in median is given by Manufacturing, for Constructions median value is negative, while for Services it is the lowest one (0.68).

For credit constraint I use the SA index, derived by Hadlock and Pierce, 2010. The index is computed in the following way:

[15] I include in Manufacturing also mining and energy. In Italian it is refereed to "industria in senso stretto".

$$SAindex = -0.737 \times SIZE + 0.043 \times SIZE2 - 0.040 \times AGE \quad (4.6)$$

where $SIZE$ is the natural logarithm of inflation adjusted total assets; AGE is defined as the number of years of the firm (since it is born or listed). Higher is the index and higher is the probability for a firm to face financial constraints (see table 4.8).

4.11 Correlations

My microeconomic indicator of irregular job is consistent with the indicator of irregular job provided by ISTAT. ISTAT irregular job rate is computed as percentage of irregular ULA over the total number of ULA. It is yearly, at regional level, and economic sector codes are grouped in 4 macro-categories: Agriculture, Mining, Construction, and Services.[16]

In this section, I present correlations between ISTAT irregular job rate wand my indicator of irregular job defined using the different types of contracts. I compare INPS irregular firms with ISTAT irregular job rate. I compute Pearson correlation coefficient, which ranges from -1 to 1. Closer to 1 means strong correlation. A negative value indicates an inverse relationship (roughly, when one goes up the other goes down).

Correlation between the share of temporary full-time contracts, defined as informal, and ISTAT irregular job rate is negative and not statistically significant (-0.3253). The same happens if I consider the share of irregular seasonal part-time and ISTAT irregular job rate: correlation is negative and not statistically significant (-0.3227).

Results are instead consistent and robust if I look at temporary part-time and permanent part-time. Table reports Pearson correlation between informal temporary part-time and ISTAT irregular job rate. I collapse irregular firms found with INPS data at regional level. Correlation between the two measures is positive, equal to about 60% (in terms of R2) and statistically significant. I compare the regional averages of the index of job irregularity with INPS data related to temporary part-time contracts against the index of irregularity provided by ISTAT, but based on Labour Force Survey. Despite the very different methods of elicitation, the two measures are correlated. Both show that Southern regions feature the highest levels of underground economy, in particular in Campania and Calabria. Northen regions, in contrast, present lowest levels, such as Veneto and Trentino Alto Adige.

Table 4.10 presents the correlation between the share of permanent part-time contracts, defined as informal, and ISTAT irregular job rate. Correlation is positive,

[16] Agricultural firms are dropped from my analytic sample.

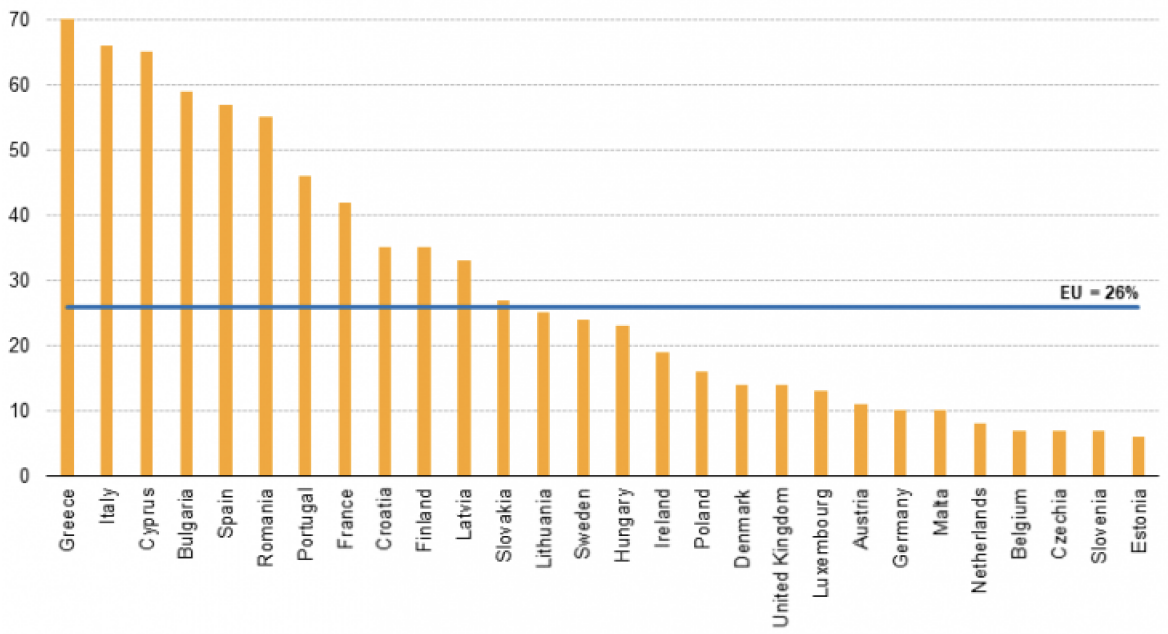
equal to about 90% (in terms of R2), and statistically significant. In addition, this correlation is more robust than the one where I use temporary part-time contracts. Figure plots the regional averages of the index of job irregularity with INPS data related to permanent part-time contracts against the index of irregularity provided by ISTAT, but based on Labour Force Survey. Again Southern regions have the highest values of irregularity such as Campania, Calabria and Sicily, while the lowest values are concentrated in Northen regions, such as Valle d'Aosta and Trentino Alto Adige.

4.12 Conclusion

In this chapter, I present an exercise where, with some steps, I construct an irregular job rate. Italy represents a good and interesting setting, due to the highest levels of evasion and underground work, and the numerous interventions against shadow economy implemented by Governments. This research analysis uses the INPS dataset, which contains information on the universe of Italian workers, with all the relative characteristics. It is possible to merge this rich dataset, with CERVED dataset, having the possibility in this way to associate to each employer/employee financial statements information. In years between 2008-2014, Italian labour market faces a huge increase of part-time contracts. It is well known in literature, how these kinds of flexible contracts, born initially with the objective of being a deterrent for undeclared workers, can represent a good chance to work in informality. What I show in this chapter is that, combining different sources of data and methods it is possible to characterize potential irregular units, given the narrow amount of information available and observed, making also the inspection procedure more efficient.

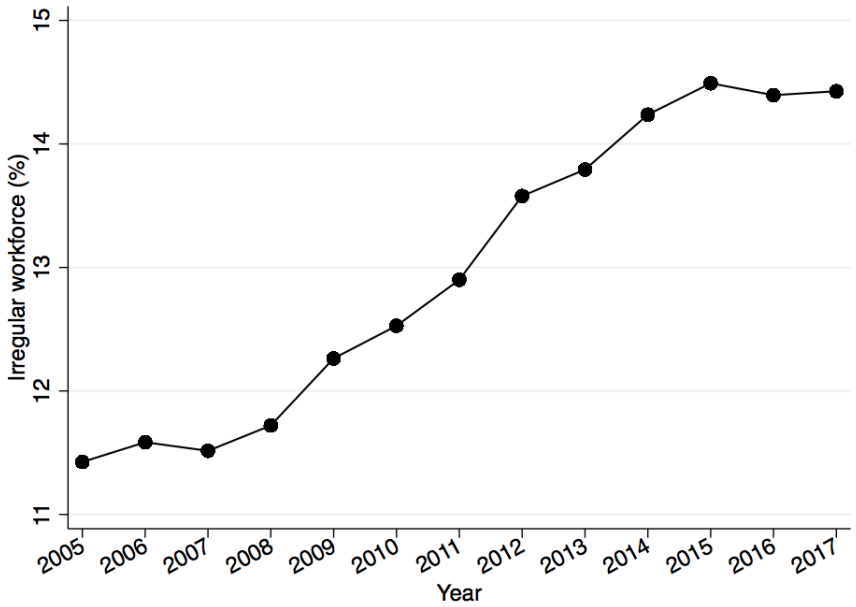
4.13 Figures and Tables

FIGURE 4.1: Part-time working due to lack of access to full-time job in 2018



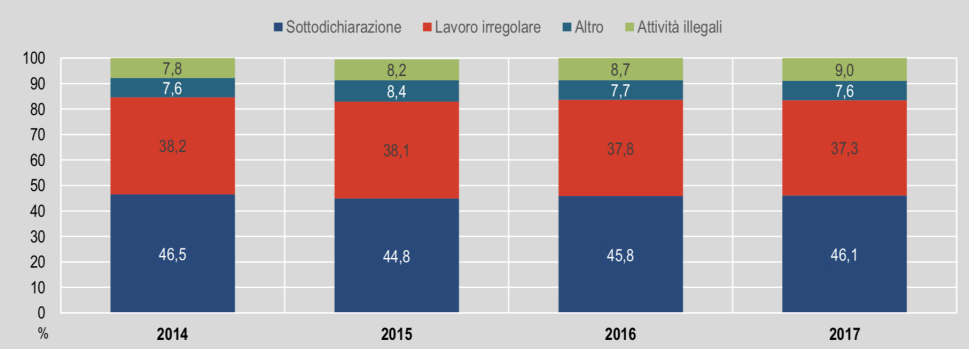
Notes: figure shows the % of part-time employed, aged 20 to 64 for the European countries in 2018, due to the lack of access to full-time job. *Source*: Eurostat dataset.

FIGURE 4.2: Irregular workforce in Italian labour market (%) 2005-2017



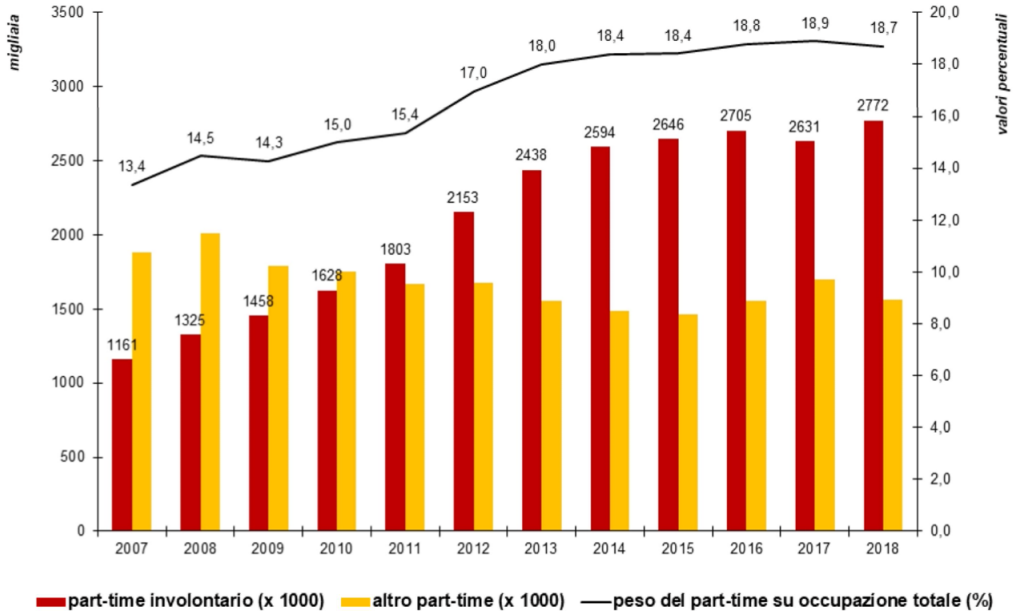
Notes: Rate of undeclared work as the % of units of undeclared work over total units of work. ISTAT defines as ULA (Units of full-time work) all the labour units for all the job positions covered by employed. ULA are computed as the share of total number of worked hours over the average number of worked hours full-time. The irregular ULA are defined as all the work units without regulation, and so that not directly observed. *Source*: ISTAT data.

FIGURE 4.3: Components of Non-Observed Economy, 2014-2017



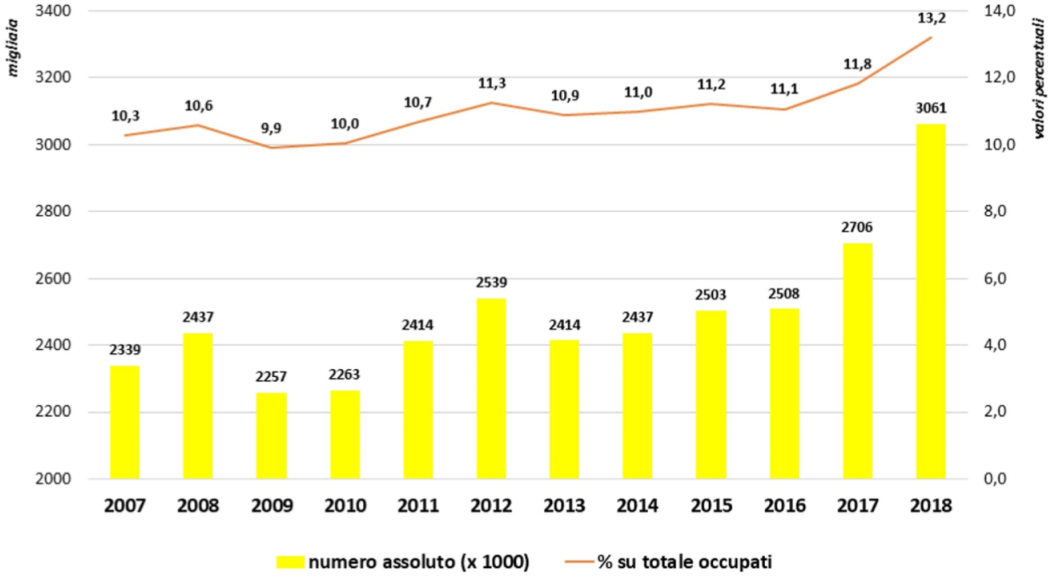
Notes: Figure shows the components of the non-observed economy in Italy for years 204-2017. Blue boxes represents under-declaration, red boxes non-regular workers, green boxes other components and illegal activities. Between all the components of the underground economy, the impact of under-declaration and irregular job is higher with respect to the unlawful activities. *Source*: ISTAT report (2019).

FIGURE 4.4: Involuntary part-time workers in Italy (2007-2018)



Notes: Figure shows the incidence of part-time (yellow bars) and involuntary part-time (red bars) contracts in Italy between years 2007-2018. Black line is the incidence of part-time over the total employment (%). The weight of involuntary part-time on the total of part-time contracts in 2007 is 38,2, in 2015 is 64,3%, in 2018 is 63,9% *Source*: Disuguaglianze e disagio nel lavoro report (2018).

FIGURE 4.5: Involuntary temporary workers in Italy (2007-2018)



Notes: Figure shows the incidence of involuntary temporary contracts in absolute values in Italy for the years 2007-2018. *Source*: Disuguaglianze e disagio nel lavoro report (2018).

FIGURE 4.6: Informal tax base

Stime Sommerso da comparazione SILC vs fisco/contributi	Num	Retrib lorda dichiarata lavoro Somme (mln)	Medie	Reddito evaso da lavoro dipendente Somme (mln)	Medie	Quote numero	Quote Y evaso
Intera retribuzione regolare	12.957.231	317.506	24.504	0	0	56.4%	0.0%
Parziale/grigio da fuori busta o da doppio lavoro	7.018.678	153.374	21.852	21.841	3.112	30.5%	49.2%
Sommerso totale lavoro nero	2.999.476	0	0	22.519	7.508	13.1%	50.8%
Totale	**22.975.385**	**470.880**	**20.495**	**44.361**	**1.931**	**100.0%**	**100.0%**

Notes: Figure reports the "informal tax base". The "informal base" as a difference between how much is declared for tax purposes and how much is declared by the same people in a research interview provided by Istat (Silc Istat) in order to empirically investigate the "grey" phenomenon. *Source*: Nadef (2019).

TABLE 4.1: Share of temporary full-time

	Adaptive (1)	Plugin (2)
tangible fixed assets	0.000000670	
intangible fixed assets	-0.000000146	
financial fixed assets	0.000000507	
credits	-0.00000955	-0.00000256
net assets	-0.000000754	
liabilities	-0.000000901	
labour cost	0.0000102	
purchases	0.000000395	
profits	0.00000371	
cash flow	0.00000210	
Selected predictors	10	1
MSE	382.3565	382.358
R^2	0.0000	0.0000
Obs	3,265,952	3,265,952

Notes: the dependent variable the share of temporary full-time over the total number of employees for each firm, each year for the sample period 2005-2017. Table shows the *out-of-sample* prediction performance of lasso methods.

TABLE 4.2: Share of temporary part-time

	Adaptive (1)	Plugin (2)
credits	-0.0000238	-0.00000392
liquid assets	-0.00000255	
total asset	0.000000257	
liabilities	0.000000133	
revenues	-0.00000272	
labour cost	-0.00000396	-0.00000156
purchases	0.00000498	
financial charges	-0.0000150	
cash flow	0.0000142	
financial debts	0.00000167	
Selected predictors	9	2
MSE	259.2875	259.3371
R^2	0.0003	0.0001
Obs	3,265,952	3,265,952

Notes: the dependent variable the share of temporary part-time over the total number of employees for each firm, each year for the sample period 2005-2017. Table shows the *out-of-sample* prediction performance of lasso methods.

TABLE 4.3: Share of permanent part-time

	Adaptive (1)	Plugin (2)
credits	-0.0000833	-0.0000158
liquid assets	-0.0000129	
profits	0.00000118	
liabilities	0.00000176	
labour cost	-0.0000775	-0.00000922
purchases	0.00000774	
financial charges	-0.0000851	
cash flow	0.0000383	
financial debts	0.0000110	
Selected predictors	9	2
MSE	1035.684	1036.636
R^2	0.0015	0.0006
Obs	3,265,952	3,265,952

Notes: the dependent variable the share of permanent part-time over the total number of employees for each firm, each year for the sample period 2005-2017. Table shows the *out-of-sample* prediction performance of lasso methods.

TABLE 4.4: Share of seasonal part-time

	Adaptive (1)	Plugin (2)
tangible fixed assets	0.000000168	
intangible fixed assets	-0.000000104	
credits	-0.00000314	
labour cost	-0.00000130	-0.000000462
purchases	0.000000264	
financial charges	-0.000000909	
cash flow	0.00000144	
financial debts	0.000000264	
Selected predictors	8	1
MSE	38.32683	38.32783
R^2	0.0000	0.0000
Obs	3,265,952	3,265,951

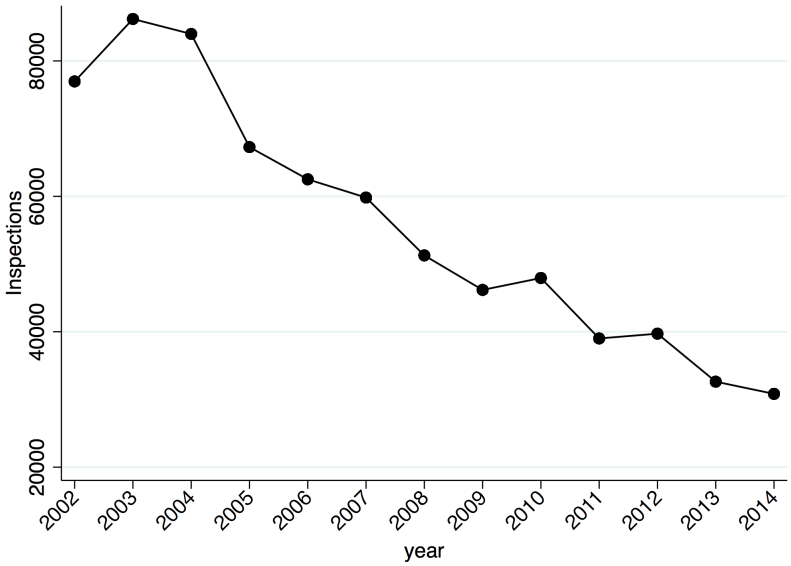
Notes: the dependent variable the share of seasonal part-time over the total number of employees for each firm, each year for the sample period 2005-2017. Table shows the *out-of-sample* prediction performance of lasso methods.

TABLE 4.5: Estimation Results

	ΔCredits (1)	ΔCredits (2)	ΔCredits (3)	ΔCredits (4)
ΔRevenues	0.139***	0.146***	0.146***	0.146***
	(0.00138)	(0.000694)	(0.000694)	(0.000694)
ΔRevenues*log assets	-0.000207**	-0.000246***	-0.000246***	-0.000230***
	(0.0000692)	(0.0000688)	(0.0000688)	(0.0000688)
ΔRevenues*age	0.0157***	0.0103***	0.0103***	0.0102***
	(0.000974)	(0.000228)	(0.000228)	(0.000228)
ΔRevenues*age^2	-0.00102***	-7.41e-09***		
	(0.000178)	((3.00e-10)		
ΔRevenues*grr_p	-7.43e-09***	-6.48e-09	-7.41e-09	-7.41e-09
	(3.01e-10)	(3.15e-10)	(3.00e-10)	(3.00e-10)
ΔRevenues*grr_n	-0.00000236	-0.00000243	-0.00000243	-0.00000330*
	(0.00000137)	(0.00000137)	(0.00000137)	(0.00000136)
log assets	-0.209**	-0.203***	-0.203***	-0.523***
	(0.0713)	(0.0713)	(0.0713)	(0.0677)
Cons.	-0.709	-4.947	-0.825	4.944***
	(1.314)	(4.494)	(1.314)	(0.356)
Sector dummies	Yes	Yes	Yes	No
Adj. R^2	0.156	0.156	0.156	0.156
Obs	6,641,075	6,641,075	6,641,075	6,641,075

Notes: I only include dummies into the model, where the outcome variable of interest is $DeltaCredits_{i,t}$ (credits variation) for each firm i in each year t of my sample periods. In my equation credits variation depends on $DeltaRevenues_{i,t}$ (revenues variation) for each firm i at time t, and a series of interactions between revenues variation and age, change in median revenues (*grr* variable), specifying with a dummy variable if median revenues is positive or negative, and $\epsilon_{i,t}$ is the error term. Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

FIGURE 4.7: INPS inspections 2002-2014



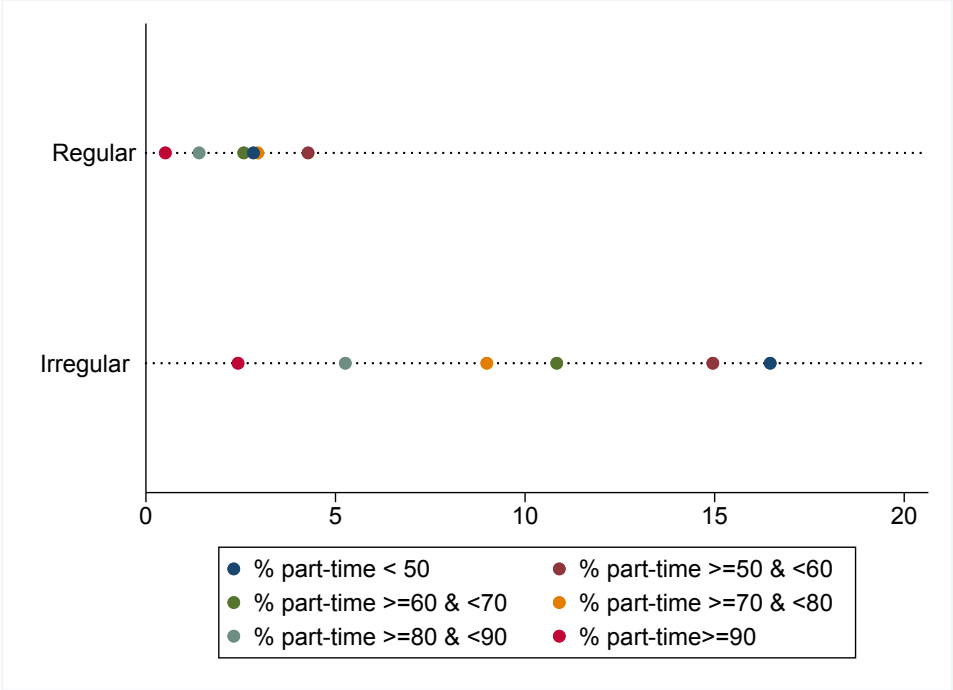
Notes: INPS inspections for years 2002-2014. For each firm record, information available is: beginning and end date of the inspections, the number of inspection for each year for each firm the result of the inspection (black workers or not, partial or total irregularities in workers' contracts). *Source*: INPS data 2002-2014.

TABLE 4.6: Irregular firms

	% irr. <=10	10<%irr<=50	%irr.>50
Fixed assets	3,191	2,671	2,688
	(21726)	(1760)	(1814)
Credits	2,394	1,307	1,291
	(1108)	(2380)	(2436)
Liquid asset	614	392	389
	(3761)	(17899)	(18361)
Total asset	8,457	5,695	5,683
	(4357)	(2372)	(2442)
Debts	964	902	903
	(7986)	(70161)	(72240)
Total liabilities	4,283	2,841	2,838
	(2792)	(2431)	(2509)
Production value	8,765	5,110	5,079
	(5552)	(1176)	(1208)
Revenues	8,676	5,070	5,041
	(5536)	(1172)	(1203)
Labour cost	1,123	699	696
	(4620)	(14116)	(14474)
Value added	1,717	1,066	1,061
	(7171)	(2889)	(2965)
Roe	11.78	13.41	13.46
	(20.36)	(22.96)	(23.02)
Roi	3.44	-6.69	-6.66
	(60.81)	(614.72)	(576.21)
Roa	5.05	4.10	4.10
	(8.84)	(10.23)	(10.26)

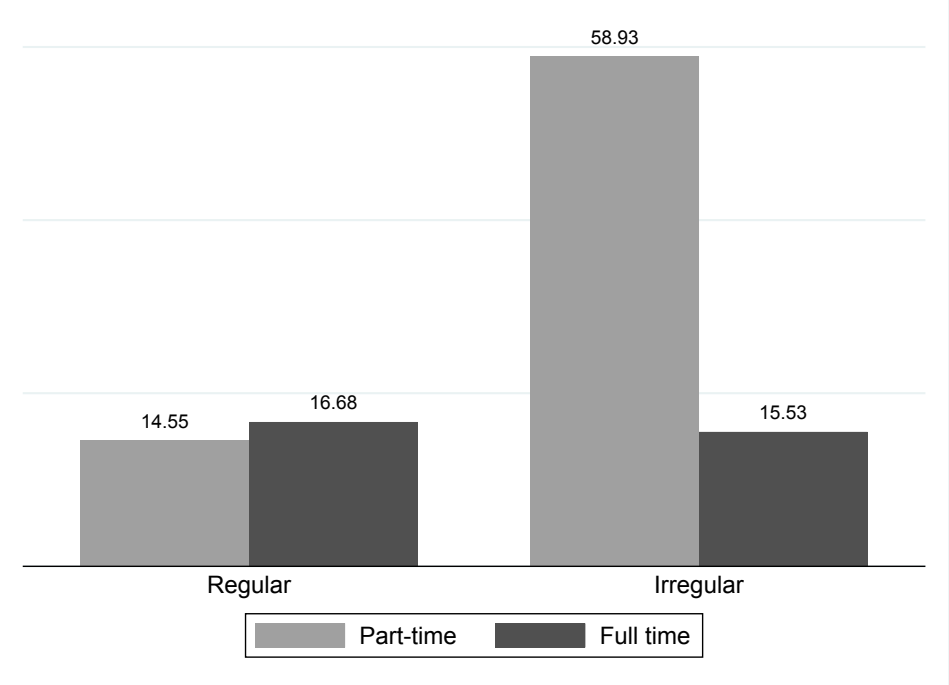
Notes: table reports mean value (standard deviation in parentheses) of the main financial statements variables for irregular firms, for the different percentage of irregularity. Values are expressed in thousands euros.

FIGURE 4.8: Percentage part-time contracts: comparison between regular and irregular firms



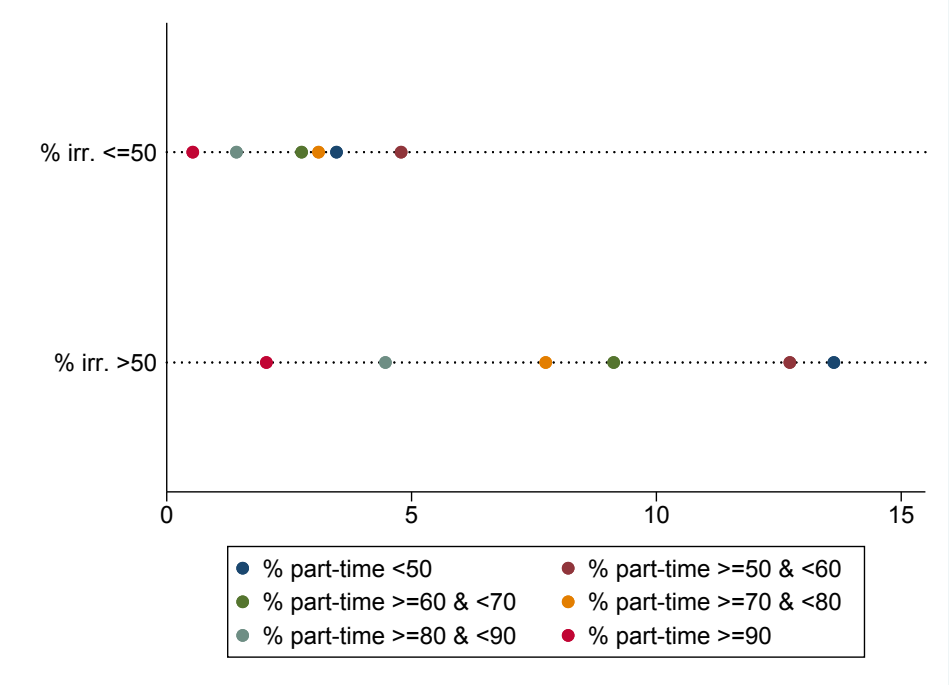
Notes: figure shows mean of part-time contracts (horizontal) looking at the percentage of part-time, comparing the group of regular and irregular firms.

FIGURE 4.9: Part-time and full time contracts: comparison between regular and irregular firms



Notes: compares in mean part-time (horizontal) contracts and full-time contracts, for both regular and irregular firms.

FIGURE 4.10: Percentage part-time: comparison between irregular firms



Notes: compares the mean of part-time contracts in percentage, for the percentage of irregularity above and below 50%.

TABLE 4.7: Accruals irregular firms

	Mean	SD	P50	P90	P99	Obs
Manufacturing	48.9	562.1	2.49	529.1	1,864	1,134
Constructions	-23.2	642.6	-9.72	407.1	1,673	386
Services	-4.28	410.4	0.68	83.4	1,287	5,182

Notes: table shows for irregular firms inspected descriptive statistics of accruals, looking at economic sector codes: Manufacturing, Constructions and Services.

TABLE 4.8: SA index

	Mean	SD	Min	p25	Median	p75	Max
Regular	-3.6	0.57	-43.5	-3.89	-3.60	-3.32	2.8
Irregular	-3.5	0.53	-76.1	-3.82	-3.53	-3.28	5.4

Notes: table reports descriptive statistics of SA index comparing regular and irregular firms. Higher is the index and higher is the probability for a firm to face financial constraints.

TABLE 4.9: Correlation ISTAT data - temporary part-time

	Irr. firms	ISTAT irr. job rate
Irregular firms	1.0000	
ISTAT irr. job rate	0.6006*	1.0000
	(0.0051)	

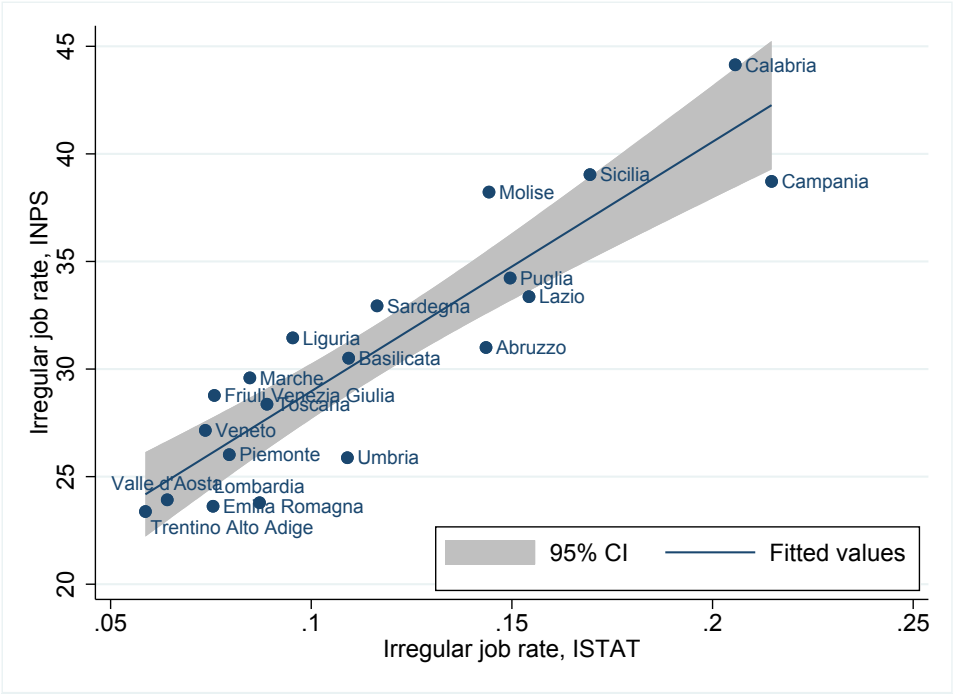
Notes: I compare INPS irregular firms with ISTAT irregular job rate. I compute Pearson correlation coefficient, ranges from -1 to 1. Closer to 1 means strong correlation. A negative value indicates an inverse relationship (roughly, when one goes up the other goes down). I collapse irregular firms found with INPS data at regional level in order to compare it with ISTAT irregular job rate. Correlation between the two measure is positive, equal to about 60%, and statistically significant. Star(0.05) sig.

TABLE 4.10: Correlation ISTAT data - permanent part-time

	Irr. firms	ISTAT irr. job rate
Irregular firms	1.0000	
ISTAT irr. job rate	0.9032*	1.0000
	(0.0000)	

Notes: I compare INPS irregular firms with ISTAT irregular job rate. I compute Pearson correlation coefficient, ranges from -1 to 1. Closer to 1 means strong correlation. A negative value indicates an inverse relationship (roughly, when one goes up the other goes down). I collapse irregular firms found with INPS data at regional level in order to compare it with ISTAT irregular job rate. Correlation between the two measure is positive, equal to about 90%, and statistically significant. Star(0.05) sig.

FIGURE 4.11: Irregular job rate: comparison between ISTAT and INPS



Appendix A

Fuzzy difference in differences - Chapter 3

In a *fuzzy* setting some units may be treated in the control group in period 0, and some units may remain untreated in the treatment group at period 1, or it can happen that the treatment rate increases more in some groups than in others, but there is no group that goes from fully untreated to fully treated, and there is also no group that remains fully untreated. When in a *fuzzy* design the share of treated units increases more in treatment group and remains stable in the control group, there is still the possibility to estimate the Wald DID, without any treatment effect homogeneity assumptions. In this way, it is possible to estimate the Wald DID when the treatment rate increases more between period 0 and 1 in the treatment than in the control group. As usual, the parameter of interest is the estimate of the effect of a treatment D on some outcomes, units can be divided in two groups, one for units which receive the treatment (treated), and the other for units which do not receive the treatment (control). Data can also be divided in time periods represented by a random variable $T \in \{1, .., \bar{t}\}$.

Fuzzy difference-in-differences relies on a set of assumptions:

Assumption 1. *(Fuzzy design)*
$E(D_{11}) > E(D_{10})$, and $E(D_{11}) - E(D_{10}) > E(D_{01}) - E(D_{00})$

Assumption 2. *(Stable percentage of treated units in the control group)*
for all $d \in S(D)$, $P(D_{01} = d) = P(D_{00} = d) \in (0, 1)$

Assumption 3. *(Treatment participation equation)*
There exist $D(0), ..., D(t)$ such that $D = D(T), D(t) \perp T | G \, (t \in \{0, ..., t\})$ and for all $t \in \{1, ..., t\}$,

$$P(D(t) \geq D(t-1)|G) = 1 or P(D(t) \leq D(t-1)|G) = 1$$

Following De Chaisemartin and d'Haultfoeuille, 2018 notation, the "switchers" are the units that become treated at the second date, $S = \{D(0) < D(1), G = 1\}$.

The parameters of interest are their Local Average Tretament Effect (LATE), defined as $\Delta = E(Y(1) - Y(0)|S, T = 1)$. All the three assumptions discussed above are valid for all the three estimators in a fuzzy difference-in-differences setting, but in order to identify Δ and better evaluate which of the three estimators is more suitable for the specific experimental setting, combinations of the following assumptions, in addition to the previous ones, are needed.

The three possible estimands using the Fuzzy DID design are:

1) Wald DID:

$$W_{DID} = \frac{E(Y_{11}) - E(Y_{10}) - (E(Y_{01}) - E(Y_{00}))}{E(D_{11}) - E(D_{10}) - (E(D_{01}) - E(D_{00}))} \tag{A.1}$$

the coefficient of D in 2SLS regression of Y on D with G and T as included instruments, and $G \times T$ as the excluded instrument. The estimator relies on:

Assumption 4. *(Common trends)*
for all $t \in \{1, ..., t\}$, $E(Y(0)|G, T = t) - E(Y(0)|G, T = t - 1)$ does not depend on G.

Assumption 5. *(Stable treatment effect over time)*
For all $d \in S(D)$ and all $t \in 1, ..., t, E(Y(d) - Y(0)|G, T = t, D(t - 1) = d) = E(Y(d) - Y(0)|G, T = t - 1, D(t - 1) = d)$.

When the treatment rate increases in the control group, the Wald DID is equal to a weighted difference of the LATEs of treatment and control group switchers in period 1. In both groups, the evolution of the mean outcome between period 0 and 1 is the sum of three things: the change in the mean of $Y(0)$ for units untreated at $T = 0$; the change in the mean of $Y(1)$ for units treated at $T = 0$; the average effect of the treatment for switchers. When the treatment rate diminishes in the control group, the Wald DID is equal to a weighted average of the LATEs of treatment and control group switchers in period 1. When the treatment rate is stable in the control group, the Wald-DID is equal to Δ plus a bias term involving several LATEs. Unless this combination of LATEs cancels out exactly, the Wald-DID differs from Δ.

2) Time Corrected Wald ratio:

$$W_{TC} = \frac{E(Y_{11}) - E(Y_{10} + \delta_{D10})}{E(D_{11}) - E(D_{10})} \tag{A.2}$$

The Wald TC relies on:

Assumption 6. *(Conditional common trends)*
for all $d \in S(D)$ and all $t \in \{1, ..., t\}$,

$E(Y(d)|G, T = t, D(t-1) = d) - E(Y(d)|G, T = t-1, D(t-1) = d)$ does not depend on G.

Instead of relying on assumptions 4-5, common trends and stable (homogenous) treatment effect, δ_{D10} term accounts for the effect of time on the outcome in the treatment group, under the assumption that the mean of $Y(0)$ (resp. $Y(1)$) among untreated (resp. treated) units at period 0 follows the same evolution in both groups. It requires that the mean of $Y(0)$ (resp. $Y(1)$) follows the same evolution over time among treatment and control group units that were untreated (resp. treated) at T = 0. The second term of the numerator allows for time as not a standard instrument: time can directly affect the outcome. The numerator of Wald TC compares the mean outcome in the treatment group in period 1 to the counterfactual mean we would have observed if switchers had remained untreated.

3) The "changes in changes" Wald ratio, the general changes in changes estimand introduced to *fuzzy* designs by Athey and Imbens, 2006:

$$W_{CIC} = \frac{E(Y_{11}) - E(Q_{D_{10}}(Y_{10}))}{E(D_{11}) - E(D_{10})} \tag{A.3}$$

The estimator relies on:

Assumption 7. *(Monotonicity and time invariance of unobservables)*
$Y(d) = hd(U_d, T)$, with $U_d \in R$ and $h_d(u,t)$ strictly increasing in u for all $(d,t) \in S(D) \times S(T)$. Moreover, $U_d \perp T|G, D(0)$.

Assumption 8. *(Data restrictions)*
1.$S(Y_{dgt}) = S(Y) = [y, y]$ with $-\infty \leq y < y \leq +\infty$,for $(d, g, t) \in S((D, G, T))$.

2.FY_{dgt} is continuous on R and strictly increasing on $S(Y)$, for $(d, g, t) \in S((D, G, T))$.

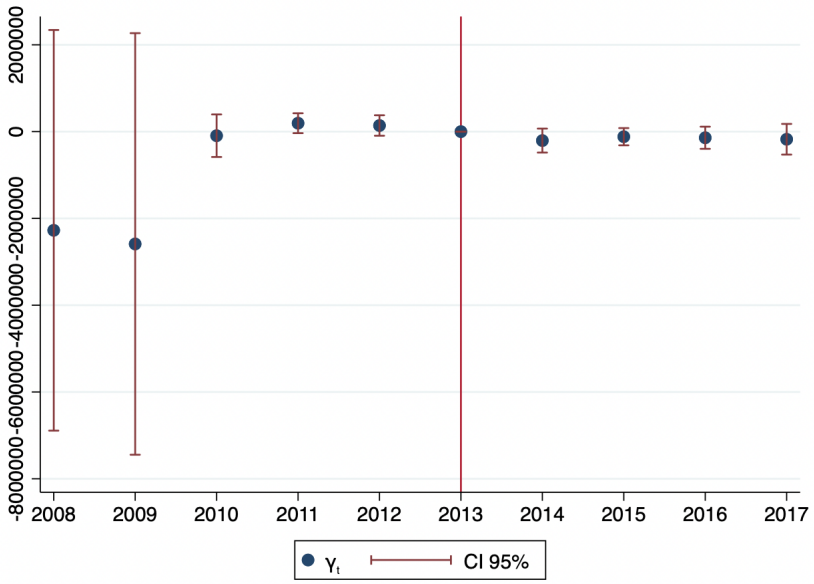
where Q is the quantile-quantile transform of Y from period 0 to 1 in the control group conditional on $D = d$. The W_{CIC} accounts for the effect of time on the outcome through quantile-quantile transform instead of the additive term δ_{D10} in W_{TC}.

Appendix B

Additional results - Chapter 3

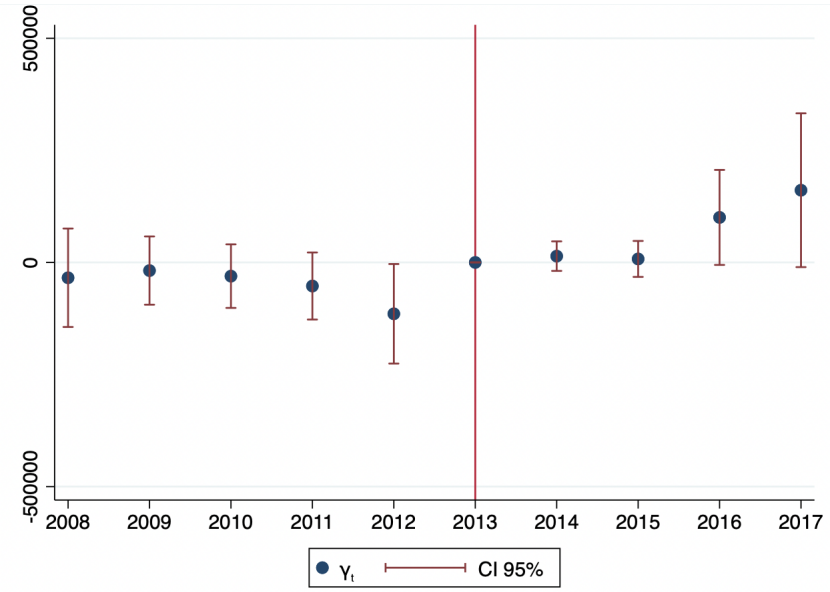
Other outcomes of Tangible Fixed Assets: In this section, I present event-study for the other components of Tangible Fixed Assets: Lands and buildings, Machinery and Other machinery. I check for trend in the outcome variables for both Treatment and Control group. It is argued that firms treated (firms that employ *BHE*) after the policy implementation decide invest more in other forms of business capital. Estimates come from equation 3.1, where the only difference is in the $Y_{i,t}$, the outcome variable. Pre-trends do not provide suggestive evidence of the exogeneity of T_i.

FIGURE B.1: Lands and Buildings



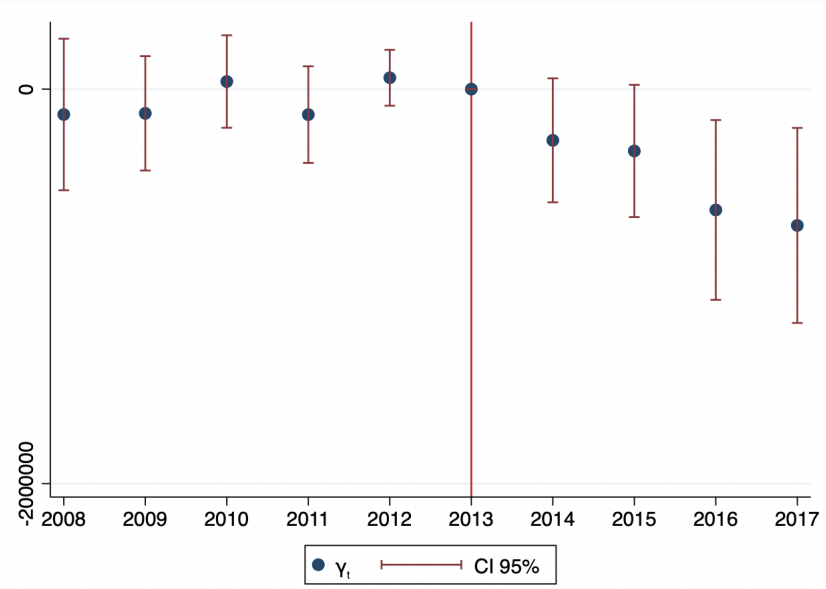
Notes: figure shows the book value of Lands and buildings response to a 1-year increase in T_i. I estimate a difference-in-differences regression comparing pre-reform years 2008-2017 with the post-reform years 2014-2017, the single reference year is 2013. Fixed effects capture time-invariant heterogeneity across firms, year fixed effects control for year-specific shocks common to all firms. Standard errors are clustered at the firm level.

FIGURE B.2: Machinery



Notes: figure shows the book value of Machinery response to a 1-year increase in T_i. I estimate a difference-in-differences regression comparing pre-reform years 2008-2017 with the post-reform years 2014-2017, the single reference year is 2013. Fixed effects capture time-invariant heterogeneity across firms, year fixed effects control for year-specific shocks common to all firms. Standard errors are clustered at the firm level.

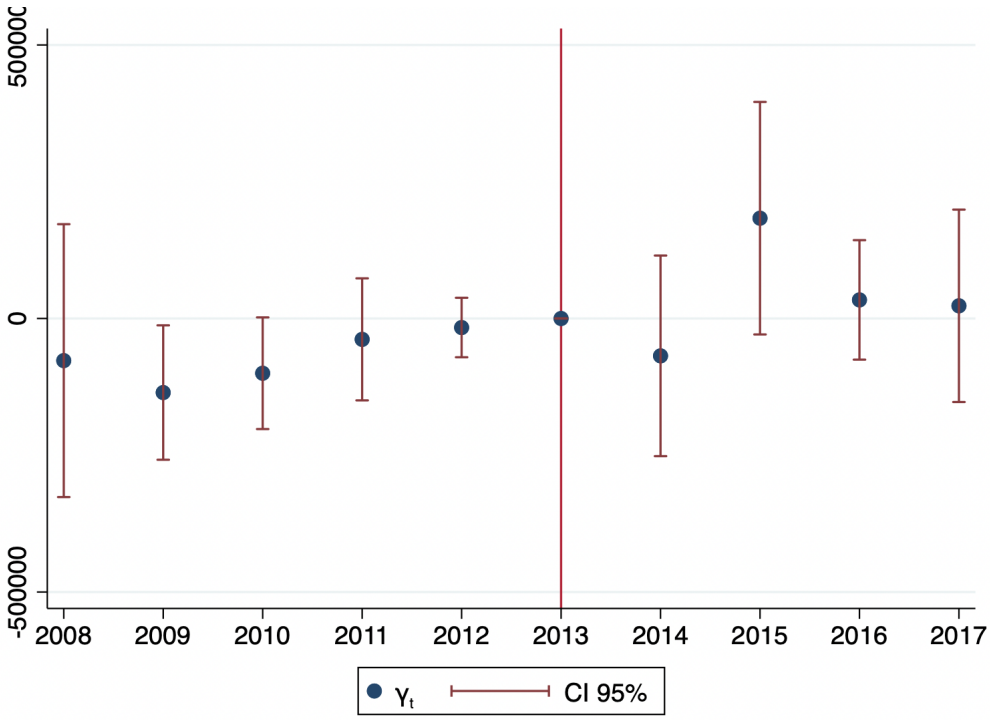
FIGURE B.3: Other machinery



Notes: figure shows the book value of Other machinery response to a 1-year increase in T_i. I estimate a difference-in-differences regression comparing pre-reform years 2008-2017 with the post-reform years 2014-2017, the single reference year is 2013. Fixed effects capture time-invariant heterogeneity across firms, year fixed effects control for year-specific shocks common to all firms. Standard errors are clustered at the firm level.

Total taxes: In this section, I present event-study for the total taxes paid by firms. I check for trend in the outcome variables for both Treatment and Control group. It is argued that, due to the policy implemntatio, firms that employ *BHE* would face a change in the level of taxes. Estimates come from equation 3.1, where the only difference is in the $Y_{i,t}$, the outcome variable. Pre-trends do not provide suggestive evidence of the exogeneity of T_i.

FIGURE B.4: Total taxes



Notes: figure shows the book value of Total taxes response to a 1-year increase in T_i. I estimate a difference-in-differences regression comparing pre-reform years 2008-2017 with the post-reform years 2014-2017, the single reference year is 2013. Fixed effects capture time-invariant heterogeneity across firms, year fixed effects control for year-specific shocks common to all firms. Standard errors are clustered at the firm level.

Heterogeneity: I define a measure of firm's cash flow level using the median of the distribution of cash flow in the pre-period (2008-2013). I rescale the variable cash flow for firm's total assets, and I split firms into two groups (high and low cash flow), based on whether they fall above or below the median of the distribution of the ratio cash flow over total assets. (hereafter, cash flow ratio). I add a triple interaction to eq 4.2, where a high cash flow ratio dummy is interacted with the treatment and the year fixed effects. I estimate the heterogeneous effect of 1-year increase of T_i on equipment in firms with high (above the median) cash flow ratio and low (below the median) cash flow ratio in the pre-reform period. Estimates come from a modified version of equation 4.2, which reads:

$$Y_{i,t} = \lambda_t + \gamma_i + \beta^T Post_t \times T_i + \beta^{T,cf} T_i \times Post_t \times CF_i + \beta^{cf} Post_t \times CF_i + \epsilon_{i,t} \quad \text{(B.1)}$$

T_i is the dummy variable which takes value of 1 if firms are *BHE* economic sector codes. CF_i is a dummy variable which takes value of 1 if firm i belongs to the top half of the distribution of cash flow ratio in the pre-period. Standard errors are clustered at the firm level. Results are reported in table B.1. The coefficient of interest $\beta^{T,cf}$ is not statistically significant.

TABLE B.1: Estimation results

	Equipment
	(1)
$T_i \times$ Post	91,070***
	(23142)
$T_i \times$ Post $\times$ Cash	25,938
	(35387)
Post $\times$ Cash	78,803***
	(22486)
Year FE	Yes
Firms FE	Yes
Adjusted R^2	0.905
Median outcome pre-2014	268,062
Observations	170,230

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

I repeat the same triple difference now testing for firms with a higher level of revenues, rescaled for total assets. I define a measure of a firm's revenues ratio level using the median of the distribution of revenues ratio in the pre-period (2008-2013). I split firms into two groups (high and low revenues), based on whether they fall above or below the median of the distribution of revenues ratio. I add a triple interaction to my specification where a high revenues dummy is interacted with the treatment and the year fixed effects. I estimate the heterogenous effect of 1-year increase of T_i on the level of equipment in firms with high (above the median) revenues and low (below the median) revenues ratio in the pre-reform period. Estimates come from a modified version of equation 4.2, which reads:

$$Y_{i,t} = \lambda_t + \gamma_i + \beta^T Post_t \times T_i + \beta^{T,rev} T_i \times Post_t \times REV_i + \beta^{rev} Post_t \times REV_i + \epsilon_{i,t} \tag{B.2}$$

T_i is the dummy variable which takes value of 1 if firms are *BHE* economic sector codes defined as *BHE* users. REV_i is a dummy variable which takes value of 1 if firm i belongs to the top half of the distribution of revenues in pre-period. Standard errors are clustered at the firm level. Results are reported in table B.2. The coefficient of interest $\beta^{T,rev}$ is not statistically significant.

TABLE B.2: Estimation results

	Equipment
	(1)
$T_i \times$ Post	117,709***
	(33141)
$T_i \times$ Post $\times$ Revenues	1,013
	(36002)
Post $\times$ Revenues	24,296
	(24859)
Year FE	Yes
Firms FE	Yes
Median outcome pre-2014	268,062
Adjusted R^2	0.905
Observations	170,230

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

I repeat the same triple difference now testing for firms if they are North of Italy. I add a triple interaction to my specification where a North dummy is interacted with the treatment and the year fixed effects. I estimate the heterogeneous effect of 1-year increase of T_i on the level of equipment in firms in North of Italy and firms not in North of Italy. Estimates come from a modified version of equation 4.2, which reads:

$$Y_{i,t} = \lambda_t + \gamma_i + \beta^{T} Post_t \times T_i + \beta^{T,North} T_i \times Post_t \times North_i + \beta^{North} Post_t \times North_i + \epsilon_{i,t} \tag{B.3}$$

T_i is the dummy variable which takes value of 1 if firms are *BHE* economic sector codes defined as *BHE* users. $North_i$ is a dummy variable which takes value of 1 if firm i is located in North of Italy. Standard errors are clustered at the firm level. Results are reported in table B.2. The coefficient of interest $\beta^{T,North}$ is not statistically significant.

TABLE B.3: Estimation results

	Equipment
	(1)
$T_i \times$ Post	118,413***
	(31175)
$T_i \times$ Post $\times$ North	-5,625
	(37972)
Post $\times$ North	6,104
	(21633)
Year FE	Yes
Firms FE	Yes
Median outcome pre-2014	268,062
Adjusted R^2	0.905
Observations	170,230

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Fuzzy DID: I compute a Fuzzy DID for "Total taxes", comparing units whose treatment status changes in post-reform period to untreated stable units, units remained untreated in the same period. I define treatment units using a variable equal to 1 (resp. 0, -1) for firm $i \times$ years t observations such that the level of equipment increased (resp. remained stable, decreased) in years 2014-2017 in that firm, due to the policy impact. I cluster the bootstrap at the firms level, to allow for firm-level correlation over time. The control units are firms which level of equipment remains stable. I estimate the effect of a 1 standard deviation increase of T_i, which is the average change in equipment for firms *BHE* users, in period 2014-2017 on the amount of taxes. The three Wald estimators are not statistically significant (see Table B.4).

TABLE B.4: Estimation results

	Total taxes
Wald DID	1.630
	(2.300)
Wald TC	485335
	(2.970)
Wald CIC	-200687
	(190642)
Mean outcome pre-2014	689,951
Mean T_i	1,603
Std. Dev. T_i	2,879
Observations	68,092

Notes: table reports the effects of a 1 standard deviation increase in the book value Total taxes, when the reform is passed, for firms that employ *BHE*, between 2014-2017. I cluster the bootstrap at the firms level, to allow for firm-level correlation over time.

Appendix C

Bolted Heavy Equipment - Chapter 3

FIGURE C.1: Bolted Heavy Equipment

Notes: they are still included into the local property tax base: soil, sheds, buildings, offices. For solar energy production, they are still included into the local property tax base: soil, buildings, technical rooms. They are not included anymore: the photo-voltaic panels fixed to the soil. For entertainment/parks they are still included into the local property tax base: soil, swimming pools, restaurants, cinema. They are excluded attractions like: Ferris wheels, roller-coaster, rides, water-slides. For Manufacturing firms, they are not included anymore: equipment related to the production, used inside the building. For wind energy production, they are still included into the local property tax base: soil, buildings, technical rooms. They are not included anymore: wind turbines.

Appendix D

LASSO Method - Chapter 4

Lasso is based on three penalization approaches, given the possibility to simplify the model selection problem to a one-dimensional problem. The lasso is used for outcome prediction and for inference about causal parameters. It is part of the so called "Shrinkage Methods", which minimize RSS (residual sum of squares) with a penalty for model size. The ability to work as a covariate-selection method makes LASSO a nonstandard estimator and prevents the estimation of standard errors. It excludes the covariates whose estimated coefficients are zero and includes the covariates whose estimates are not zero. It does the *model selection*, choosing the one with the best performance *out-of-sample*. When a few of many potential covariates affect the outcome and it is important to include only the covariates that have an effect, the problem is that it is not known which covariates are important and which are not. LASSO produces estimates of the coefficients and solves this covariate-selection problem. The model selected is suitable for making predictions in samples outside the one it is used for estimation. LASSO finds solution for the following general problem:

$$y_i = \beta_0 + \beta_1 x_{1,i} + ... + \beta_p x_{p,i} + \epsilon_i \tag{D.1}$$

by minimizing the prediction error subject to the constraint so that the model is not too complex (sparse). LASSO measures complexity by the sum of the absolute values of $\beta_1, \beta_2, ..., \beta_p$, minimizing the following formula:

$$\frac{1}{2N}(y - X\beta')'(y - X\beta') + \lambda \sum_{j=1}^{p} |\beta_j| \tag{D.2}$$

the first term $(y - X\beta')'(y - X\beta')$ is the in-sample prediction error; the second term $\lambda \sum_{j=1}^{p} |\beta_j|$ is a penalty that increases in value the more complex the model is. LASSO shrinks parameter estimates towards zero, and the extent of shrinkage is determined by the *tuning parameter* λ. LASSO minimizes 4.4 for given values of λ, then it chooses one of those solutions as best based on another criterion, such as an estimate of the *out-of-sample* prediction error. It provides various ways of selecting λ: CV, adaptive lasso, and a plugin estimator. CV selects the λ that minimizes an

estimate of the *out-of-sample* prediction error. Adaptive lasso performs multiple lassos, each with CV. After each lasso, variables with zero coefficients are removed and remaining variables are given penalty weights designed to drive small coefficients to zero. In the first lasso a λ is selected and penalty weights are constructed from the coefficient estimates. Then, these weights are used in a second lasso where another λ is selected. Thus, adaptive lasso typically selects fewer covariates than CV. The plugin method was designed to achieve an optimal sparsity rate. It tends to select a larger λ than CV and, therefore, fewer covariates in the final model. It computes λ based on an iterative formula. Coefficient estimates are obtained only for this single value of λ.

D.0.1 Results without LASSO

I try the same estimates, but now without relying in LASSO. I use all the 17 covariates available in CERVED dataset, and I select irregular firms, in order to assess the difference of LASSO with respect to the more classical OLS regression to estimate the share of part-time and temporary full-time contracts. OLS estimates are robust with respect to estimates using LASSO. LSSO is a selection method: it rules out all the coefficient very close to zero or equal to zero, leaving the only predictors which have a real impact on the outcome variable of interest. Identifying the true model is one of the common problems in applied econometric. If there are many predictors, OLS is likely to suffer of overfitting: good in-sample fit (large R2) but poor *out-of-sample* prediction performance. Regularized regression methods tend to outperform OLS in terms of *out-of-sample* prediction. Regularization techniques exploit the variance-bias-tradeoff: they reduce the complexity of the model (through shrinkage or by dropping variables). In doing so, they introduce a bias, but also reduce the variance of the prediction, which can result in improved prediction performance. In this sense, using OLS it is reasonable that results are the same because many of the predictors are close to zero, so they hav no impact, and the only predictors with an effect are exactly the ones choosen by LASSO. In my specific case, I have 17 predictors from financial statements, so I have the possibility to compare OLS performance using all the predictors, given the number not particularly high to create issues in terms of computation. But it can be argued that, in presence of a dataset with more than 17 predictors, such as 100 or 200 predictors, using all the preditors in the OLS would not perform well. In a situation like this, without a clear idea of how to choose a predictor instead of another, LASSO will be the best solution to choose the only variables of interest, performing exactly as in OLS situation, but without suffering of overfitting or difficulties in the computations.

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