Local Economy, Housing Prices and Neighborhood Change

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Abstract

This paper investigates the impact of real estate prices on local economic activities within cities. I use a novel geo-located dataset of retailers and service providers, combined with information on sale and rental prices. I propose a unique empirical strategy that leverages the staggered implementation of a district heating system in Turin as an exogenous shock to housing prices. The analysis reveals that housing prices differently affect local economic sectors. While tradable sectors show resilience, non-tradable sectors experience a notable decline following the housing price shifts, exhibiting an elasticity of approximately -3%. This is probably due to demographic changes, particularly among college students, who are primary consumers in the non-tradable sector. The paper contributes to highlighting the complex interplay between housing market changes, demographic shifts, and urban economic activities. Moreover, it emphasizes the critical role of housing market dynamics in shaping urban planning and policy decisions.

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1 Introduction

How does the local economy respond to changes in real estate prices? Cities are, by their nature, heterogeneous entities that are constantly evolving in response to a variety of factors. In particular, changes in house prices alter neighbourhood dynamics and local consumer behaviour, affecting the availability and variety of goods and services. This can happen through two main channels. First, price changes can directly affect endogenous activities, such as higher prices leading to higher costs. Secondly, changes in property prices can affect demographic and gentrification patterns within the city, which in turn affect local activities. The relevance of these channels depends on how urban activities respond to changes in sales and rental prices.

In this paper, I examine the relationship between fluctuations in house prices and local economic activity in urban areas. The focus is on understanding how changes in the housing market can influence different dimensions of urban dynamics. These influences are important because they can significantly affect the welfare of residents, alter access to services, and potentially reshape the social and economic dynamics of neighbourhoods. In addition, the research question sheds light on a relevant aspect of urban environments: the retail and service sectors. These sectors are an integral part of the urban ecosystem, not only providing essential services and goods to residents but also contributing significantly to employment. In Italy, for example, these sectors accounted for around 20% of employment in 2019[1]. The analysis therefore provides insights into the wider effects of property market trends, offering a view of their impact on the urban structure, as the distribution of economic activities.

To establish the causal relationship between real estate prices and local economic activities, I deal with several endogeneity challenges. The research question is susceptible to potential reverse causality. In addition, unobservable characteristics of the area, whether time-variant or invariant, may affect variables differently, introducing potential bias into the results. To address these concerns, I exploit the quasi-experimental variation introduced by the staggered adoption of *Teleriscaldamento* (TRL) in the city of Turin, Italy. Operated through a collaboration between a private firm and the city council, the TRL is a network linking energy production plants to buildings for providing heated water for domestic use. The system has been expanded since the 1980s and now covers

[1]Source: ISTAT

around 57% of the city area. The TRL offers a more cost-efficient alternative compared to the traditional heating system. These cost benefits are reflected in the improved energy performance of the houses and, consequently, in an increase in house prices. By acting as a house price shock, the TRL creates an exogenous variation in local economic activity, similar to the methodology used by Borraz et al. (2023).

The research focuses on the city of Turin and covers the period from 2012 to 2019. Beyond the TRL data, I gather a collection of unique and highly specific datasets, including semestral sale and rent asking prices at the census tract level from Idealista, as well as a list of active licences for retailers and services in the city, including information on their location and category. These datasets are used in the empirical strategy, which relies on a staggered difference-in-difference approach, in both dynamic and static specifications. To address the pre-trend assumption, the analysis conditions on a set of time-invariant covariates, and a detailed discussion on the SUTVA and the no-anticipation effect assumption are provided. Furthermore, the specification compares treated areas with nearby and similar control areas.

The results emphasize the impact of housing sales and rents induced by the TRL implementation on local economic activities. Specifically, I examine several measures of activity, including the variety of goods and services and the presence of both tradable and non-tradable sectors. The analysis shows a significant and negative impact on non-tradable sectors, with an elasticity of around -3%. In contrast, tradable sectors and the range of offerings in the area do not experience significant changes due to housing price shifts. In light of these findings, and assuming that the measures of economic activity are a reliable reflection of consumer supply, the welfare of established residents appears to decline as house prices rise.

This study intersects with several strands of literature on urban economics, gentrification and real estate dynamics. A primary focus is on the impact of housing markets on local economies. In this context, Stroebel and Vavra (2019) oexplore the complex relationship between house prices and local retail prices, finding an elasticity of 15-20%. They argue that these estimates are not affected by demographic shifts or gentrification trends, suggesting instead that fluctuations in house prices alter homeowner vbehavior, leading to increased firm mark-ups. Borraz et al. (2023) investigate the effect of new housing stock on retail prices and product variety in Montevideo, Uruguay, highlighting

how local prices decrease with increased demand driven by either more competitors or a greater variety of supply.

The literature also extensively covers the effects of neighbourhood change and gentrification on local outcomes, as shown in studies (Vigdor et al., 2002; Vigdor, 2010; Handbury and Weinstein, 2015; Ding and Hwang, 2016; Brummet and Reed, 2019; Behrens et al., 2022; Curci and Yousaf, 2022; Couture and Handbury, 2023). Glaeser et al. (2023) provide a notable contribution, measuring gentrification with poverty measures, accounting for either student density or rent growth prices. They find that gentrifying neighbourhoods experience faster growth in retail establishments and business closures, indicating a substitution effect of tradable sectors in favour of non-tradable sectors. The role of non-tradable services in urban revival is highlighted in papers by Couture and Handbury (2020) and Baum-Snow and Hartley (2020), with the latter highlighting racial disparities in the valuation of amenities and suburban job opportunities.

Furthermore, the paper aligns with the literature on endogenous consumption amenities (Glaeser et al., 2001; Couture, 2016; Allcott et al., 2019; Davis et al., 2019; Behrens et al., 2022). Key quantitative models from Guerrieri et al. (2013), Couture et al. (2023) and Almagro and Domınguez-Iino (2022) illustrate the self-reinforcing nature of housing demand, in particular how increases in personal income and housing demand can drive gentrification and enhance city centre amenities.

Finally, the paper looks at the relevant impact of energy performance on the housing market, drawing on the energy policy literature. Empirical studies by De Ayala et al. (2016), Fuerst et al. (2016) and Kholodilin et al. (2017) demonstrate the positive impact of energy efficiency on house prices, reinforcing the importance of energy performance in property dynamics.

This paper contributes to the existing literature by providing new empirical evidence on the causal relationship between property prices and local economic activity. It presents a comprehensive analysis covering a wide range of local businesses such as bars, restaurants, beauticians, hairdressers and retailers. The study highlights the impact of shifts in neighbourhood demand on local economic conditions, with a particular focus on the processes of gentrification. By shifting the focus to a European city, the paper examines the housing market-induced effect on demand channels, changing perspective from prior literature that predominantly concentrated on US cities. This analysis in a

European setting allows for comparison with previous studies while acknowledging the distinct differences between US and European urban landscapes. Finally, the paper contributes by providing additional evidence on how improvements in energy efficiency can lead to increases in property values.

The structure of the paper is organized as follows: Section 2 provides an introduction to the background, highlighting the data used in the empirical strategy. Section 3 presents the empirical analysis, describing the strategy and conceptual framework used to interpret both expected and observed results. Section 4 discusses these findings, and Section 5 presents the robustness checks. Finally, Section 6 concludes the paper and outlines future directions for the project.

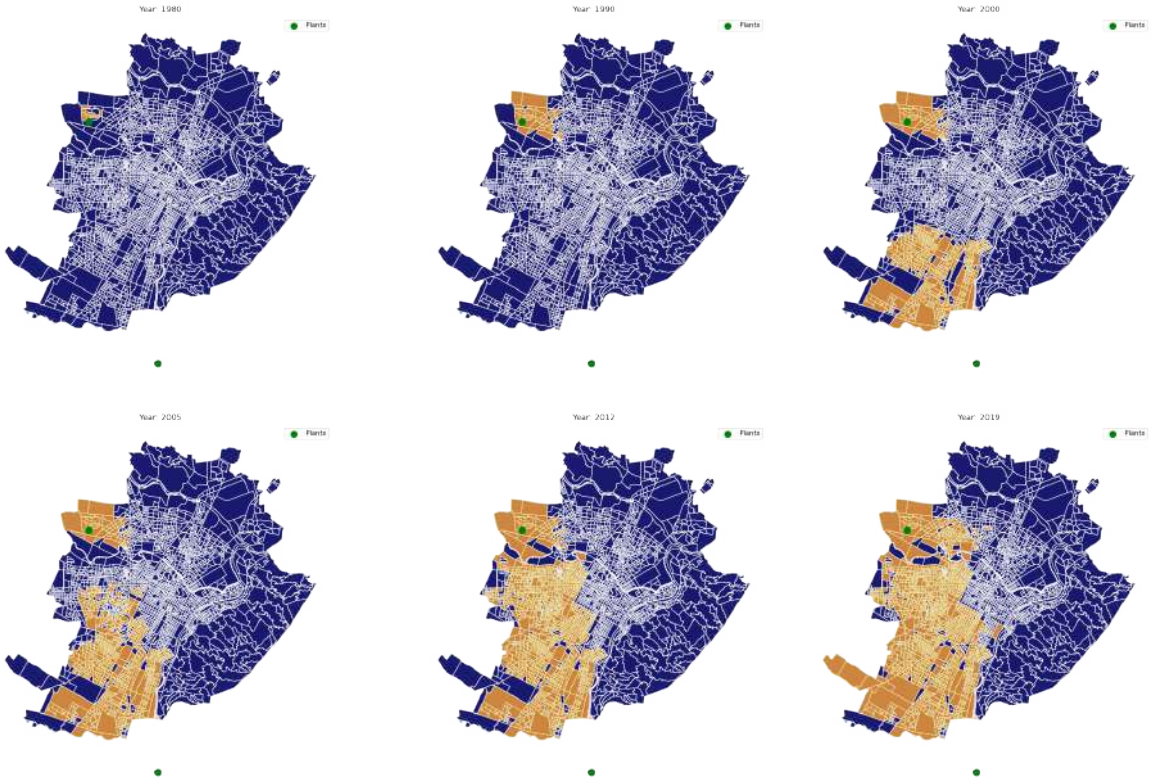
2 Background

In this section, I provide an overview of the dataset utilized in the empirical analysis, focusing on the city of Turin, Italy, spanning the years 2012 to 2019. Turin comprises 3850 census tracks, distributed across 23 distinct neighborhoods (Figure A1). The empirical strategy relies on the Teleriscaldamento (TRL), which I describe first. Subsequently, I present data and descriptive statistics related to housing prices and local economic activities.

2.1 The Teleriscaldamento

The TLR is a district heating network available in Turin. This service is managed by Iren, a company that provides electricity, natural gas, and other products and sectors to individuals, companies, and public entities. In the 1980s, Iren sought to utilize the waste heat generated by its electricity production plants to heat water for private heating and usage, a process known as cogeneration. This initiative presented an opportunity for the company to enhance its production efficiency, transitioning from a 56-58% efficiency in full electric production to 85-90% in a complete cogeneration setup. To achieve this, the company began constructing a pipeline system to connect its plants to its customers. The construction was possible thanks to an agreement with the municipality, which saw in the TRL a potential and significant contribution to the reduction of pollutant emissions from domestic heating.

Figure 1: TRL's evolution from 1980 up to 2019



Notes:The graph plots the implementation of the TRL network. The orange areas are those in which a TRL pipeline was present at the year reported. Green points show the location the the two Iren production plants.

The Turin's setting is not isolated. The system is developed in Europe mainly in the Scandinavian and Baltic countries, where the served population varies from 42% in Sweden to 99% in Iceland. Italy is one of the European countries where TLR is least developed, with district heating covering only about 2.3% of the national heating demand[2]. There are district heating systems established in more than 200 urban centers across Italy, comprising over 400 networks scattered throughout the country[3]. The gradual expansion of the district heating network has positioned Turin as the most TRL-heated city in Italy per buildings' volume served, representing almost 15% of the Italian network. Furthermore, Turin stands out as one of the most district-heated metropolises in Europe. In 2022, it served over 645,000 inhabitants, with 69.9 million m^3 connected[4], equivalent to approximately 57% of the built volume in the urban area.

[2]Source: "Assessing the potential for efficient district heating deployment across the country" by the Polytechnic of Milan and Polytechnic of Turin
[3]Source: AIRU Statistical Yearbook
[4]Source:Torino Vivibile

Practically, the TRL system encompasses both the pipeline infrastructure, PIs, and heating units (or boilers), HUs, installed in buildings tied to the system. Depending on agreements between the company and building administrators, one HU can serve multiple surrounding buildings. Each HU has a defined power capacity, determined by the size of the buildings it serves. If a building administrator, appointed by the apartment owners, opts to utilize the service, they must contact the company. The company, in turn, will provide various options, typically without any installation fees for the HU. The TRL's HU replaces the existing centralized HU, and all associated management and maintenance costs are covered by the company.

By construction, the TRL system generates several positive externalities. The higher production efficiency of the cogeneration system results in pollution savings equivalent to that produced by 780,000 cars. Additionally, the absence of traditional boilers reduces the risk of breakdowns and heating interruptions. From the consumers' perspective, the TRL system avoids a list of costs (see Table 2). Notably, for an 80 m^2 flat, the annual management cost of a central heating system averages around €1800[5]. However, this cost savings opportunity is only available if the building already has a centralized HU, otherwise, the replacement would not be feasible. For instance, TRL's HU can not be used in cases where the building has independent HUs located in each apartment. Furthermore, given Iren's direct production, savings in raw materials are estimated at around 10-15% compared to systems previously fueled with fossil fuels.

Nonetheless, even before COVID-19, the TRL system faced substantial criticisms. The district heating sector, characterized by high economies of scale and density in distribution network implementation, presents the typical characteristics of a natural monopoly. The duplication of networks is not sustainable from an economic point of view. Moreover, since the sector is not regulated and driven by the recent energy crises, the resultant price increase has impacted TRL consumers, leading to numerous criticisms directed at both Iren and the municipality.

It is important to highlight the declared strategy implemented by Iren in implementing the TRL network. Indeed, Turin's network is composed of two heat production plants, that are situated in the southern and north-western parts of the city, respectively. As illustrated in Figure 1, the company began by linking the closed plant area and

[5]Source: ISTAT

subsequently expanded to various parts of the city. Indeed, the orange colour indicates areas where at least one pipeline was already in place during that specific timeframe. The extension of the TLR network is physically constrained, as the temperature of the heat-carrying fluid decreases with the distance travelled. Iren claims that the choice to implement the TRL in a specific area is guided by two primary considerations: potential consumer demand and the cost of laying pipelines. As the TRL serves as an alternative to the traditional centralized heating system, Iren conducts market research to identify areas with a higher density of such traditional systems. Additionally, the cost of pipeline installation varies across different parts of the city. Some areas pose significantly higher expenses for pipeline placement compared to others. In Turin, two neighborhoods were deliberately excluded from TRL implementation: the downtown ("Centro") and the hilly neighbourhoods (see Figure 6). The Centro constitutes the historical part of the city of Roman origin, and the TRL's provider decided to exclude this area from the network to avoid costly delays in construction due to archaeological discoveries. Similarly, the hilly part of the city was excluded due to the high cost associated with the area's morphological structure.

The data set, directly provided by Iren, is composed of the entire system, both PI and HU. Due to the sensitive nature of these data for the company, all subsequent representations of the data will be in aggregate form at the census track level. To provide an idea of the granularity and detail of the data, a small sample is shown in Figure A2.

2.2 Housing Prices and Local Economic Activities

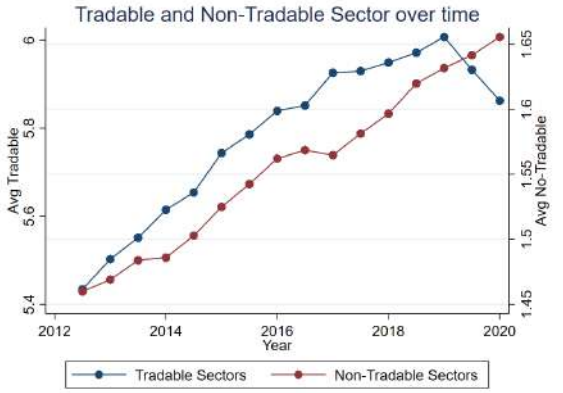
The second source of data is the list of licenses for retailers, bars, restaurants, beauticians and hairdressers in Turin from 2012 to 2019 provided by the City Council. To open a new business or expand an existing one, the owner must request a license without any additional cost. The database includes information about the type of merchandise, location, and opening and closing dates for each license. The licenses are divided into 41 categories (see Table A1) by the City Council. Since the request for a license is a more reliable indicator of economic activity than the opening or closing of a physical establishment, I use the opening and closing dates of the licenses to construct a variable that counts the number of active licenses per semester and category.

The average number of local economic activities significantly increased from 2012

Figure 2: Housing Prices Descriptive

Notes: The graph plots the incremental variation over time of sale and rent price with respect to 2012, with the standard deviation per semester.

Figure 3: Economic Activities Descriptive



Notes: The graph plots the evolution of the activities over time, divided into tradable good sellers and non-tradable services providers. The value is the area's average

to 2019. Figure 3 illustrates the evolution of tradable and non-tradable sectors over time, with non-tradable sectors being bars, restaurants beauticians and hairdressers, and tradable goods being everything else. The two types of sectors show a similar trend until the latter half of 2018 when tradable sectors experienced a sharp decline. The variety of different goods and services for residents also follows a similar trend, with a consistently increasing supply until a few years before the pandemic when the trend turns. Anecdotally, this decrease in establishments number follows the European trend already started before the COVID-19 pandemic and continued even after[6].

Furthermore, I gathered the data for both house and rental prices from Idealista, a popular online real estate platform in Italy. The data is semestral, covering the years 2012-2019, and reports the "median asking price" per squared meters at the census track level. This median is computed by taking the mean of prices listed on the platform once the outliers and duplicated advertisements have been removed, therefore it may not reflect the final market price for either houses or rentals. These measures have advantages and disadvantages. On one hand, they do not allow for a direct comparison of posted prices with actual prices. Despite this, Garcia-López et al. (2020) and Chapelle and Eyméoud (2022) have shown that posted prices can be a good indicator of actual prices. Moreover, since bargaining is a common part of the buying and renting process, the asking price could show the house owner's attempt to monetize several possible features related to the house or the neighborhood.

[6]Examples of newspaper articles: England (2019), Italy (2022) and Spain (2023)

During the period of analysis the city experienced a significant decrease in real estate prices (see Figure 2), following the average national trend. Over the period between 2012 to 2019, sale prices experienced an average decrease of nearly 25%, with a steeper decline observed from 2012 to 2014, followed by a more gradual decline. Similarly, rent prices also decreased, hitting a low point of approximately -15% in 2016. It is important to highlight that rental contracts in Italy may be categorized as either agreed or free. In instances of agreed rent, property owners offer houses for rent within a specified price range, with both a maximum and minimum limit. In such cases, they are eligible for tax reductions. The quotations are established through agreements between the municipality and local housing associations, aligning with market dynamics[7]. Notably, these quotations generally cover a broad spectrum of prices, with the actual proposed price typically following market trends. However, it is noteworthy that the confidence interval for rental prices is considerably narrower than that for sales prices, indicating a lower variability in rental prices within the city.

2.3 Further Data

I supplement the primary data sets with additional information that includes time-variant socio-demographic variables from the Turin City Council's statistical department, as well as some time-invariant characteristics from the 2011 National Census. Moreover, the Piedmont Region office provided the distribution in 2011 of both centralized and independent heating systems in the city.

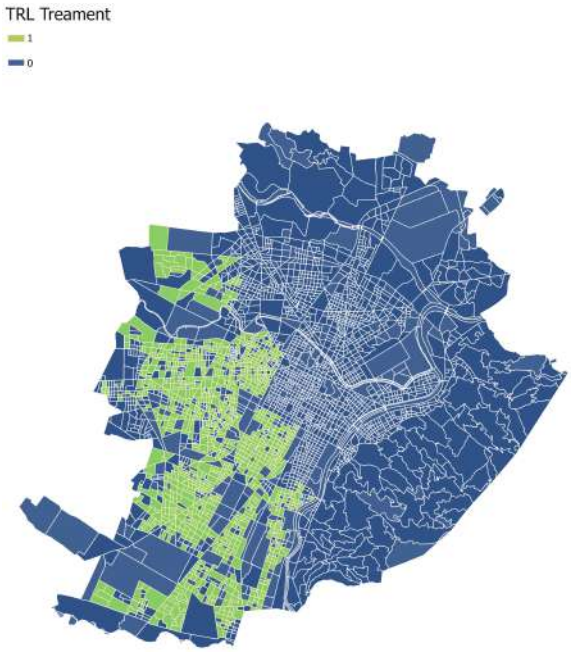
3 Empirical Analysis

The primary objective of the empirical analysis is to quantify the impact of shifts in housing prices on local economic activities. This analysis digs into three key aspects of economic activities: the variety of goods offered and the densities of both tradable and non-tradable goods and service providers. These outcomes collectively contribute to shaping the welfare that consumers derive from participating in the local market.

Analysing the impact of housing prices on local economic activities poses challenges, given that housing prices may be influenced by the concentration of nearby shops and

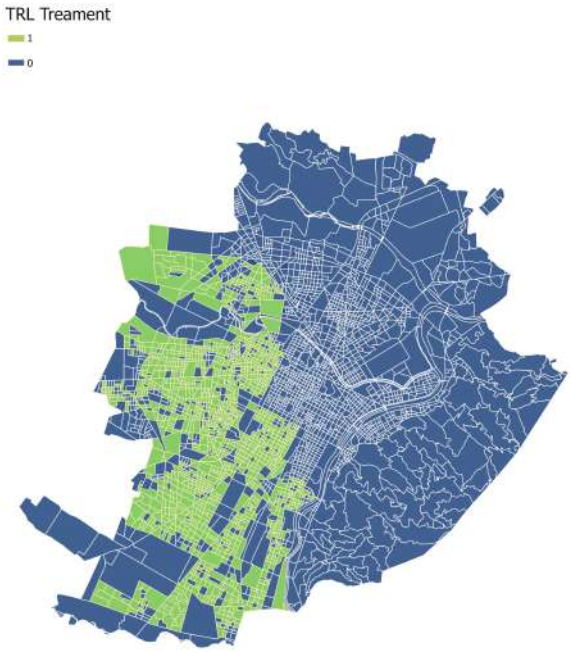
[7] An example here

Figure 4



Notes: The graph plots the treated (green) and control (blue) tracts in 2012

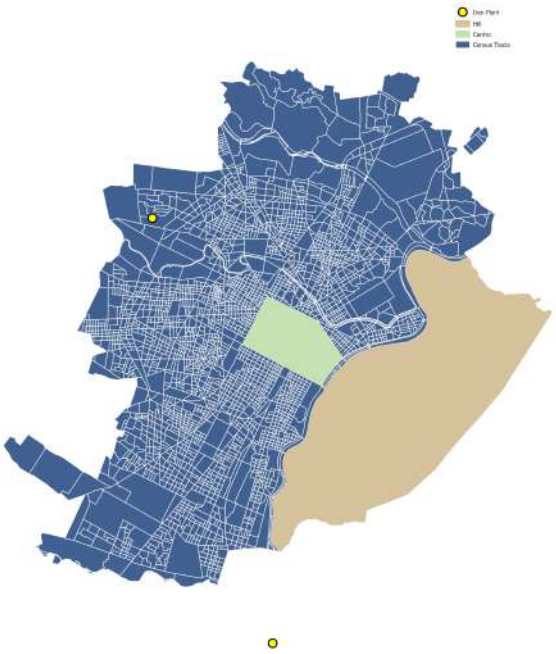
Figure 5



Notes: The graph plots the treated (green) and control (blue) tracts in 2019

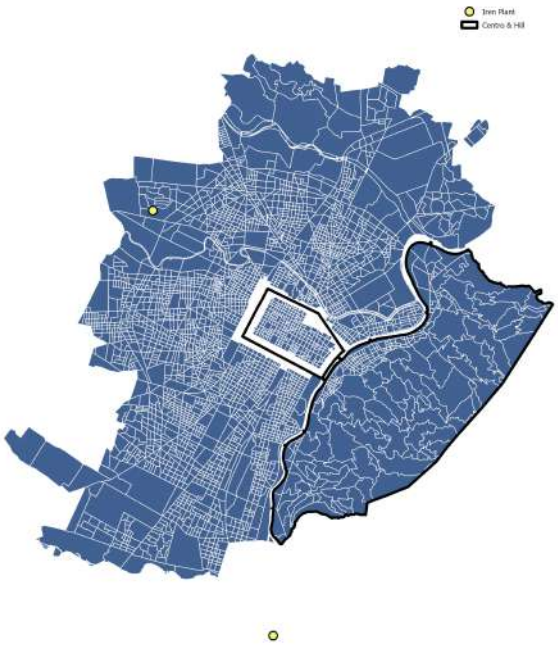
the variety of supplies available to consumers. Furthermore, various local factors, such as gentrification processes and changes in both amenities and disamenities, may simultaneously and distinctly affect both housing prices and the supply of goods and services. To address these endogenous concerns, the empirical strategy relies on leveraging the variations in housing prices induced by the implementation of the TRL. Specifically, I utilize the staggered roll-out of the TRL adoption in the city of Turin, occurring between 2012 and 2019. Under a set of assumptions described below, the quasi-experimental variation generated by the staggered TRL roll-out allows me to estimate the causal effect of housing prices on local economic activities. Initially, I demonstrate how the TRL network influenced shifts in housing prices, and subsequently, I discuss the methodology and the conceptual framework for estimating the effect of housing price shifts on local economic activities.

Figure 6



Notes: The graph plots both the Centro (in green) and the hilly (in brown) neighborhoods.

Figure 7



Notes: The graph plots the census tracts included in the baseline analysis. The black lines represent the Centro and the hilly neighborhoods' edges.

3.1 Housing Prices and TRL

3.1.1 Empirical Strategy

To estimate the TRL-induced variation on housing prices, I employ the following two-way difference-in-difference (TWFE) specification:

$$Log(P_{ijt}) = \beta(TRL_{ijt}) + \gamma X_{i,2011} + \delta_i + \tau_{jt} + \epsilon_{ijt} \tag{1}$$

where $Log(P_{ijt})$ denotes either the sale or rent price ($€/m^2$) in the census tract i at semester and year t. The variable TRL_{ijt} takes the value 1 if TRL operates in census tract i during semester j of year t and 0 otherwise. Figure 4 and 5 show the treatment's distribution across the city in 2012 and 2019 respectively. The specification is complemented with both tract δ_i and semester-year, τ_{jt}, fixed-effects. Beyond the error term, ϵ_{ijt}, I include a set of control variables, $X_{i,2011}$, at the census tract level, which is time-invariant and dated back at 2011, in order to avoid potential endogeneity induced by the treatment. The covariates account for differences such as the tract's sociodemo-

graphic characteristics, residential building composition and commercial pattern in the area. Moreover, the parallel trend assumption holds conditioning on that covariates, as outlined below.

In Eq.1, the control group consists of census tracks that were not subjected to treatment by the TRL in semester j of year t. Furthermore, in the baseline specification, the control group is comprised exclusively of individuals who have not yet been treated. To address concerns associated with employing a TWFE model in a staggered adoption scenario, as heterogeneous treatment exposure (Borusyak et al., 2021; De Chaisemartin and d'Haultfoeuille, 2020; Goodman-Bacon, 2021), I utilize the robust estimation method proposed by Callaway and Sant'Anna (2021) in both the static (Eq.1) and the dynamic specification.

The validity of Eq.1 relies on three identification assumptions: the stable unit treatment value assumption (SUTVA), the no-anticipation effect assumption and the parallel trend assumption. SUTVA may be compromised if either individual transits from the treatment group to the control group or if potential outcomes for a given observation are influenced not only by its treatment status but also by the random assignment of others, leading to spillover effects. It is important to note that the TRL installation is permanent concerning the treated census tracts, making the shift from treated to control groups by census tracts technically unfeasible. Nevertheless, spillover effects are noteworthy in cities, especially in short distances. While the individual fixed effect partially addresses externalities from nearby areas that maintained constant influence throughout the analyzed period, robustness checks are conducted to provide additional evidence in support of the SUTVA.

Concerning the assumption of no-anticipation effects, it would be violated if the treatment has a causal impact before its implementation. However, this scenario appears unlikely, as the TRL is provided by a private firm that lacks any advantage in anticipating the implementation schedule. Moreover, both the pipeline's installation and the boiler installation require no more than 40 days, and this duration is encompassed within the semesterly data exploited in the analysis.

Ultimately, the parallel trend assumption holds, conditioning on time-invariant covariates (Callaway and Sant'Anna, 2021). These variables are managed by exploiting a Doubly Robust Estimator (Sant'Anna and Zhao, 2020). As discussed in Section 2, the

TRL implementation has followed a declared strategy, assessing potential demand and cost implications. However, Iren may have, consciously or unconsciously, considered various factors, such as prioritizing wealthier areas over poorer ones. The observable and unobservable processes underlying TRL implementation can potentially influence both the trend of outcomes and treatment effects differently. To address this, I complement the specification with a set of control variables. Firstly, I include the density of residential buildings with an independent heating system due to the relevance of the heating system composition in the area in determining the potential TRL demand. Secondly, I consider the distance of the area from the two plants, as the TRL network has progressively expanded from these production plants. These variables are relevant for improving the matching between treated and controlled areas, favouring comparisons among neighboring tracts that share more similarities. Thirdly, I account for the building composition in the area, including the share of residential buildings, the share of buildings constructed in each decade since the 70s, and the proportion of residential buildings in excellent and poor conditions. Moreover, I account for areas with different propensities in hosting both retailers and service providers, including the density of commercial licenses in the tract. Lastly, even though it is not explicitly stated, TRL construction may be prioritized based on areas with either higher income levels or varying degrees of gentrification. While this scenario is plausible, the current structure of the TRL network does not seem to support it. As illustrated in Section 2, Iren made rational decisions to avoid the Centro and hilly neighborhoods (see Figure 6), despite their status as some of the city's wealthiest areas, as shown in Table A2. Nevertheless, to further control this possibility, I control for sociodemographic characteristics in the area, including the share of foreign residents, young residents (ages 0-30), old residents (over 66 years old), the population and household densities, the share of employment, the share of household owner and the level of education. Additionally, these sociodemographic variables allow for further control of differences in consumer demand. Tables A4, A5 and A6 show the balance test of all these variables concerning the outcome variables and the TRL treatment.

The Centro and the hilly neighbourhoods, due to their structural characteristics, impact both the expansion of TRL and potentially influence the generation of outcome variables. Therefore, to address this issue and strengthen the parallel trend assumption, I exclude tracts located at a distance up to 200 meters from the Center edge. In contrast,

Table 1: Primary Energy Factor (PEF) for different energy types.

Energy Vector	PEF
Iren TRL	0.63[a]
Natural Gas	1.05[b]
GPL	1.05[b]
Gasoil and Fuel Oil	1.07[b]
Coal	1.10[b]
Solid/Liquid Biomass	1.00[b]
Electricity from the grid	2.42[b]
Thermal energy from solar collectors	1.00[b]
Electricity generated by photovoltaic	1.00[b]

Notes: Data at 2016.
Source: [a] Iren Group
Source: [b] Italian Ministry of Enterprises and Made in Italy

Table 2: Cost avoided with the TRL respect the traditional centralized heating system.

Cost	approx.
System installation	20000€/installation
Ordinary boiler maintenance	5000€/year
Reading and repairing the boiler	600€/year
Extraordinary interventions	depending on breakdowns
Fire prevention certification renewal	500€ every 5 years
Boiler renewal	

Sources: TRL.eu

the hilly neighborhood is separated from the other tracts by the city's river, and, therefore, I consider the barrier represented by the river sufficient for mitigating the identified problem. As a result, Figure 7 illustrates the census tracks included in the final sample.

3.1.2 Conceptual Framework

This section introduces a conceptual framework to explain how TRL may impact housing prices. Additionally, the framework guides the interpretation of the results.

The effect of TRL treatment on housing prices, as in Eq.1, is expected to be positive. As discussed in Section 3.1.2, the TRL heating system offers a cost-effective alternative for consumers compared to traditional heating systems. Typically, the primary installation and management costs are borne by the service provider. With this more economical option available to consumers, those selling or renting houses may seek to leverage these savings by increasing their asking prices. Consequently, TRL adoption could result in elevated selling and rental prices.

The expected positive result finds additional support in the energy policy literature. Since 2005, Italy has implemented the *Energy Performance Certificate* (EPC) in accordance with the guidelines outlined in the 2002/91/CE Directive on the energy performance of buildings[8]. The EPC serves as a certification of a house's energy performance and must be presented at the time of purchase or rental. Accredited certifying bodies, listed nationally and regionally, are responsible for issuing the EPC, which considers the individual energy services utilized in the house. By EPC construction, the heating system, or in general the heating water system, is a key contributor in determining the house's

[8]Source: Legislative Decree 19/05/2005

Table 3: ATT - Housing Prices on TRL

Dep. Variable	(1) Log (Sale)	(2) Log (Rent)
TRL	0.002	0.018***
	(0.005)	(0.006)
Obs.	38,080	38,080

Notes: Significance is indicated by * p<0.1. ** p<0.05, and *** p<0.001. Standard errors, in parenthesis, are clustered at the census tract level. Control variables are the share of independent heating systems, the distance of the area from the two plants, the share of residential buildings, the share of buildings constructed in each decade since the 70s, the share of residential buildings in excellent and poor conditions, the density of commercial licenses in the tract, the share of foreign residents, young residents (ages 0-30), old residents (over 66 years old), the population and household densities, the share of employment, the share of the household owner and the level of education.

energy class and directly impacts energy performance. The system energy assessment is based on the *Primary Energy Factor* (PEF). The PEF quantifies the amount of primary energy required to generate a unit of electricity or usable thermal energy. Therefore, lower PEF values mean higher system efficiency. Certified controllers identify the PEF, and as demonstrated in Table 1, the TRL provided by Iren exhibits greater efficiency than other energy carriers, resulting in a higher energy class. The literature on energy policy provides further evidence of the positive impact of EPC on housing prices with an increase in EPC ratings (Fuerst et al., 2016; De Ayala et al., 2016; Kholodilin et al., 2017).

3.1.3 Results

Before delving into the empirical analysis of housing prices' impact on local economic activity, I first present the results showing how housing prices respond to the introduction of the TRL in the tracts. Table 4 displays the static average treatment effect. Column (1) details the outcomes using the logarithm of sale prices, while Column (2) considers the logarithm of rent prices. Both results are conditioned on time-invariant covariates, encompassing various socio-demographic characteristics that reflect differences in population, households, education, and income, as well as several building and local commerce attributes. As specified in Eq.1, the coefficients indicate the elasticity of real estate prices to the TRL treatment. The TRL's effect on sale prices appears positive but not statistically significant. In contrast, a notable and significant impact is observed with rent prices, where the elasticity is approximately 2%. This aligns with the rationale

Figure 8: Event study - Sale prices on TRL

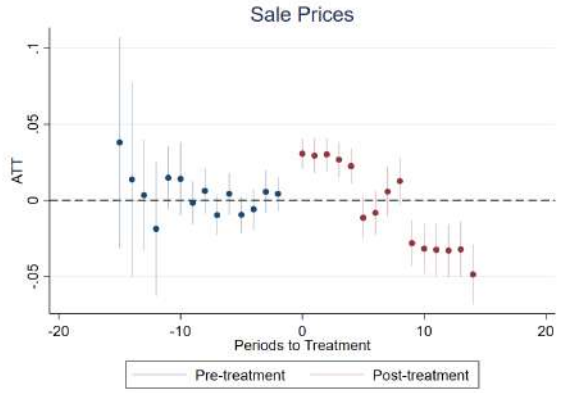
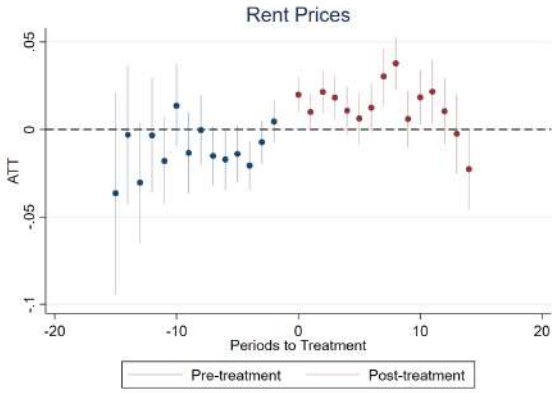


Figure 9: Event study - Rent prices on TRL



Notes: Control variables are the share of independent heating systems, the distance of the area from the two plants, the share of residential buildings, the share of buildings constructed in each decade since the 70s, the share of residential buildings in excellent and poor conditions, the density of commercial licenses in the tract, the share of foreign residents, young residents (ages 0-30), old residents (over 66 years old), the population and household densities, the share of employment, the share of the household owner and the level of education.

presented in Section 3.1.2. However, at first glance, sale prices do not seem to follow this expectation.

Figures 8 and 9 depict the dynamic effect of housing prices following the TRL implementation, using an event study approach. This approach allows for the evaluation of the parallel trend assumption and the evolution of results over time. These results remain conditioned on the covariates. In the pre-treatment period, as shown by the blue areas representing the 95% confidence interval, each coefficient is not significantly different from zero. However, for rent prices, the coefficient at $t-3$ notably differs from zero. It is important to note that, when compared to the pre-treatment period plotted in Figures A10 and A11, the parallel trend assumption would be violated without the inclusion of time-invariant control variables, as discussed in Section 3.1.1.

Focusing on the post-treatment periods in Figures 8 and 9, the outcomes differ. For sale prices, as shown in Figure 8, the effect is, on average, positive and significant during the first five semesters following the TRL implementation, and then becomes non-significant and negative in the later periods. Conversely, rent prices demonstrate consistently positive and significant results, particularly in the periods closest to the TRL implementation.

3.2 Economic Activities and TRL

3.2.1 Empirical Strategy

The empirical strategy now turns on the effect of the TLR on the local economic activities. The estimation relies on the following TWFE difference-in-difference:

$$Log(Y_{ijt}) = \beta(TRL_{ijt}) + \gamma X_{i,2011} + \delta_i + \tau_{jt} + \epsilon_{ijt} \tag{2}$$

The specification aligns with Eq. 1 in the composition. In contrast, $Log(Y_{ijt})$ represents other outcomes. To examine the impact of TRL on economic activities, I explore both the logarithm of tradable licenses and non-tradable licenses active in area i during semester j and year t. Tradable goods sellers encompass categories providing goods to consumers, while non-tradable service providers include bars, restaurants, beauticians, and hairdressers. Additionally, I investigate whether TRL implementation influences the availability of diverse products and services in an area. This variable is defined as the number of category varieties, computed as the count of categories experienced in an area.

The discussion of assumptions and the composition of the sample follow the previous discussion in Section 3.1.1. Moreover, the balance tests are illustrated in Tables A7, A8 and A9.

3.2.2 Conceptual Framework

The positive impact of TRL on housing prices raises questions regarding its influence on local economic activities. To address this, I employ the rise in housing prices attributable to TRL as an exogenous shock to local economic activities. This approach allows for a focused analysis solely on the impact of TRL on local economic activities.

Fluctuations in housing prices can impact economic activities through two primary channels. Firstly, there is a direct effect induced by housing prices. An increase in housing prices results in elevated costs for activities, such as increased rental expenses, potentially prompting marginal activities to exit the market, while incumbents may not enter the market. Secondly, housing price shifts may give rise to an indirect effect. Indeed, changes in housing prices may result in shifts in activity demand, potentially accelerating or impeding gentrification processes that alter the area's average income. This includes changes in population density, population composition, consumer behaviors, or a combi-

Table 4: ATT - Housing Prices on TRL

Dep. Variable	(1) Log (Tradable)	(2) Log (Non-Tradable)	(3) Log (Variety)
TRL	-0.012	-0.029**	0.010
	(0.017)	(0.015)	(0.012)
Obs.	38,080	38,080	38,080

Notes: Significance is indicated by * p<0.1. ** p<0.05, and *** p<0.001. Standard errors, in parenthesis, are clustered at the census tract level. Control variables are the share of independent heating systems, the distance of the area from the two plants, the share of residential buildings, the share of buildings constructed in each decade since the 70s, the share of residential buildings in excellent and poor conditions, the density of commercial licenses in the tract, the share of foreign residents, young residents (ages 0-30), old residents (over 66 years old), the population and household densities, the share of employment, the share of the household owner and the level of education.

nation of these factors. Variations in demand can influence profits, consequently affecting firm decisions regarding market entry, persistence, or exit. The direction of this indirect effect remains ambiguous.

The interplay between the so-called indirect effect and the direct effect determines the significance of these two channels.

3.2.3 Results

This section presents the results on the impact of house prices on local economic activity. By using the TRL as an exogenous shock to house prices, the empirical strategy is based on quantifying its impact on economic activities, following the methodology described in Eq.2. Table 4 shows these results, using the TRL as the explanatory variable. Columns (1), (2) and (3) present different dependent variables: the log of tradable sectors, the log of non-tradable sectors and the log of sectors' variety, respectively. These results include control variables that take into account the socio-demographic characteristics of the area, variables on the composition of the buildings and the initial composition of the heating systems.

Looking at the results, I observe distinct patterns across sectors. In the tradable sectors (Column 1), the average treatment effect is negative but not statistically significant. In the non-tradable services sector, on the other hand, the coefficient is not only negative but also significantly different from zero. Specifically, the elasticity is -2.9%. Concerning the variety of goods and services offered in the tract, the coefficient is not statistically significant but suggests a positive effect.

Figure 10: Event study - Tradable Sectors on TRL

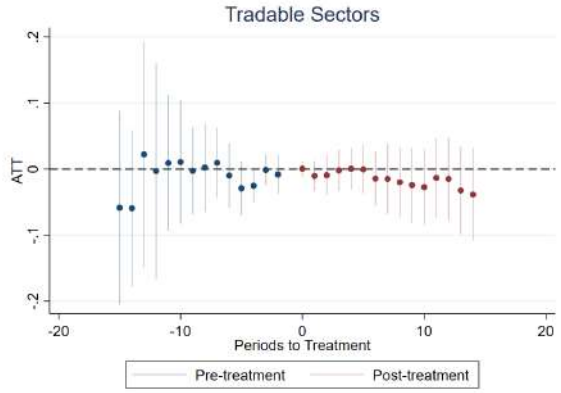


Figure 11: Event study - Non-Tradable Sectors on TRL

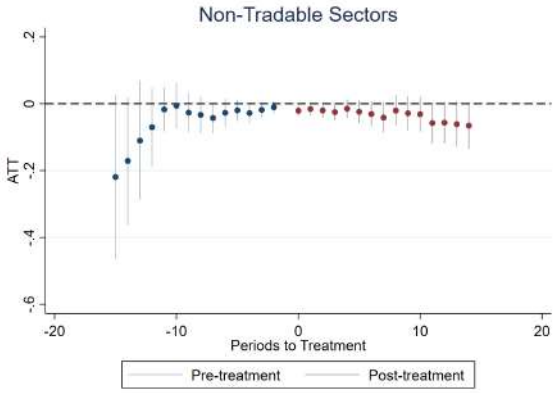
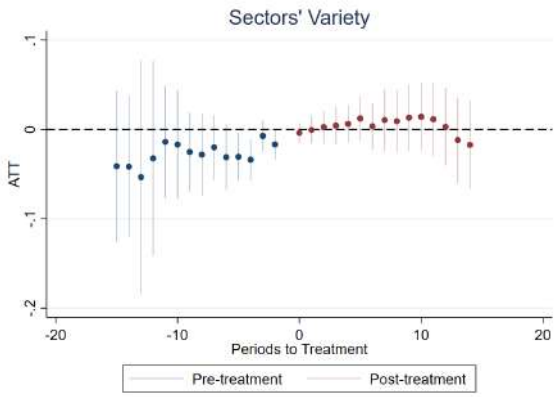


Figure 12: Event study - Sectors' Variety on TRL



Notes: Control variables are the share of independent heating systems, the distance of the area from the two plants, the share of residential buildings, the share of buildings constructed in each decade since the 70s, the share of residential buildings in excellent and poor conditions, the density of commercial licenses in the tract, the share of foreign residents, young residents (ages 0-30), old residents (over 66 years old), the population and household densities, the share of employment, the share of the household owner and the level of education.

Figures 10, 11 and 12 illustrate the event study specification for the tradable sector, non-tradable sectors, and sector variety, respectively. Building on the findings from Section 3.1.3, these figures graphically represent the dynamic effects of the TRL on the dependent variables under study. Their purpose is twofold: validating the parallel trend assumption and assessing how the effect of TRL has evolved over time. In these figures, the blue coefficients represent the pre-treatment periods, while the red coefficients denote the post-treatment periods.

During the pre-treatment period, Figures 10 and 11 show coefficients that are not significantly different from zero in all periods for both tradable and non-tradable sectors. This consistency supports the validity of the parallel trend assumption in analyzing the

Table 5: Population descriptive by year

	Total Pop.[a]		Total Foreign Pop.[a]		N. of households[a]		N. of University Students[b]	
Year	Levels	% wrt 2010	Levels	% wrt 2010	Levels	% wrt 2010	Levels	% wrt 2010
2010	908,568		129,067		449,495		92,317	
2011	906,874	-0.19%	133,869	3.72%	449,904	0.09%	94,388	2.24%
2012	911,823	0.36%	142,191	10.17%	453,941	0.99%	94,378	2.23%
2013	905,014	-0.39%	140,138	8.58%	450,802	0.29%	95,841	3.82%
2014	898,714	-1.08%	138,076	6.98%	449,036	-0.10%	97,077	5.16%
2015	892,276	-1.79%	136,262	5.57%	447,067	-0.54%	98,665	6.88%
2016	888,921	-2.16%	132,730	2.84%	447,845	-0.37%	101,593	10.05%
2017	884,733	-2.62%	132,806	2.90%	447,638	-0.41%	105,970	14.79%
2018	879,004	-3.25%	133,137	3.15%	446,662	-0.63%	108,816	17.87%
2019	872,316	-3.99%	132,878	2.95%	446,347	-0.70%	111,586	20.87%

Source: [a] Turin Statistical Office
Source: [b] MIUR

TRL's impact on these sectors. Moreover, as shown in Figures A12 and A13, the absence of the time-invariant covariates would lead to a violation of the parallel trend assumption, even though not so marked.

In contrast, the analysis of sector variety, as depicted in Figure 12, indicates a potential violation of the parallel trend assumption, particularly in periods $t-3$ and $t-4$. Interestingly, even after integrating the covariates into the analysis, the findings remain consistent with those obtained without controlling for the covariate, as shown in Figure A. A14.

I now turn to compare the results from before and after the treatment. In Figures 10 and 12, the coefficients for both the tradable sector and the variety of goods and services are not statistically significant. Specifically, the coefficient for the tradable sector remains close to zero around the time of the TRL's implementation and shows a decline in the subsequent periods. Conversely, for the variety offered in the tracts, an increase in the effect is observed in the latter period. In the case of the non-tradable sectors, there is a continuous decrease in the effect after the implementation of the TRL. In particular, this effect is statistically significant in the first semesters after the introduction of the TRL.

4 Discussion

In this section I proceed with the discussion of the results, providing a conceptual interpretation of them and the mechanism that might occur. Regarding the TRL effect on house prices, the effect follows the conceptual framework illustrated in Section 3.1.2, with few exceptions. Notably, for the rent prices the effect is positive and significant for

most of the post-treatment periods. On the other hand, the sale prices effect is positive and significant for the initial semesters afterwards the TRL implementation, turning firstly no significant and close to zero, and lastly negative and statistically different from zero. The initial positive influence is explained by the increase in energy performance due to the TRL adoption in the area. However, the subsequent decreasing effect is counterintuitive. A possible explanation could be that in Italy, the average age at which a person buys a house was 43 years in 2018[9]. Examining the descriptive statistics by age range (Table A3), it becomes evident that the number of people aged between 18 and 49 has significantly dropped over the years. This decline has led to a reduction in housing demand and consequently, a decrease in sale prices. Even though Eq.3 account for the sociodemographic characteristics in the area, the covariates are time-invariante for avoiding endogenous issues, therefore, these changes in the distribution of young residents within the city could have induced this negative impact in the last semesters post-treated analysed.

The effect of TRL on local economic activity, while not immediately clear, is consistent with Glaeser et al. (2023) findings, despite differences in research focus and treatment definition. In section 3.2.2, the result is not straightforward, arising from the interaction between direct effects on housing costs and indirect effects on socio-demographic characteristics. Section 3.2.3 shows that for tradable sectors the interaction of direct and indirect effects seems to neutralise each other. This suggests that although there is a small, statistically insignificant downward effect, the variety of goods in these areas is not significantly affected by rising housing costs. Several establishments at the margin may exit the market, but they are replaced by others, maintaining the variety of goods.

Significant impacts are observed in non-tradable sectors, particularly in the initial periods post-TRL adoption, where a meaningful negative effect emerges. This is attributed to TRL-induced shifts in housing prices. Previous findings indicate that TRL positively influences rental and sale prices, especially in the initial post-treatment periods. Consequently, when both rental and sale prices increase due to TRL, the effect on non-tradable sectors is negative and statistically significant. However, in later periods, when sale prices are no longer positively impacted by TRL, the effect on non-tradable service providers becomes non-significant, though it remains negative. The interpretation of this

[9]Idealista

effect on the non-tradable distribution is related to evidence provided by the literature on urban revival and particularly by Couture and Handbury (2020) and Baum-Snow and Hartley (2020). They highlight how the presence of college students has changed the distribution and consumption of non-tradable services in America, showing the establishments' tendency to stay close to these young students. It is not hard to believe that university students massively consume in the rental housing market, and therefore they are particularly hit by changes in prices. Thus, the continuous rent price increase due to TRL alters the presence of students in the city, and consequently, the distribution of non-tradable services. Although lacking direct data on student distribution, anecdotal evidence suggests that the favorable condition of the rent market in Turin (see Figure 2) have encouraged the increase in the student population (Table 5), around 20% in ten years, especially from other Italian regions or countries, as detailed in Figure 6, while the general population measures has changed not more than 4%. Therefore, given this significant student presence, it is plausible that students are opting for areas with lower rents, leading to a decline in non-tradable service providers.

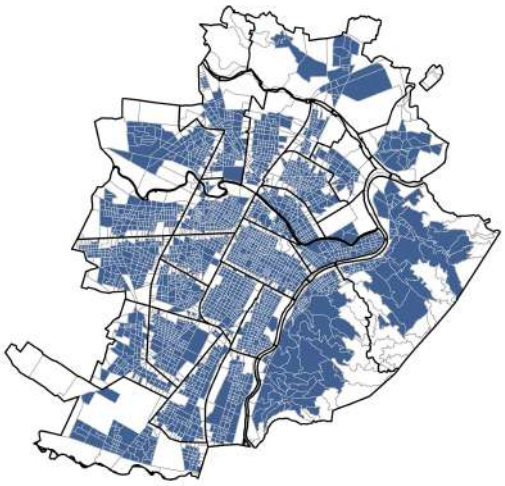
5 Robustness Checks

Figures A12 and A13, the absence of the time-invariant covariates would lead to a violation of the parallel trend assumption, even though not so marked.

In this section, I provide an exercise to these the robustness of the findings.

As discussed in Section 3.1.1, a potential threat to the empirical analysis is the spillover effect. This issue arises from the proximity of the tracts under study, which may influence each other. In urban environments, eliminating the spillover effect is challenging. Nevertheless, I propose a method to mitigate this by excluding from the initial sample the areas contiguous to the neighborhood's administrative borders. While areas within a single neighborhood may not be homogeneous, the differences between neighborhoods are more pronounced. The individual fixed effect partially addresses externalities from nearby areas that maintained constant influence throughout the analyzed period. These influences are more likely to occur within the same neighborhood. By additionally excluding bordering tracts of contiguous neighborhoods, as depicted in Figure 13, I further address differences and spillovers between neighborhoods.

Figure 13: Sample used for the spillover robustness check



Notes: Blue tracts are those included in the sample for the robustness check. White areas are contiguous to neighborhood borders, therefore are excluded from the sample for the robustness check. Neghborhoods' borders are plots with the thick black line.

Figure 14: Robustness Check - ATT with reduced sample

	TRL	
Dep. Var.	Coef.	St.Err.
Log (Sale)	0.003	0.006
Log (Rent)	0.014**	0.007
Log (Tradable)	-0.008	0.019
Log (Non-Tradable)	-0.027*	0.016
Log (Variety)	0.018	0.013
Obs.	29,392	

Notes: Significance is indicated by * p<0.1. ** p<0.05, and *** p<0.001. Standard errors, in parenthesis, are clustered at the census tract level. Control variables are the share of independent heating systems, the distance of the area from the two plants, the share of residential buildings, the share of buildings constructed in each decade since the 70s, the share of residential buildings in excellent and poor conditions, the density of commercial licenses in the tract, the share of foreign residents, young residents (ages 0-30), old residents (over 66 years old), the population and household densities, the share of employment, the share of the household owner and the level of education.

Table 14 presents the results derived from omitting the white areas shown in Figure 13. The impact of the TRL on the outcome variables is consistent with previous findings. However, the significance for rent prices and non-tradable sectors have diminished with the reduced sample size, leading to increased standard errors.

6 Conclusions and Next Steps

This paper provides an analysis of the relationship between real estate prices and local economic activities, using the city of Turin, Italy, as a case study. The unique dataset employed in this research, combined with the use of the staggered adoption of Teleriscaldamento (TRL) as an exogenous shock for housing prices, affords a detailed exploration of this challenging research question.

The introduction of the TRL system, designed to enhance energy performance in housing, is expected to influence housing prices. Theoretically, improvements in energy efficiency should translate into higher property values. This study confirms this hypoth-

esis, at least in the initial semesters post-TRL implementation, where an increase in rental prices is observed, reflecting the capitalization of energy efficiency benefits. However, while rental prices continue to show a significant positive effect, the impact on sale prices diminishes and eventually becomes negative over time. Potentially, this effect might be attributed to demographic shifts in the city, particularly the decrease in the young resident population.

A significant finding of this paper is the differentiated impact of housing price changes on tradable versus non-tradable sectors in the local economy. While tradable sectors show resilience to these changes, non-tradable sectors experience a notable negative impact, especially in the periods immediately following the TRL's implementation. This phenomenon can be linked to the demographic shifts driven by rising housing costs, particularly among college students who are pivotal consumers of non-tradable services. As housing prices, especially rentals, increase, these demographic groups might opt to relocate, leading to a decline in demand for services such as bars, restaurants, and personal care.

The empirical strategy employed leads to questions about the internal validity. The use of the TRL as exogenous variation provides a robust mechanism to isolate the effects of housing price changes on local economic activities. The staggered nature of the TRL's implementation allows for a quasi-experimental setup, reducing concerns about confounding variables and ensuring that the observed effects can be attributed more confidently to the treatment. However, when considering external validity, the study's findings may have limitations in their applicability to other contexts. Turin's unique demographic changes, urban structure, and the specific characteristics of the TRL system may not be directly comparable to other cities, especially those outside of Italy or Europe. Nonetheless, in Section 2, I provide several information to support the comparability of this specific case with both the Italian and European general settings.

Further analyses are needed. While in this paper I propose a conceptual framework and comprehensive analysis, additional research is needed to delve deeper into the underlying mechanisms. These could entail diverse analytical exercises, potentially requiring access to more extensive data. The robustness of the Teleriscaldamento (TRL) as an exogenous shock is a key of this study, however, more robustness checks would reinforce the findings. Moreover, the unique nature of TRL's implementation, dating back to

the 1980s, opens up opportunities to apply advanced empirical strategies. For instance, employing the methodology suggested by Borusyak and Hull (2020) could offer a new perspective, treating the TRL as an exogenous shock with a non-random exposure.

In conclusion, this study highlights the significant influence of housing market shifts on local economic activities, sheding light on the intricate interplay between neighborhood change, demographic shifts, and economic dynamics. The findings provide insights into urban economic processes, contributing to the ongoing debate of urban planning and policymaking.

References

Allcott, H., Diamond, R., Dubé, J.-P., Handbury, J., Rahkovsky, I., and Schnell, M. (2019). Food deserts and the causes of nutritional inequality. *The Quarterly Journal of Economics*, 134(4):1793–1844.

Almagro, M. and Domınguez-Iino, T. (2022). Location sorting and endogenous amenities: Evidence from Amsterdam. *Available at SSRN 4279562*.

Baum-Snow, N. and Hartley, D. (2020). Accounting for central neighborhood change, 1980–2010. *Journal of Urban Economics*, 117:103228.

Behrens, K., Boualam, B., Martin, J., and Mayneris, F. (2022). Gentrification and pioneer businesses. *Review of Economics and Statistics*, pages 1–45.

Borraz, F., Carozzi, F., González-Pampillón, N., and Zipitría, L. (2023). Local retail prices, product varieties and neighborhood change.

Borusyak, K. and Hull, P. (2020). Non-random exposure to exogenous shocks: Theory and applications. Technical report, National Bureau of Economic Research.

Borusyak, K., Jaravel, X., and Spiess, J. (2021). Revisiting event study designs: Robust and efficient estimation. *arXiv preprint arXiv:2108.12419*.

Brummet, Q. and Reed, D. (2019). The effects of gentrification on the well-being and opportunity of original resident adults and children. *Available at SSRN 3421581*.

Callaway, B. and Sant'Anna, P. H. (2021). Difference-in-differences with multiple time periods. *Journal of Econometrics*, 225(2):200–230.

Chapelle, G. and Eyméoud, J. B. (2022). Can big data increase our knowledge of local rental markets? A dataset on the rental sector in France. *PloS one*, 17(1):e0260405.

Couture, V. (2016). Valuing the consumption benefits of urban density. *University of California, Berkeley, Working Paper*.

Couture, V., Gaubert, C., Handbury, J., and Hurst, E. (2023). Income Growth and the Distributional Effects of Urban Spatial Sorting. *The Review of Economic Studies*, page rdad048.

Couture, V. and Handbury, J. (2020). Urban revival in America. *Journal of Urban Economics*, 119:103267.

Couture, V. and Handbury, J. (2023). Neighborhood Change, Gentrification, and the Urbanization of College Graduates. *Journal of Economic Perspectives*, 37(2):29–52.

Curci, F. and Yousaf, H. (2022). Gentrifying Cities, Amenities and Income Segregation: Evidence from San Francisco. *Available at SSRN 4315271*.

Davis, D. R., Dingel, J. I., Monras, J., and Morales, E. (2019). How segregated is urban consumption? *Journal of Political Economy*, 127(4):1684–1738.

De Ayala, A., Galarraga, I., and Spadaro, J. V. (2016). The price of energy efficiency in the Spanish housing market. *Energy Policy*, 94:16–24.

De Chaisemartin, C. and d'Haultfoeuille, X. (2020). Two-way fixed effects estimators with heterogeneous treatment effects. *American Economic Review*, 110(9):2964–2996.

Ding, L. and Hwang, J. (2016). The consequences of gentrification: A focus on residents' financial health in philadelphia. *Cityscape*, 18(3):27–56.

Fuerst, F., McAllister, P., Nanda, A., and Wyatt, P. (2016). Energy performance ratings and house prices in wales: An empirical study. *Energy Policy*, 92:20–33.

Garcia-López, M.-À., Jofre-Monseny, J., Martínez-Mazza, R., and Segú, M. (2020). Do short-term rental platforms affect housing markets? Evidence from Airbnb in Barcelona. *Journal of Urban Economics*, 119:103278.

Glaeser, E. L., Kolko, J., and Saiz, A. (2001). Consumer city. *Journal of Economic Geography*, 1(1):27–50.

Glaeser, E. L., Luca, M., and Moszkowski, E. (2023). Gentrification and retail churn: theory and evidence. *Regional Science and Urban Economics*, 100:103879.

Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics*, 225(2):254–277.

Guerrieri, V., Hartley, D., and Hurst, E. (2013). Endogenous gentrification and housing price dynamics. *Journal of Public Economics*, 100:45–60.

Handbury, J. and Weinstein, D. E. (2015). Goods prices and availability in cities. *The Review of Economic Studies*, 82(1):258–296.

Kholodilin, K. A., Mense, A., and Michelsen, C. (2017). The market value of energy efficiency in buildings and the mode of tenure. *Urban Studies*, 54(14):3218–3238.

Sant'Anna, P. H. and Zhao, J. (2020). Doubly robust difference-in-differences estimators. *Journal of Econometrics*, 219(1):101–122.

Stroebel, J. and Vavra, J. (2019). House prices, local demand, and retail prices. *Journal of Political Economy*, 127(3):1391–1436.

Vigdor, J. L. (2010). Is urban decay bad? is urban revitalization bad too? *Journal of Urban Economics*, 68(3):277–289.

Vigdor, J. L., Massey, D. S., and Rivlin, A. M. (2002). Does gentrification harm the poor? *Brookings-Wharton papers on urban affairs*, pages 133–182.

Appendix

Tables

Table A1: List of license categories in the dataset

Category	Category
Animals Articles	Automatic Machines
Appliances and Electronics	Bar and Restaurants
Building Material	Candies
Children Articles	Clothing
Cosmetics and Perfumery	Coffee Pods
Extralimentary	Food
Fabrics and Rugs	Gift Articles
Flowers and Plants	Hairdressers and Beauticians
Fuels	Mixed
Furniture	Objects
Games	Second Hand
Hardware Store	Sport Articles
Health and Orthopedic Articles	Supermarkets
Home Articles	Newspapers
House and Person Hygiene Articles	Optics
Jewellery	Pharmacy and Herbalist Articles
Laundry	Photography
Libraries	Sexy Shop
Motor and Car	Spare Accessories
Musical Instruments	Stationery Articles
Tobacco	

Table A2: Descriptive statistics per city area

	All Tracks without Centro & Hill			Centro & Hill			All Tacks		
Share of graduate people in 2011	50896	.1285054	.1101622	10672	.2608681	.1596865	61568	.1514488	.1302394
Share of undergraduate people in 2011	50896	.2529958	.1199731	10672	.2343875	.1320833	61568	.2497703	.1223601
Share of people with secondary school license in 2011	50896	.2416164	.1232215	10672	.1479094	.1014285	61568	.2253735	.1248719
Share of people with a primary school licence in 2011	50896	.1339976	.0785082	10672	.0819234	.0702353	61568	.1249712	.0796161
Share of illiterates people in 2011	50896	.0067286	.0124406	10672	.0032928	.0121921	61568	.0061331	.0124658

Source: ISTAT

Table A3: Population descriptive by age range

	Pop. 0y-17y[a]		Pop. 18y-29y[a]		Pop. 30y-39y[a]		Pop. 40y-49y[a]		Pop. 50y-65y[a]		Pop. More than 66y	
Year	Levels	% wrt 2010	Levels	% wrt 2010	Levels	% wrt 2010	Levels	% wrt 2010	Levels	% wrt 2010	Levels	% wrt 2010
2010	131,090		103,839		135,152		144,917		185,413		208,157	
2011	131,947	0.65%	102,594	-1.20%	130,687	-3.30%	146,215	0.90%	187,051	0,88%	208,380	0.11%
2012	133,244	1.64%	103,691	-0.14%	128,114	-5.21%	148,225	2.28%	187,100	0,91%	211,449	1.58%
2013	133,180	1.59%	102,197	-1.58%	122,,424	-9.42%	146,950	1.40%	186,693	0,69%	213,570	2.60%
2014	132,796	1.30%	100,626	-3,09%	116,518	-13.79%	145,457	0.37%	187,422	1,08%	215,895	3.72%
2015	131,704	0.47%	99,117	-4.55%	112,055	-17.09%	143,949	-0.67%	189,325	2,11%	216,126	3.83%
2016	130,246	-0.64%	98,804	-4.85%	109,470	-19.00%	141,457	-2.39%	191,964	3,53%	216,980	4.24%
2017	129,188	-1.45%	99,155	-4.51%	106,720	-21.04%	138,170	-4.66%	194,880	5,11%	216,620	4.07%
2018	127,192	-2.97%	98,864	-4.79%	104,510	-22.67%	134,436	-7.23%	197,652	6,60%	216,350	3.94%
2019	125,168	-4.52%	98,478	-5.16%	103,159	-23.67%	129,943	-10.33%	199,829	7.78%	215,739	3.64%

Source: [a] Turin Statistical Office

Figures

Figure A1: Turin divided in census tracks

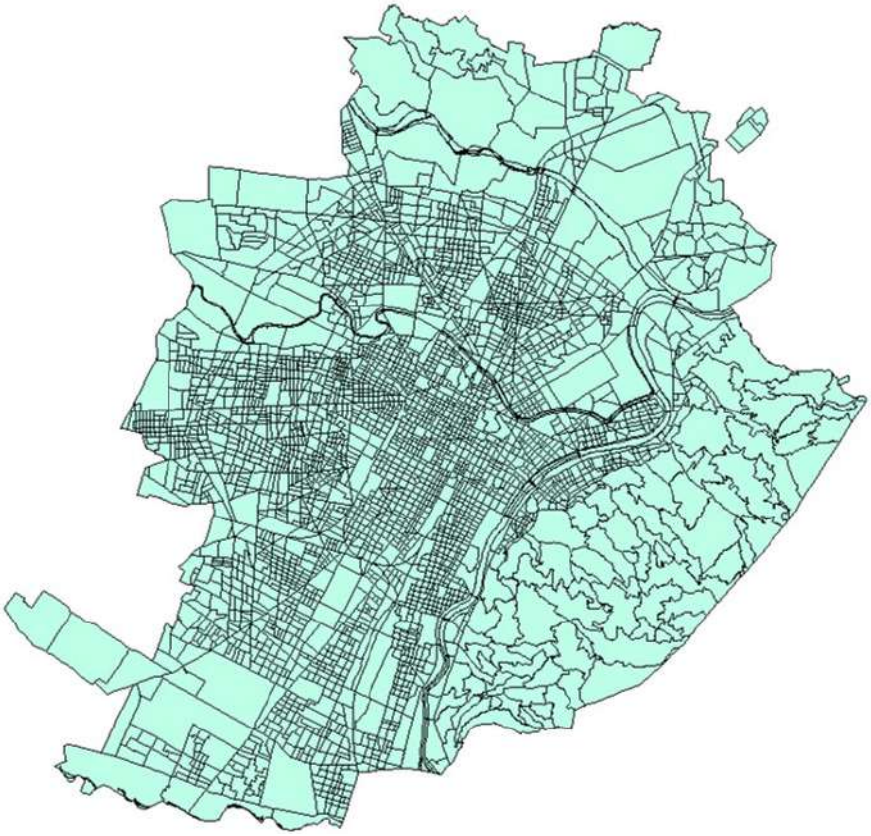


Figure A2: TLR network snapshot

Figure A3: KWatts of TRL installed in the tracts - Year 2019

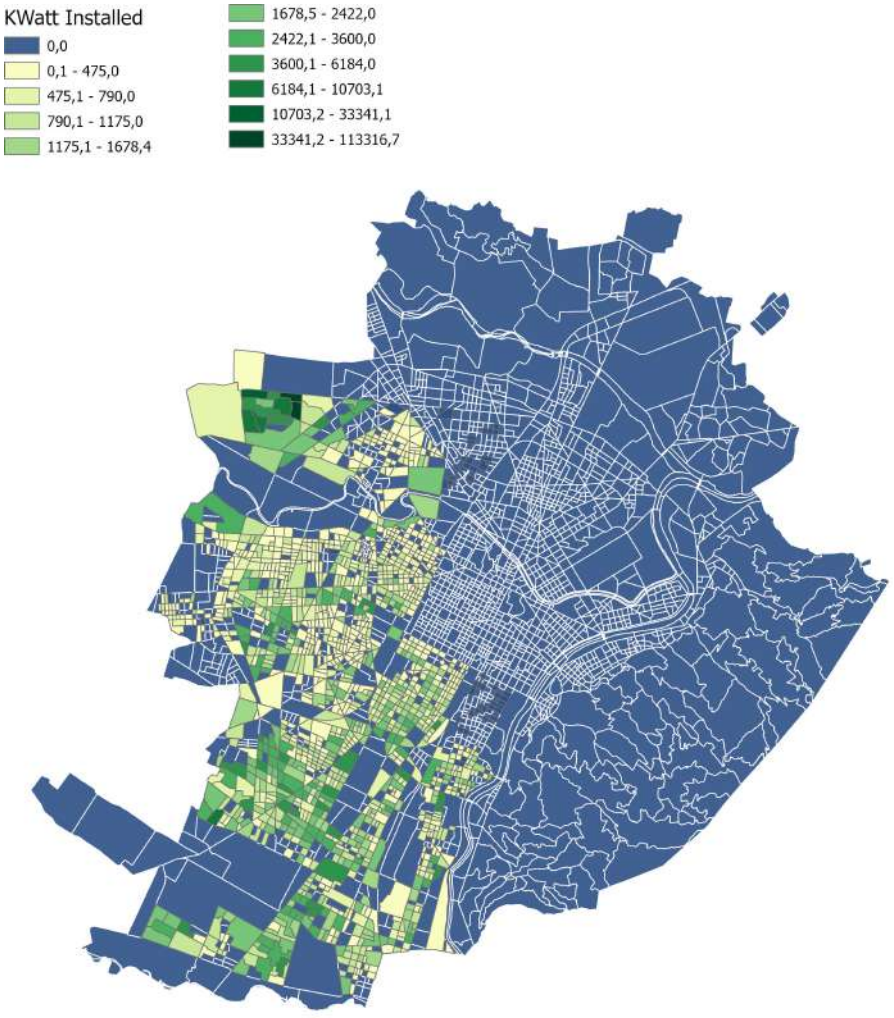


Figure A4: Balance Tests - TRL Treatment

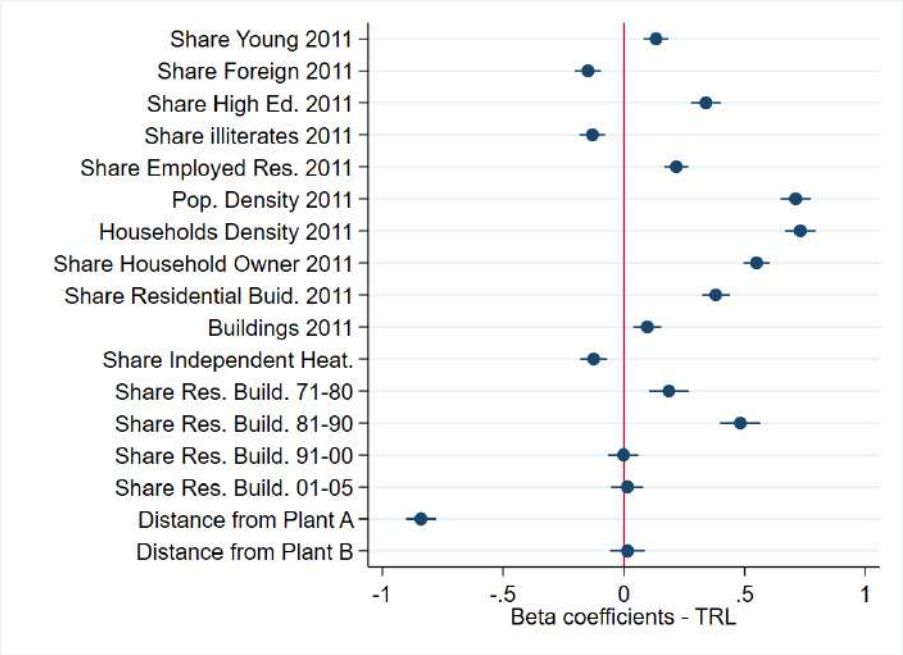


Figure A5: Balance Tests - Sale Prices

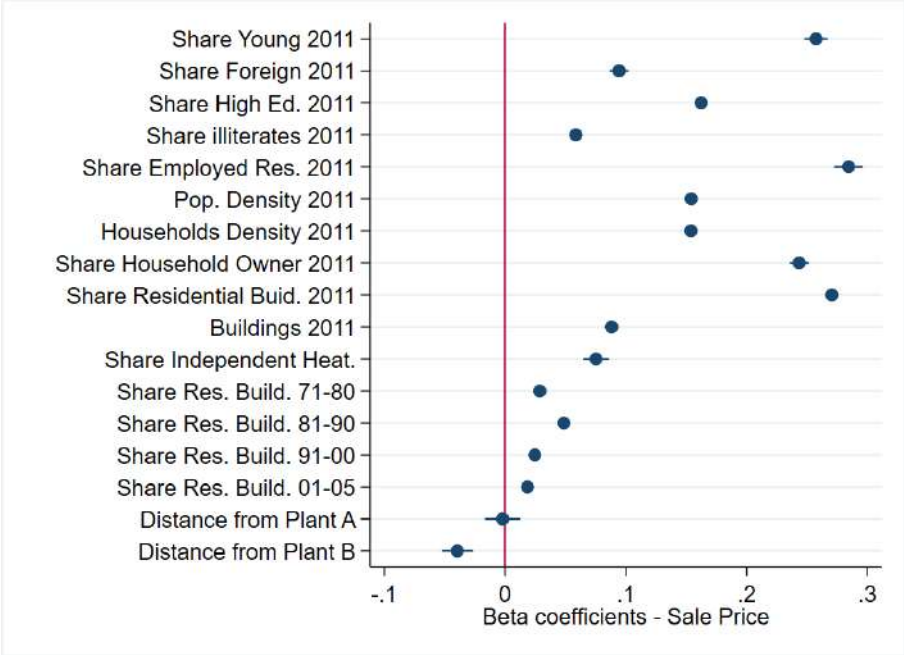


Figure A6: Balance Tests - Rent Prices

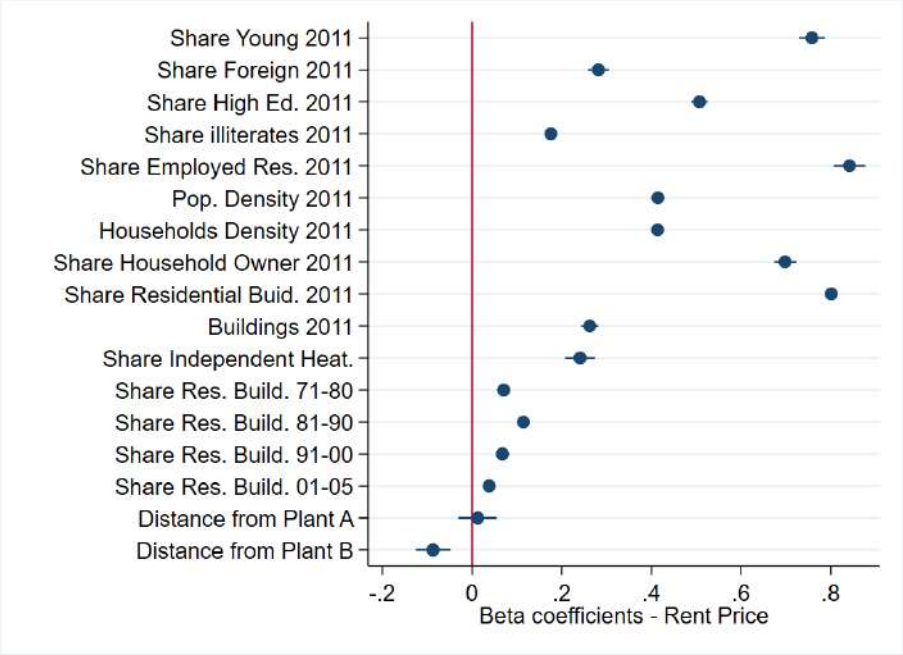


Figure A7: Balance Tests - Tradable Sectors

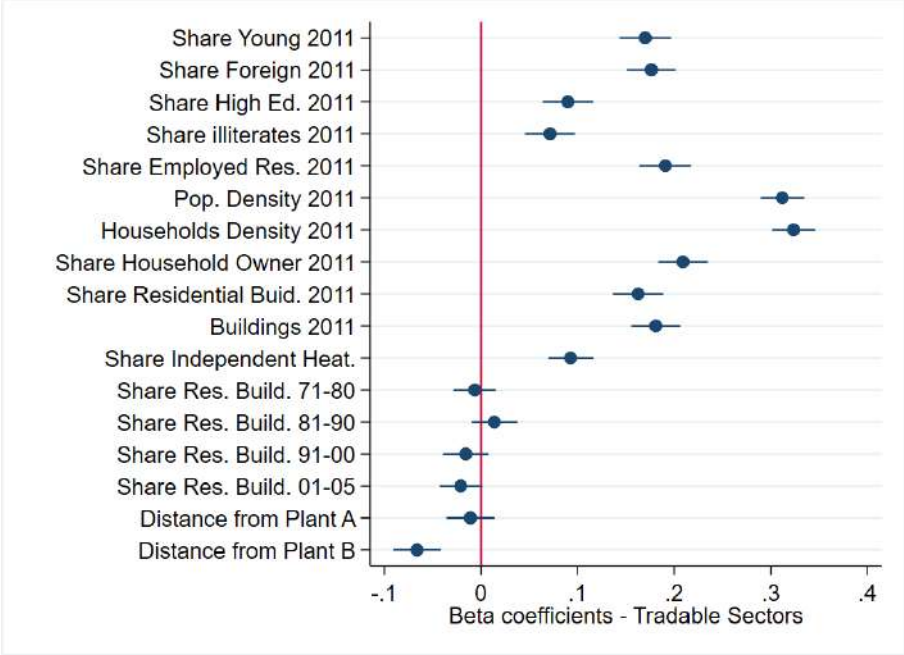


Figure A8: Balance Tests - Non-Tradable Sectors

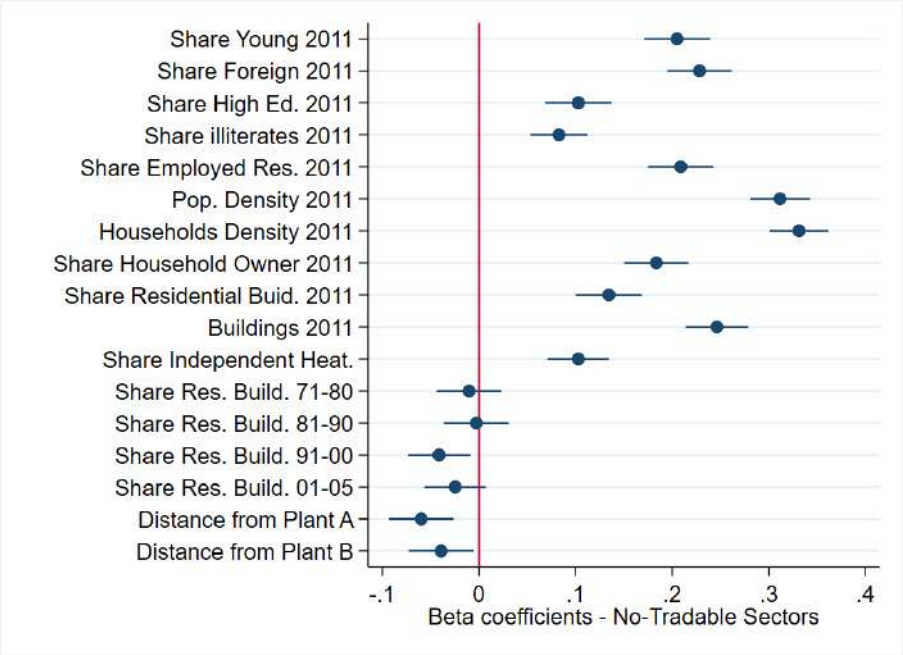


Figure A9: Balance Tests - Sectors' Variety

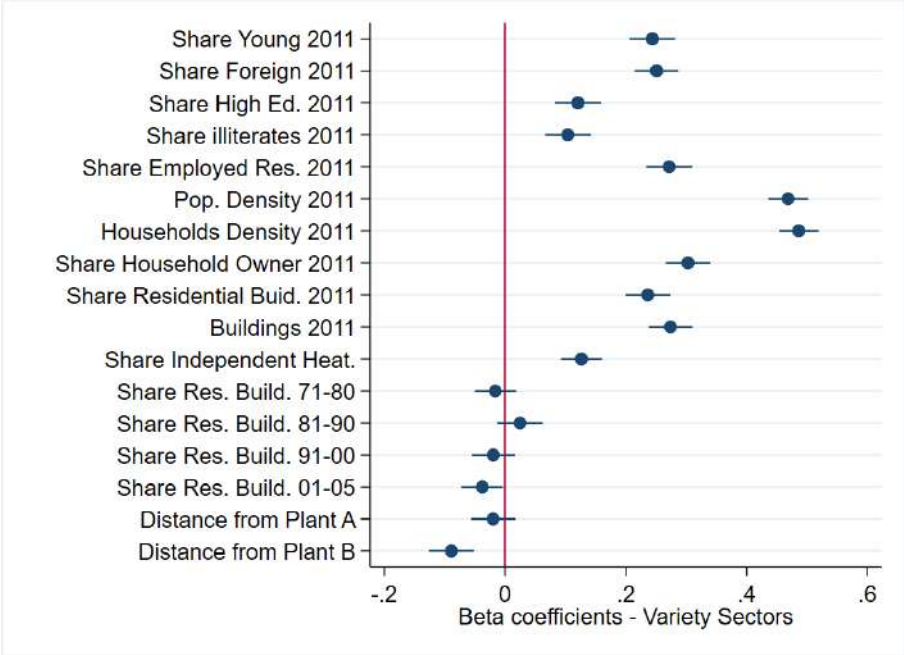


Figure A10: Event Study - Sale Prices on TRL without covariates

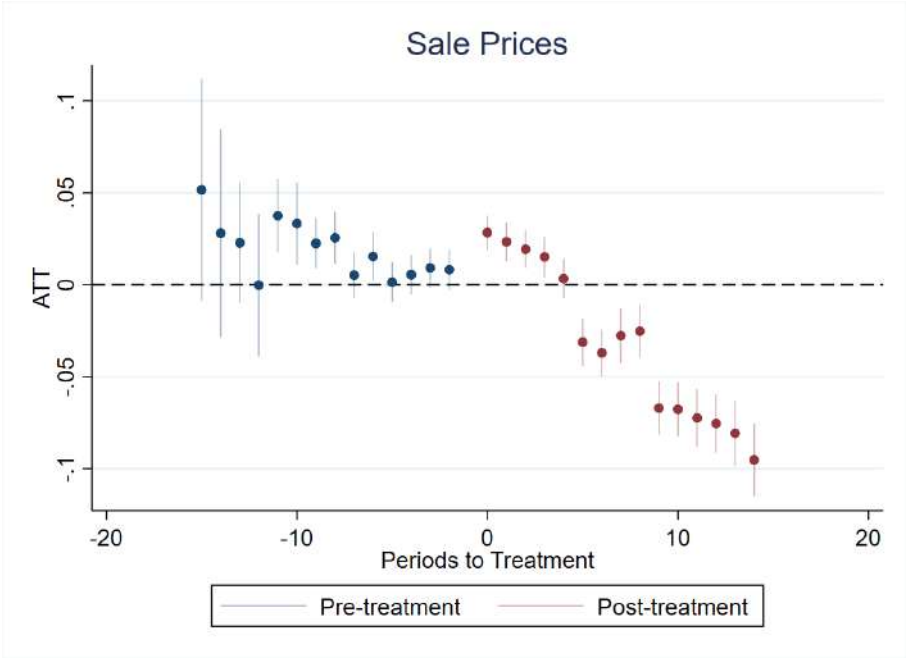


Figure A11: Event Study - Rent Prices on TRL without covariates

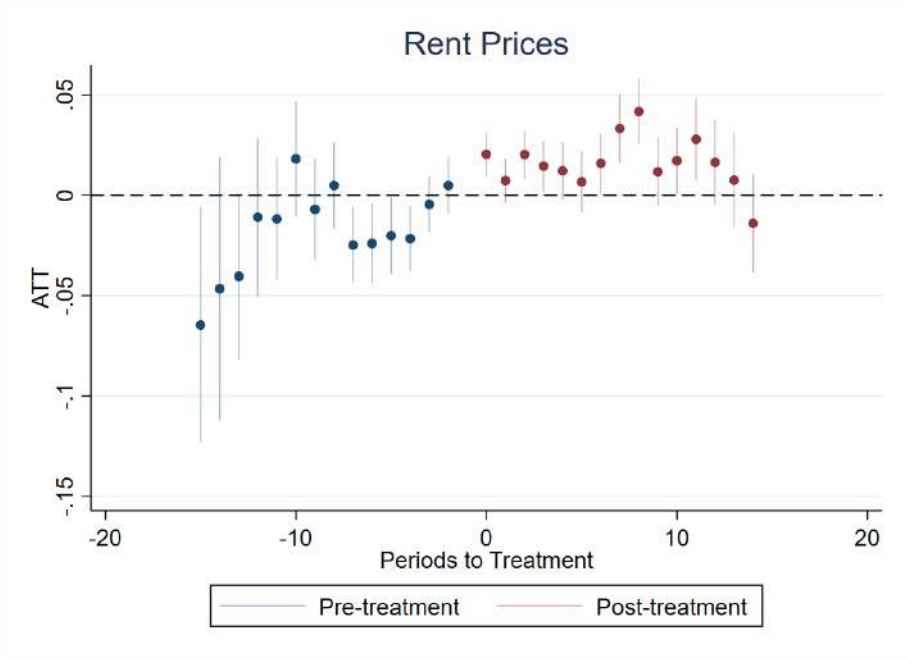


Figure A12: Event Study -Tradable Sectors on TRL without covariates

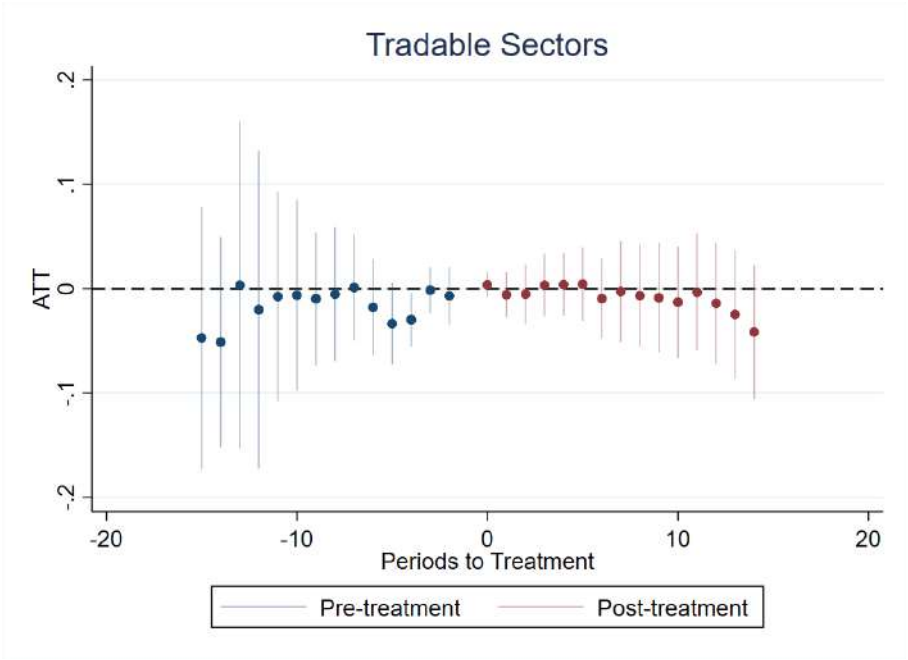


Figure A13: Event Study - Non-Tradable Sectors on TRL without covariates

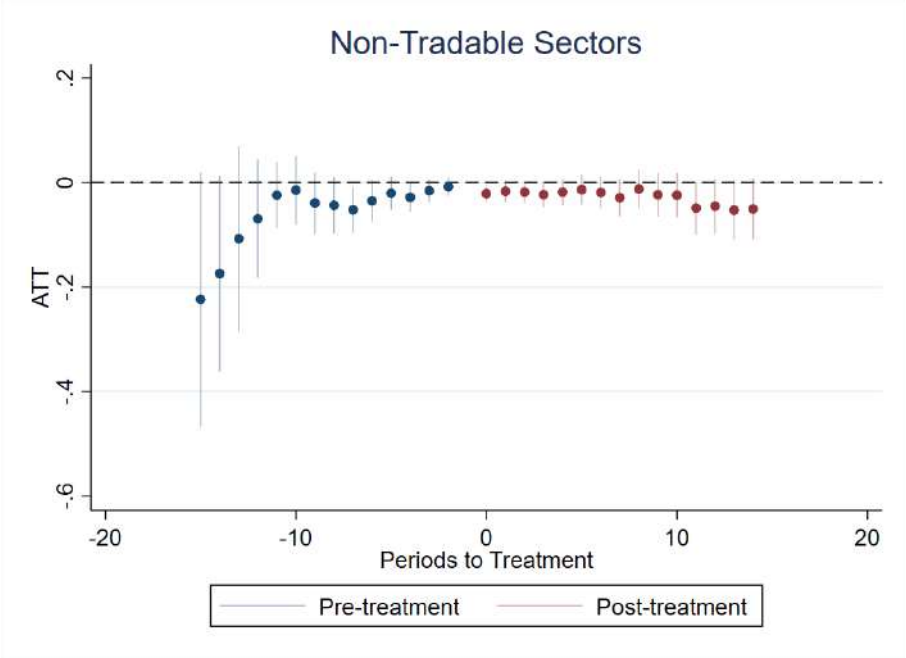
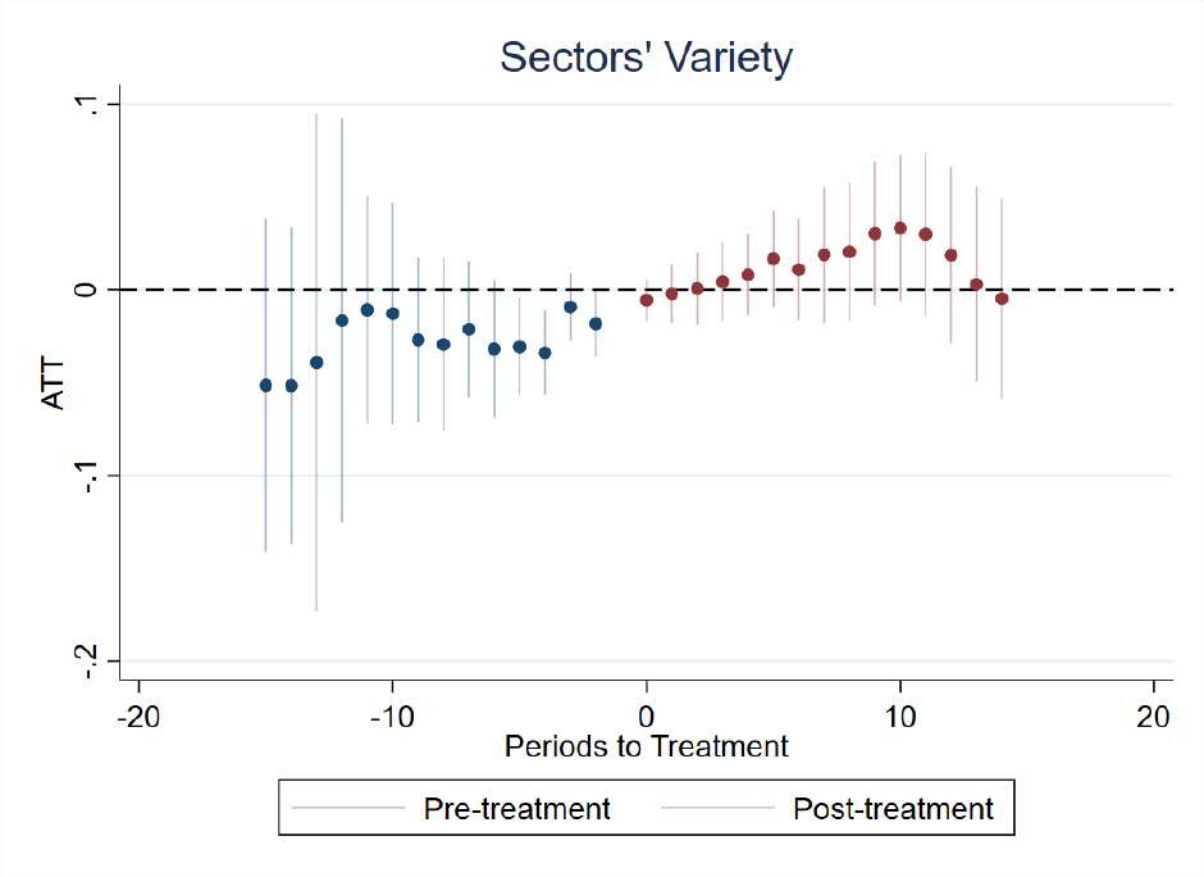
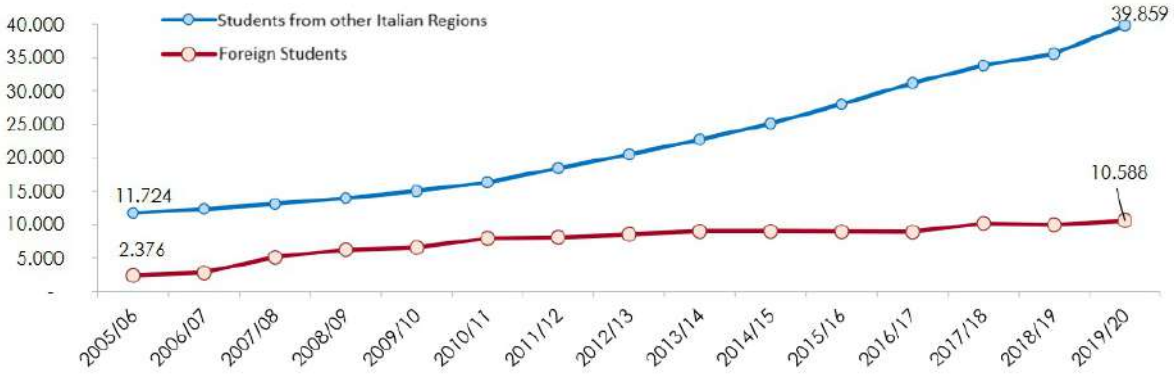


Figure A14: Event Study - Sectors' Variety on TRL without covariates





Source: Ires Piemonte