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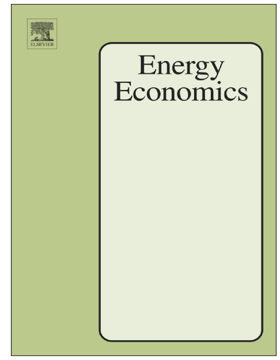

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Climate Change, Environmental Policies In The Housing Sector Of Italy, And The Impact On Social Welfare

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Abstract

The European Commission has significantly increased its focus on sustainability issues and the growing energy deficit. Residential consumption has been identified as one of the most energy-intensive segments, prompting the Commission to propose an Energy Performance of Buildings Directive. This directive aims to establish minimum standards for buildings to be met within specified timeframes. In this context, it is crucial to identify and address all potential drawbacks of such measures, ensuring that not only environmental but also social and economic aspects of sustainability are considered. This paper examines the impact of a fiscal incentive, called the Superbonus, implemented by the Italian government to promote sustainable investments and facilitate the recovery of the real estate sector following the pandemic. The work contributes to the growing literature on climate policies by focusing on the indirect effects on households and welfare through the analysis of the allocation of government resources across geographical areas and its impact on the housing market. The study employs a difference-in-differences approach with a continuous treatment variable to analyze the impact of the Superbonus on the real estate market, using data from Milan's residential market over the period 2016–2021. The results indicate that, while the fiscal incentive may have produced undesired welfare effects, the impact on the housing market led to a more equitable redistribution, albeit limited to those who already owned properties. The paper disentangles the main underlying mechanisms behind these effects, contributing both from an academic perspective and offering several political insights.

Keywords

climate policy; housing; welfare; fiscal incentives

1. Introduction

Climate change mitigation has taken unprecedented significance in recent years, urging the need for immediate policies and actions. The role of actions and policies, in addition to counteracting the advance of climate change, is also that of promoting sustainability from a social and economic perspective thereby improving households' welfare by fostering innovation, growth, and reducing inequalities. Climate policy can alter the dynamics of competitiveness and inequality both at macro level between nations and at micro level within them.

At EU level, buildings account for 43% of final consumption and residential buildings account for two-thirds of this consumption; hence, building construction policies may be associated with a high untapped energy savings potential (Enerdata, 2021). From an economic perspective, the EU's construction industry contributes around 9.6% of the EU's value-added and employs almost 25 million people in 5.3 million firms. Moreover, approximately 70% of EU residents own their homes. As a consequence, real estate assets are the main store of household wealth in most countries, with 70% in Italy (OECD, 2022).

Meanwhile, housing often constitutes the largest portion of a household's financial statement including both assets and liabilities, and any policy affecting such an asset should consider all potential implications. Heylen et al. (2012) show how income inequality increases when disposable income is corrected for housing expenses. Moreover, this effect was amplified due to the rise in inflation that occurred in the same period (ECB, 2022).

To address these issues, the European Union has introduced the Energy Efficiency of Buildings Directive. The program, which is part of the European Green Deal, sets minimum standard requirements that countries must align with at pre-determined schedules.

In 2020, in the wake of efficiency measures introduced by local authorities, the Italian government introduced a tax incentive called the Superbonus which was aimed at increasing the efficiency of residential homes.

This measure was introduced in May 2020 to boost the real estate sector and improve the energy efficiency of residential buildings. The incentive offers a 110% tax deduction for expenses related to energy efficiency, seismic risk reduction, and other specific upgrades. Furthermore, it allows the beneficiaries to either claim the deduction over four years or sell the credit to third parties. The policy goal was to make renovations accessible, even for households with limited liquidity, by enabling credit transfers and invoice discounts.

This paper builds upon a growing stream of literature that attempts to understand the welfare consequences of climate change mitigation policies on social welfare through the housing sector. Indeed, while the overall impact on energy consumption is quite trivial to assume, the indirect consequences can represent a crucial aspect in the analysis of the costs and benefits of a policy.

In addition to exploring the beneficial impacts of such policies, the analysis will examine the main challenges that have accompanied the implementation of the policy. The administrative bottlenecks and the financial constraints that have created numerous obstacles will be addressed to realize the full potential of such programs and ensure policy guidance for the future.

While providing a snapshot of the overall distribution of the resources, the paper will focus on the impact of the housing market across the different quantiles of the price distribution.

In particular, the main research questions of the paper can be summarized as:

RQ1) What is the impact of the Superbonus on the real estate market?

RQ2) What are the direct and indirect effects of the Superbonus on households' welfare and inequality?

The main reason, as stated above, is that housing represents the major assets and liabilities in households' financial statements. Given the direct impact on buildings through reduced refurbishment costs, it is essential to examine how this policy shock has influenced equilibrium conditions in the housing market.

The debate on the adequateness and the efficacy of the policy is still very heated. National and international newspapers are trying to disentangle all the possible facets deriving from the Superbonus but there is still a general lack of consensus (Reuters, 2024; The Guardian, 2023; Corriere della Sera, 2023); this means that, as of now, the only academic contribution that has delved into the impact of the Superbonus on the Italian economy has focused the attention on the effect on the building sector and the growth of the economy as a whole (Bank of Italy, 2024); indeed, the paper recognizes the lack of attention on several important issues such as environmental benefits and house prices. This paper will attempt to contribute to this academic discourse by providing a different perspective about the impact of the Italian Superbonus, focusing on the housing sector and its indirect effect on welfare and inequality. The assessment will be conducted following the approach of Filandri et al. (2014) who consider ownership and housing well-being as the two major sources of inequality.

In conclusion, as the world confronts the urgency of climate change, recognizing the synergy between sustainable building practices and societal well-being offers a compelling pathway to progress. This paper contributes to the evolving dialogue on policy-driven climate action and the quest for a more sustainable, equitable, and resilient future.

Section 2 introduces the literature that serves as the foundation of this analysis. Section 3 describes the scenario with a detailed description of the policy, Sections 4 and 5 provide a brief overview of the data and the main quantitative implications deriving from the analysis respectively, and Section 6 presents a general discussion of the main results. Finally, the paper will conclude with a brief summary of the key insights and future policy implications.

2. Literature Review

Herrero et al. (2012) show that levels of energy building efficiency are associated with households that include elderly, retired, low-income, and vulnerable individuals. Furthermore, policies to limit greenhouse gas emissions will raise the prices of carbon-intensive goods and the search for greener solutions will exclude the less well-off (Vandyck et al., 2021) and, as a consequence, the difference in treatment is amplified by several indirect effects. Many studies have demonstrated the regressive nature of environmental taxes (Harrison, 1995; Speck, 2017; Zhang and Baranzini, 2004). Several channels have been studied as a possible cause of this distortion, in particular disproportionately increasing costs for low-income households, influencing factor incomes differently across the income distribution, and exacerbating regional disparities due to variations in resource endowments and sectoral compositions (Mirrlees et al., 2010). Within this framework, a stream of literature has investigated the consumption responses to environmental policies (Decoster, 1995; Johnson et al.,1990). Ravallion et al. (2000) find that a trade-off between climate control and both social equity and economic growth exists. However, by interacting with the interdependencies between economic growth, climate, and social goals they find that more pro-poor growth processes offer better long-term trajectories of carbon emissions. D'alessandro et al. (2020) find comparable results and propose different political scenarios to address the issue of climate change mitigation policies, social welfare (i.e. inequality), and public deficit. Hence, much attention must be paid to the possible social implications of these regulations.

Several attempts have been proposed to shrink the undesired effect of green policies. Among the most popular measures proposed to dampen this imbalance is to tax the extra-profit deriving from the introduction of green-driven restrictions or incentives to promote social well-being, however, the impact of such measures strongly depends on local idiosyncratic characteristics (Metcalf, 2021; Vandyck et al., 2014).

In the housing sector, the literature related to the impact of environmental issues has grown significantly in recent years although the first studies date back as much as 50 years ago with the works of Anderson et al. (1971) and Ridker at al. (1967), among others. More recently, He et al. (2020) show that air pollution affects housing prices while noise and discharge of wastewater do not seem to have an impact. Zheng et al. (2014) identify similar findings, however, their contribution also provides an understanding of the moderating role of household income in amplifying the relationship between pollution and housing prices. Similar streams of literature have attempted to investigate the role of environmental policies on both house prices and pollution. Moreover, the nexus with other socio-economic variables has been debated. Chai et al. (2015) exploit the introduction of the Clean Air Act and show that the benefits associated with improved air quality increased house prices by approximately $45 billion US dollars between 1970 and 1980. The importance of green amenities has been increasing over time. Furthermore, cities with higher per capita FDI are associated with lower pollution levels. They attribute their findings to a plausible shift in these cities from a production-based to a consumption-based economy (Zheng et al., 2010).

From a more theoretical perspective the goal of this paper can be assimilated to House et al. (2010). Despite the empirical setting being different, and it does not consider either the housing industry nor the environmental aspects, the policy implications and the main contribution are similar. Indeed, the work relies on a temporary tax incentive introduced in the economy of the United States of America (US) to alleviate short term costs for long-lasting investments through a tax subsidy. The reason why investigating the Superbonus effect is relevant relies in the main takeaway of their contribution; according to their model, since long-lived investments are mainly driven by long-run considerations the timing in which to start the investment does not strongly affect the decision-making process. However, the response to strong temporary subsidies will alter the willingness to invest in the timing slot and the price movement will reflect the subsidy regardless of its supply. Moreover, given the immediacy in its introduction and the limited lifetime of the Superbonus, the quantity of housing stock is certainly fixed so the impact of the subsidy cannot be amplified by stock adjustment mechanisms. As for the existing stock, the possibility of benefiting from the bonus leads to a reduction in the supply available on the market (already lower than the total housing stock), thus amplifying the effects of the incentive on prices (Gleaser et al., 2008).

3. Empirical Setting

During the Covid-19 pandemic, the Italian Government proposed a new law aimed at boosting the real estate sector out and emerge from the crisis as well as improving the energy efficiency of residential buildings.

Italy is among the most inefficient countries in Europe with respect to per capita housing emissions; indeed, despite being better than several countries, Italy benefits from a mild climate that guarantees low energy consumption for heating and it is positioned worse than countries with a similar climate such as France, Spain, and Greece. Most of the emissions derive from the direct consumption, which is linked to the fact that, in Italy, the main source of heating continues to be gas.

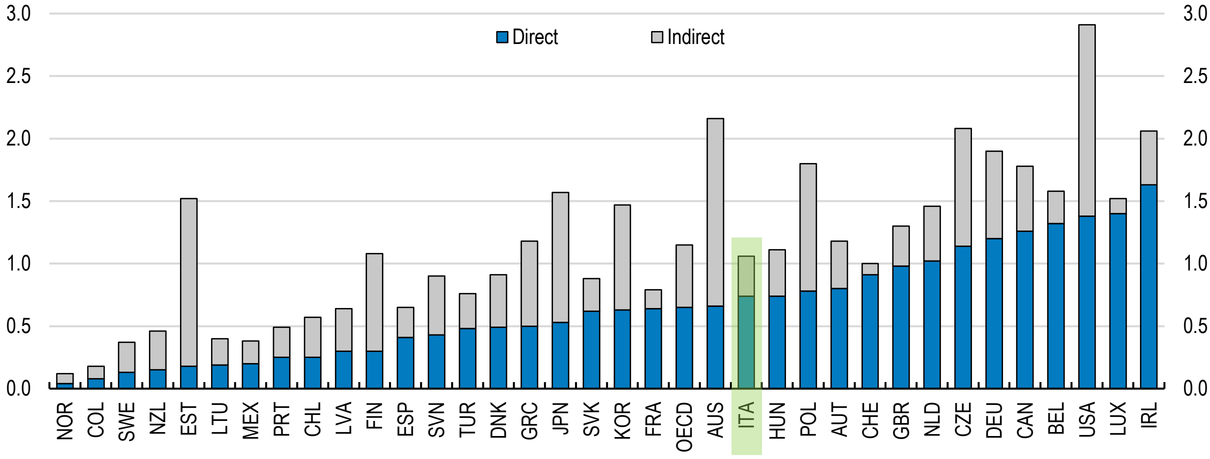

Figure 1: Total CO_2 emissions per capita from the residential sector by country, ton, 2020[1]

The construction industry is vital for the European economy, providing 18 million direct jobs and accounting for 9% of the EU's GDP[2].

A fiscal measure called Superbonus 110% was brought into force in May 2020. This measure is a tax benefit governed by Article 119 of legislative decree No. 34/2020 (relaunch decree)[3] which consists of a 110% deduction of expenses incurred starting from 1 July 2020 for the implementation of specific interventions aimed at improving the energy efficiency and static consolidation or reducing the seismic risk of buildings. The subsidized interventions also include the installation of photovoltaic systems and infrastructures for charging electric vehicles in buildings[4].

The deduction is recognized in the amount described above and must be divided among those entitled, in four annual installments of the same amount, within the limits of capacity of the annual tax deriving from the declaration of the income.[5]

Meanwhile, in order to produce a non-discriminatory incentive based on the liquidity available to carry out the work and the individual's fiscal capacity (i.e. income), as an alternative to directly using the deduction the government has also introduced the possibility to opt for an advance contribution in the form of a discount applied by the suppliers of the

[1] Source: IEA (2021), Energy Efficiency Indicators Database; and IEA (2021), Emission Factors Database and OECD calculations. Indirect emissions are calculated as follows: (Energy use) * (pe + pdh) * EF, where pe is the proportion of energy generated by electricity, pdh is the proportion of energy generated by district heating, and EF represents the emission factor for both electricity and district heating.

[2] European commission: https://single-market-economy.ec.europa.eu/sectors/construction_en#:~:text=The%20construction%20industry%20is%20very,social%2C%20climate%20and%20energy%20challenges.

[3] Source: Agenzia delle Entrate (The Revenue Agency is a non-economic public body that operates to ensure the highest level of tax compliance)

[4] For a more detailed summary of the incentive, visit the Revenue Agency website (https://www.agenziaentrate.gov.it/portale/superbonus-110%25). This paper will focus only on those aspects considered relevant to the research findings.

[5] The amount of deductions was initially spread over five years for expenses incurred in 2020. However, starting from expenses in 2021, the number of years was reduced to four.

goods or services (discount on the invoice) or for the assignment of the credit corresponding to the deduction due.

The transfer can be arranged in favor of:

- the suppliers of the goods and services necessary for the implementation of the interventions.
- other subjects (natural persons, including those conducting self-employed or business activities, companies, and organizations);
- credit institutions and financial intermediaries.

Given the average amount of construction sites that the incentive has generated (around 500,000 euros for condominiums and 100,000 for individual real estate units), the possibility to transfer the incentive towards other subjects remains a crucial aspect for the actual implementation. According to the Italian National Statistics Institute (ISTAT), in 2020 the average net family income was 32,812 euros but half of the families do not exceed 26,597 euros. Although the measure did not in itself represent a redistributive policy by favoring only the holders of real rights on properties, a further discrimination on liquidity and fiscal capacity, under these conditions, would have represented a measure reserved for a very narrow and wealthy slice of the population.

However, as the Superbonus began to be implemented, several issues have started to emerge. The three governments that have followed in these three years have tried to mitigate the potential pitfalls by making changes to the original amendment fourteen times. Most of the changes were aimed at preventing potential fraud arising from fictitious reconstruction projects that could create illicit credit thereby making legal accountability challenging to manage once the credits were sold to a third party. Hence, the government has tightened the regulations on controls and responsibilities of credit originators and buyers.

The more stringent legislation has led to a block in the trading of credits which, although permitted by the legislation, is not guaranteed by the state and its real effectiveness depends on the well-functioning of the private market. In November 2021[6], almost all financial institutions stopped purchasing fiscal credits deriving from the Superbonus since they were considered assets too risky to hold in their portfolios. As a consequence, the building company that was using invoice discounts with their customers, and subsequently turned to the institutions to settle the credits acquired, faced a huge liquidity crisis as they were holding huge volumes of credits in their portfolio and had no liquidity to pay their suppliers. At the same time, when the invoice discount was not applied, private individuals found themselves having paid the restructuring costs, sometimes through a bank loan, without the possibility of deducting or liquidating the credits generated and, consequently, with the risk of completely losing the tax benefit. Moreover, the law states that in order to obtain credit it is necessary to achieve minimum requirements in terms of efficiency and to complete the reconstruction within specific dates (varying across the different asset classes).

All of these factors, amplified by a surge in raw material costs, have generated a huge need for intervention to support the real estate industry and private households. A large number of construction sites have stopped halfway through construction; as of now, the market for credits

[6] The Law Decree n. 157/2021 aimed at avoiding fraud relating to deductions and assignments of credits for construction works.

is still at a standstill and the government is mitigating the impact by extending deadlines for construction projects already in progress. In such a context, there are several social issues that could arise; since the mechanism that should have guaranteed the non-discriminatory nature of the law are dependent on the private market, the government's possibilities for intervention are reduced to incentive mechanisms.

In the next sections, data patterns will be monitored to try to understand the social repercussions of an incentive that, to date, has cost the government around 130 billion euros, approximately five times the Italian budget maneuver.

4. Data

In order to proceed with the analysis, the work combines various sources of data. The magnitude and dispersion of the policy are investigated using the ENEA (The Italian National Agency for New Technologies, energy and sustainable economic development) monthly report[7]. The data contains information at regional level about the number of statements uploaded on the dedicated site (i.e. the number of open construction sites), the absolute value of investments eligible for deduction declared in the statement, and the absolute value of the works already completed. Indeed, while in the first statement, the owners must specify the works that they intend to carry out in order to access the tax benefit (i.e., the absolute value of investments eligible for deduction). The last measure provided in the dataset only considers those works that have been completed. Moreover, the three measures are offered separately for the different housing classes (i.e. condominiums and detached units).

Other regional information about demographic and economic characteristics was extracted from the ISTAT database; these measures are used to understand how national resources, managed individually by private citizens and firms, are distributed across the territory.

In order to understand the impact on the housing market, the analysis is focused at neighborhood level; housing data are provided by the main online property advertisement in Italy (Immobiliare.it). The listings of properties are extracted on the same day of every month and aggregated at micro-level[8] in order to construct local averages. The dataset allows us to distinguish information on the average sale and rental asking prices for all properties available in the dataset within the reference period, properties classified by their structure (Apartment, detached, loft), and properties classified by their refurbishment level (new, completely refurbished, average conditions, and in need of refurbishment). This last piece of information will allow the authors of this paper to analyze the effects of the Superbonus and evaluate potential repercussions in terms of well-being and social equity. Unfortunately, the combination of type and refurbishment level is not available and one will have to account for possible sources of bias deriving either from differences in the quality of the property or in their structure.

In order to minimize the potential bias and use the best available data, it is shown that the variance in the quality of refurbishment is much bigger than the variance in property structure. In this regard, the analysis of the number of adverts included in the sample shows that the

[7] Data can be accessed at the following website: https://www.efficienzaenergetica.enea.it/detrazioni-fiscali/superbonus/risultati-superbonus.html

[8] The city of Milan is divided in 144 micro areas which have been defined by real estate practitioners taking into consideration the characteristics of the housing market. This should guarantee a sufficient degree of homogeneity in the properties that contribute to the creation of the neighborhood indexes.

average share of listings, in each area and period, that are classified as apartments is equal to 86.4%; moreover, another 6% of the sample is, on average, classified as a penthouse which can be considered as a sub-category of apartment. Conversely, the maintenance status is much more heterogeneous; in each period and area an average of 41.8% of the listings are in excellent condition, 22.4% are in good condition and 11.2% are in need of refurbishment. Finally, there is a remaining share of the listings that are classified as new/in construction or are not classified. Hence, price estimates could be much more affected by the differences in the degree of refurbishment than in the property structure.

Table 1 provides an overview of the characteristics of the original dataset by highlighting the volume and reference prices at neighborhood level for asset class and refurbishment status. As can be seen, for any price level, the share of apartments represents a very large share of the whole sample and there seems to be no correlation with the price level. On the other hand, the share of properties in the sample that are in excellent condition not only represents a much lower share of the sample but the refurbishment level seems to be positively correlated with the sale prices. This implies that potential sources of bias could much more likely derive from differences in the refurbishment level than from the type of structure. In order to avoid other potential sources of bias the analysis is limited to a very narrow area, the municipality of Milan, focusing on neighborhood level so as to keep other parameters constant across the sample. Similarly, Table 2 discusses the characteristics of other variables in the model.

Table 1: Data Characteristics

	N	**Mean**	**Std. Dev.**	**max**	**min**
Price (€/sqm)	**5889**	**5390.665**	**2202.742**	**15000**	**1389**
Share Apartment	5889	**0.874**	0.063	1.000	0.522
Share Penthouse / Attic	5889	0.052	0.040	0.308	0.000
Share Detached House	5889	0.005	0.008	0.082	0.000
Share Building / Palace	5889	0.006	0.010	0.129	0.000
Share Rustic / Country House	5889	0.000	0.002	0.04	0.000
Share Villa	5889	0.014	0.024	0.391	0.000
Share Townhouse	5889	0.003	0.008	0.157	0.000
Share Loft / Open Space	5889	0.045	0.043	0.4	0.000
Share New Construction	5889	**0.154**	0.103	0.765	0.000
Share Excellent / Renovated	5889	0.432	0.095	0.769	0.099
Share Good / Habitable	5889	0.272	0.082	0.607	0.011
Share Needs Renovation	5889	**0.1**	0.053	0.471	0.000

Table 1: Data characteristics

The unit of observation is at neighborhood level. Neighborhoods are constructed by real estate experts in order to cluster homogenous properties within the same area.

	N	Mean	Std. Dev.	max	min
Relative Price	5163	1.362	0.339	5.669	0.253
Relative Demand	5252	1.11	1.012	25.333	0.046
Relative Supply	5252	2.224	3.829	87	0.028
% of old	5252	0.102	0.049	0.471	0.01
% of new	5252	0.163	0.096	0.664	0.009
Price growth rate	4870	0.004	0.023	0.151	-0.152
% of new ads	5252	29.212	10.792	84.13	2.13
% of sale	5252	3.035	1.488	14.825	0.657
Average Price	5252	4498.153	1920.979	14510	1589

Table 2: Summary statistics of the main variables under analysis

The panel structure of the data allows one to estimate changes in the price, supply and demand for housing. Indeed, the introduction of the policy within the time frame analyzed allows the authors of this paper to examine market conditions both before and after the intervention. At the same time, the ability to control multiple cross-section identifiers, given the nested structure of the data, and time-specific variation contributes to the robustness of the results (Correia, 2016;). It is useful in partialing out the unobserved heterogeneity from the observed data. This model helps to control heteroskedasticity in simple panel data models that fix only one or two cross sectional identifiers. Furthermore, the interaction between the identifiers can be explored using High-dimensional fixed effects (HDFE) making it a consistent estimator (Clarke & Tapia-Schythe, 2021).

4.1. Geographical distribution of resources

While Figure 1 provides an overview of the resources that were planned and the actual completed volumes across the three main areas of the Italian territory, Figure 2 provides a graphical overview of the fairness of resource allocation; it is clear how the per capita amount allocated in each area is positively correlated with the average family income. Since the system had non-discriminatory mechanisms for resource allocation in terms of both liquidity and income, the ability to attract greater resources was generated through a more efficient private market.

<Figure 2 comes here>

Figure 2: Volumes of investments directly generated by the policy.

However, as previously mentioned, the system of credit assignments and invoice discounts has been significantly hindered by a series of regulatory corrections aimed at ensuring greater transparency and reducing the risk of fraud.

<Figure 3 comes here>

Figure 3: Incentive distribution and family income.

While the previous figures provide a snapshot of the current situation, Figures 3 and 4 show the growth of the number of construction sites and their volumes respectively. To fully understand these graphs, it is important to specify that the regulator has intervened differently for condominiums and individual units, precisely with the aim of protecting the most vulnerable segments of the population; at the end of 2021 (period 15) the Superbonus tax incentive for single units had been strongly **restricted**. Three major changes have been made with respect to condominiums:

- The deadline to complete refurbishment for single-unit sites started before September 2021 (period 14) was postponed to December 2022 while the deadline for condominiums was December 2023;
- The deadline to complete refurbishment for single-unit sites started after September 2021 (period 14) was postponed to June 2022;

- The opportunity to access the tax benefit for owners of individual units is reserved for residents with an income below €15,000 in ISEE[9].

<Figure 4 comes here>

Figure 4: Number of construction sites and volume growth

Figure 4 (left): growth in terms of number of construction sites (base month=1).

Figure 4 (right): growth of the completed investment generated by the policy (base month=1).

Given the market conditions, and no market for credit, the third point has practically closed the possibility of accessing the Superbonus for owners of single-family buildings. Figure 4 shows that these restrictions were able to speed up the growth of condominiums. However, looking at the right graph (Figure 4), one notices that the difference in the growth of the completed investments has been diverging (in favor of condominiums) more in the northern and central areas of the nation. This may imply that, despite the regulator's effort to favor condominiums, the less wealthy regions have not managed to give impetus to the Superbonus to promote redistributive effects within their areas.

Additionally, Figure 4 shows that the total amount received for completed works is similar across the two asset classes (single-unit and condominium) and across location. Figure 4 right shows the overall pattern of the volumes of the same sites (in billions). As one can see, although the number of sites is much higher for single units (detached and townhouses) the volume of investment is similar. Figure 4 left shows number of building sites (in thousands) that had started using the Superbonus. For single units, one construction site corresponds to a single beneficiary and for condominiums multiple beneficiaries correspond to a single building site (all units included in the condominium). It shows that the number of sites for single units compared to condominiums is much higher in the north. This may imply that the relative amount received by owners of single units, with respect to apartment owners, was higher in the southern regions. However, this difference could also be driven by a heterogeneity in the size of condominiums which, unfortunately, is not able to be controlled with the data available.

Currently, one of the main concerns about the Superbonus is due to the inability of household and building construction firms to complete their projects. The main reason, as previously highlighted, is the lack of liquidity resources due to the bad functioning of the private credit for markets. The government has temporarily addressed this issue by extending the deadlines for the completion of both condominium and individual unit projects to December 2023. Anyone who fails to complete the work within the deadline will risk losing the benefit even on work already completed.

<Figure 5 comes here>

Figure 5: Share of completed investments compared to planned.

Figure 5 shows that, while in the first stage, the difference between condominiums and single units was slightly reducing and the condominiums suffered when the market for credits started creaking. Figure 5 offers insight into the evolution of the share of completed

[9] The ISEE is an indicator that considers income, assets (movable and real estate), and the characteristics of a family unit (by number and type).

investments in comparison to the initially planned ones. The index is constructed as $\frac{Amount\ of\ completed\ investments}{Amount\ of\ planned\ investments}$

5. Methodology

This section will be devoted to understanding the impact of the Superbonus on the housing market and, as an indirect effect, on households' social welfare. From a methodological perspective, the model starts from the assumption that building costs are, given the same quality, homogeneous across locations. As a consequence, the relative impact of the cost of refurbishment is inversely correlated with property prices. This assumption is supported by several authors (Yoshida, 2020; Halket et al., 2020) and the Superbonus itself given that it allocates equal resources regardless of property value.

The empirical analysis will investigate the impact of the arrival of the incentive on the dynamics of the housing market across different areas, focusing on the impact across the different quantiles of the price distribution to account for possible heterogeneous effects. The welfare consequences can be extrapolated by the antecedent literature that relates environmental policies, the housing market, and social welfare, as presented in Chapter 2 (House et al., 2010; Filandri et al., 2014). This adds to what was discussed in the data section.

The main issue with the empirical strategy is that the incentive was announced in late March 2020 and officially started in May 2020 during the Covid-19 pandemic. During this particular period the government response to the pandemic forced people to work and spend their free time inside their homes. This situation caused people to change their housing preferences towards larger and more comfortable properties with outdoor spaces.

The available dataset does not allow control for such characteristics and, as a consequence, looking at the price level across neighborhoods without taking into consideration this shift in consumer preferences would result in poorly interpretable results.

In order to provide reliable results on the real effect of the Superbonus, the analysis will focus on the variation in the relative prices, demand, and supply for newly constructed and old (in need of refurbishment) properties. The idea is that while the pandemic may have shifted the preferences across locations and property characteristics, the only channel that may have changed consumer preferences between new or old houses is the tax incentive provided by the government.

A difference-in-difference regression with continuous variable treatment (Callaway et al., 2024) is implemented to take into account differences in housing costs and, as a consequence, the degree of treatment; the variable used to analyze the effect of the tax incentive is the product of a dummy variable that attempts to capture for the arrival of the incentive (i.e., dummy=0 before the introduction and 1 after) and a continuous variable Treat constructed by normalizing prices (hence, by construction, the deterioration rate) between zero and one.

The period between the announcement of the incentive (in late March) and the moment in which the policy came into effect (end of May) are removed from the analysis to account for possible anticipation effects.

The continuous variable is, more precisely, constructed as:

$$Treat_i = \frac{P_{i,Jan20} - \max(P_{\mathrm{Jan20}})}{\min(P_{Jan20}) - \max(P_{Jan20})} \quad (1)$$

Where P_i is the average price for the properties in need of refurbishment in location i, max P and min P are the maximum and minimum average price respectively across all neighborhoods. The variable is constructed in January 2020, just prior to the arrival of the Superbonus and the Covid-19 pandemic.

A dynamic version of the treatment variable, where the variable is computed at each period using prices at t-1, is also exploited. This allows one to consider the mechanism of adjustment that may affect the degree of treatment across and within locations as time goes on.

Then, the static version of the model can be written as:

$$Y_{i,t} = \beta_0 + \beta_1 Superbonus_{i,t} + \beta_n X_{i,t} + \varepsilon_{i,t} \quad (2)$$

Where

$$Superbonus_{i,t} = D_t * Treat_i \quad (3)$$

while the dynamic equation will have:

$$Superbonus_{i,t} = D_t * Treat_{i,t-1} \quad (4)$$

$Y_{i,t}$ is constructed as the ratio between newly constructed properties and those in need of refurbishment in the levels of prices, demand and supply (i.e. $Y_{i,t} = \frac{New_{i,t}}{Old_{i,t}}$).

More precisely, the ratio is constructed using the average level of prices that are present on the website on the 15th of each month; the demand side is proxied using the average number of requests for information each advertisement receives during the month in area i. Finally, the supply side is represented by the number of listings entering in the reference period.

$X_{i,t}$ is a set of controls that includes the share of new and old properties in the listings, the percentage of new listings[10], the percentage of stock on sale[11], the average sqm price of the neighborhood, and its growth rate over time.

Some of these parameters allow to control for idiosyncratic trends at the neighborhood level that could be affected by different regulatory frameworks or structural characteristics. Nonetheless, the limited geographical area under which the policy is investigated should limit these issues itself. Average prices and growth rates are used to control for the different shapes that characterize the movement of the housing market at different quantiles of the distribution during boom-and-bust periods (Hilber et al., 2021; Dieci and Westerhoff, 2016).

As stated, given the high granularity of the dataset, one should be able to prevent any potential distortion deriving from demographic and economic differences within neighborhoods. By doing so, the control variable (Superbonus) should be able to capture the asymmetry across the neighborhoods in the treatment received from the program in the relative prices, demand, and supply between new and old properties.

The dynamic version of the model constructed updating the degree of treatment in order to account for price adjustment over time is used as a robustness test. However, a simultaneous

[10] Constructed as $\frac{\text{number of new listings for sale}_{i,t}}{\text{all listing for sale}_{i,t}}$

[11] Constructed as $\frac{\text{number of listings for sale}_{i,t}}{\text{all housing stock available}_{i,t}}$

change in the control and in the dependent variable, only for the price level regression, induced by a change in the level of the prices could induce a bias in the estimate. In order to solve this issue the variable is constructed using the one period lagged price levels. Moreover, an increase in the average price for the properties in need of refurbishment[12] would, at the same time, produce a decrease in both variables and, as a consequence, a positive correlation between them. However, the result of the price level regression shows a negative effect of the control on the dependent variable, as expected, and this source of distortion only produces a downward bias of the estimate. Furthermore, the dynamic version allows for the introduction of additional fixed effects in the model without affecting the original model[13]. This allows for additional controls to be added to the model and leverage fixed effects to control for common trends over time and across areas.

6. Results

The Superbonus is about to end its life cycle. Hence, it should be possible to account for the costs and benefits that the incentive has conferred on society. Indeed, the analysis of an environmental policy should consider all three dimensions of sustainability (i.e. environmental, social, and economic). Although the environmental dimension has certainly been improved by contributing to the redevelopment of several buildings, this paper will present some numbers related to the other two dimensions.

In Italy, the northern regions tend to be more economically advantaged. For this reason, many policies aim to encourage entrepreneurship in this region and on the islands (Sicily and Sardinia). From a geographical perspective, while the need for resources in the Northern areas may be higher due to harsher climate conditions, the Southern part of the country has much higher levels of seismic activity and more dilapidated buildings. Therefore, considering the shared environmental concerns, a redistributive policy should allocate additional resources to bolster employment and enhance well-being in economically disadvantaged regions.

Likewise, internal allocation should be sought to help the weakest segments of the population. The next section will analyze how the resources were distributed within and between the various regions and how changes to the law have impacted these dynamics.

Tables 3, 5, and 7 provide the results of the equations for price, supply, and demand respectively. The price model (Table 3) is based on 3735 observations. The significant F test confirmed the model is a good fit while the selected independent variables explain 18.39% of the changes in the price. The supply model (Table 5) is based on 3779 observations. The significant F test confirms that the model is a good fit while the selected independent variables explain 32.62% of the changes in the supply of housing. The demand model (Table 7) is based on 3779 observations. The significant F test confirms that the model is, again, a good fit while the selected independent variables explain 0.91% of the changes in the demand for housing.

Table 4 provides an overview of the expected value of the main dependent variable at each decile of the treatment distribution[14] before and after the implementation of the Superbonus.

[12] The data used to construct the control and the dependent variable.

[13] For example, Time fixed effect does not allow to measure the impact of the policy due to collinearity with the static model.

[14] The treatment distribution is constructed as described in Equation 1. The treatment distribution is equal to (1-price distribution) meaning that properties located at the lowest quantile of the treat distribution are the most

The results show that the impact of the Superbonus has decreased, on average, the relative price of new properties in the least expensive locations 9% less compared to the most expensive ones.

Tables 6 and 8 show how the price shift is driven by both an increase in demand and a reduction in the supply of older properties, aimed at exploiting the incentive. While the supply and demand shifts are similar across quantiles, the price effect (as shown in Table 4) reveals a different discount rate for the long-term incentives of the policy. The results confirm the timing effect of investments generated by the policy as pointed out in House et al. (2014) and suggest a potential redistributive effect with greater benefits for lower-cost locations. This aligns with the idea that the depreciation varies directly with the value share of the building structure given that real estate is made of non-depreciating land and depreciating structures where building costs do not vary as much as land prices (Yoshida, 2020). Indeed, despite common supply-demand adjustment mechanisms the impact of prices was inversely correlated with the housing value of the investigated areas.

HDFE Linear regression	Number of obs =	3,735
Absorbing 1 HDFE group	F(9, 3725) =	92.18
	Prob > F =	0.0000
	R-squared =	0.1839
	Adj R-squared =	0.1819
	Within R-sq. =	0.1839
	Root MSE =	0.2928

Price	Coef.	Robust Std.Err.	t	P>t	[95%Conf.	Interval]
Treat	0.349	0.096	3.630	0.000	0.161	0.538
1.Dummy Superbonus	0.060	0.061	0.970	0.332	-0.061	0.180
Dummy*Treat						
Treat						
1	-0.166	0.077	-2.160	0.031	-0.316	-0.015
% of old	-0.478	0.115	-4.140	0.000	-0.705	-0.252
% of new	0.312	0.067	4.680	0.000	0.181	0.442
Price growth rate	0.550	0.266	2.070	0.039	0.028	1.073
% of new ads	-0.003	0.001	-4.970	0.000	-0.004	-0.002
% of sale	0.023	0.004	5.800	0.000	0.015	0.030
Average Price	-0.000	0.000	-7.120	0.000	-0.000	-0.000
_cons	1.279	0.101	12.660	0.000	1.081	1.478

Table 3: The impact of climate policies and incentives on the price in the housing market.
(MWFE estimator converged in 1 iterations)

expensive. The logic underlying this choice follows the user-cost approach and the relative impact of housing cost on properties as discussed in the methodological section.

	Margin	Delta-method Std.Err.	z	P>z	[95%Conf.	Interval]
At Dummy Superbonus						
1 0	1.127	0.068	16.560	0.000	0.994	1.260
1 1	1.170	0.065	18.040	0.000	1.043	1.297
2 0	1.162	0.058	19.870	0.000	1.047	1.277
2 1	1.188	0.056	21.160	0.000	1.078	1.298
3 0	1.197	0.049	24.460	0.000	1.101	1.293
3 1	1.207	0.048	25.390	0.000	1.114	1.300
4 0	1.232	0.039	31.250	0.000	1.155	1.309
4 1	1.225	0.039	31.460	0.000	1.149	1.301
5 0	1.267	0.030	42.270	0.000	1.208	1.325
5 1	1.243	0.030	40.810	0.000	1.184	1.303
6 0	1.302	0.021	63.000	0.000	1.261	1.342
6 1	1.262	0.022	56.670	0.000	1.218	1.305
7 0	1.337	0.012	112.710	0.000	1.313	1.360
7 1	1.280	0.015	86.820	0.000	1.251	1.309
8 0	1.371	0.006	219.110	0.000	1.359	1.384
8 1	1.299	0.010	134.110	0.000	1.280	1.318
9 0	1.406	0.011	127.030	0.000	1.385	1.428
9 1	1.317	0.011	117.920	0.000	1.295	1.339

Table 4: Predictive price of new versus old properties, at each treatment decile, before and after the Superbonus. Variables that uniquely identify margins: Treat and Dummy Superbonus.

HDFE Linear regression
Absorbing 1 HDFE group

Number of obs =	3,779
F(9, 3769) =	46.23
Prob > F =	0.0000
R-squared =	0.3262
Adj R-squared =	0.3246
Within R-sq. =	0.3262
Root MSE =	3.4701

Supply	Coef.	Robust Std.Err.	t	P>t	[95%Conf.	Interval]
Treat	-3.930	0.939	-4.190	0.000	-5.770	-2.089
1.Dummy Superbonus	-1.460	0.685	-2.130	0.033	-2.804	-0.117
Dummy*Treat						
Treat						
1	2.013	0.904	2.230	0.026	0.242	3.785
% of old	-13.939	1.155	-12.060	0.000	-16.204	-11.674
% of new	19.843	1.776	11.170	0.000	16.360	23.326
Price growth rate	8.357	2.681	3.120	0.002	3.101	13.613
% of new ads	0.076	0.011	6.660	0.000	0.054	0.098
% of sale	0.295	0.053	5.590	0.000	0.191	0.398
Average Price	-0.000	0.000	-5.170	0.000	-0.000	-0.000
_cons	1.956	0.747	2.620	0.009	0.492	3.420

Table 5: The impact of climate policies and incentives to the supply in the housing market.
(MWFE estimator converged in 1 iterations)

		Delta-method				
	Margin	Std.Err.	z	P>z	[95%Conf.	Interval]
At dummy 110						
1 0	5.115	0.682	7.500	0.000	3.779	6.451
1 1	3.856	0.583	6.620	0.000	2.714	4.998
2 0	4.722	0.589	8.020	0.000	3.569	5.875
2 1	3.664	0.506	7.230	0.000	2.672	4.657
3 0	4.329	0.495	8.740	0.000	3.358	5.300
3 1	3.473	0.431	8.050	0.000	2.628	4.318
4 0	3.936	0.403	9.770	0.000	3.147	4.725
4 1	3.281	0.357	9.190	0.000	2.581	3.980
5 0	3.543	0.311	11.410	0.000	2.934	4.152
5 1	3.089	0.285	10.850	0.000	2.531	3.647
6 0	3.150	0.220	14.320	0.000	2.719	3.581
6 1	2.898	0.216	13.380	0.000	2.473	3.322
7 0	2.757	0.134	20.560	0.000	2.494	3.020
7 1	2.706	0.158	17.170	0.000	2.397	3.015
8 0	2.364	0.072	32.840	0.000	2.223	2.505
8 1	2.514	0.122	20.550	0.000	2.275	2.754
9 0	1.971	0.100	19.720	0.000	1.775	2.167
9 1	2.323	0.131	17.680	0.000	2.065	2.580

Table 6: Predictive supply of new versus old properties, at each treatment decile, before and after the Superbonus. Variables that uniquely identify margins: Treat and Dummy Superbonus.

HDFE Linear regression		Number of obs =	3,779
Absorbing 1 HDFE group		F(9, 3769) =	4.20
		Prob > F =	0.0000
		R-squared =	0.0091
		Adj R-squared =	0.0068
		Within R-sq. =	0.0091
		Root MSE =	0.9495

Demand	Coef.	|Robust Std.Err.	t	P>t	[95%Conf.	Interval]
Treat	0.307	0.227	1.350	0.177	-0.139	0.752
1.Dummy Superbonus	-0.215	0.267	-0.800	0.421	-0.739	0.309
Dummy*Treat						
Treat						
1	0.050	0.315	0.160	0.873	-0.568	0.669
% of old	0.218	0.378	0.580	0.564	-0.523	0.959
% of new	-0.276	0.179	-1.550	0.122	-0.626	0.074
Price growth rate	0.942	0.727	1.300	0.195	-0.483	2.368
% of new ads	-0.001	0.002	-0.360	0.722	-0.004	0.003
% of sale	0.038	0.015	2.570	0.010	0.009	0.066
Average Price	0.000	0.000	0.750	0.455	-0.000	0.000
_cons	0.742	0.255	2.910	0.004	0.242	1.241

Table 7: The impact of climate policies and incentives on demand within the housing market.
(MWFE estimator converged in 1 iterations)

		Delta-method				
	Margin	Std.Err.	z	P>z	[95%Conf.	Interval]
At dummy 110						
1 0	0.917	0.159	5.760	0.000	0.605	1.229
1 1	0.707	0.276	2.560	0.010	0.166	1.248
2 0	0.948	0.137	6.930	0.000	0.680	1.216
2 1	0.743	0.239	3.110	0.002	0.275	1.210
3 0	0.978	0.114	8.550	0.000	0.754	1.203
3 1	0.778	0.202	3.860	0.000	0.383	1.173
4 0	1.009	0.092	10.930	0.000	0.828	1.190
4 1	0.814	0.165	4.940	0.000	0.491	1.137
5 0	1.040	0.071	14.740	0.000	0.901	1.178
5 1	0.850	0.128	6.640	0.000	0.599	1.100
6 0	1.070	0.050	21.560	0.000	0.973	1.168
6 1	0.885	0.092	9.670	0.000	0.706	1.065
7 0	1.101	0.031	35.030	0.000	1.039	1.163
7 1	0.921	0.056	16.300	0.000	0.810	1.032
8 0	1.132	0.023	48.580	0.000	1.086	1.177
8 1	0.957	0.028	33.990	0.000	0.902	1.012
9 0	1.162	0.034	34.570	0.000	1.096	1.228
9 1	0.992	0.034	28.890	0.000	0.925	1.060

Table 8: Predictive demand of new versus old properties, at each treatment decile, before and after the Superbonus. Variables that uniquely identify margins: Treat and Dummy Superbonus.

The price and supply regressions confirm the initial hypothesis about the heterogeneous impact of such a policy across the different quantiles of the price distribution. Indeed, while some areas seem not to be affected by the arrival of the incentive, the cheapest locations were able to reverse the increasing gap between the price of new versus old properties.

Looking at Table 3, one can see how the Treat variable highlights the overall heterogeneity in the relative price of new properties, providing additional evidence of the higher impact of housing costs in the most fragile areas. The dummy variable that attempts to assess the impact of the arrival of the Superbonus on the benchmark variable seems not to be statistically significant. The data are confirmed by the predicted estimates of the dependent variable provided in Figure 6. The impact of the Superbonus variable, however, highlights a beneficial effect of the policy in reducing the gap between new and old properties as highlighted by the interaction variable (Treat*Dummy). In particular, the effect has a beneficial impact on alleviating the cost of refurbishment in the least expensive areas. The results achieved by the policy are even more satisfactory given that, as shown by the effect of the growth rate of prices, the housing market in Milan has been facing a huge boom in the value of properties that would have further amplified the price delta. The results are in line with the findings of House et al. (2010) through the approach of Filandri et al. (2014) that assesses the role of housing on welfare and inequality.

The effect of the incentive on the supply of new properties also appears to be heterogeneous across areas. The pandemic has obviously affected the production of new properties, generating a stop in production and leading to an overall reduction in their availability. Moreover, the Treat variable highlights how the most affordable areas generally suffer from an availability of new properties, however, the arrival of the Superbonus has produced less detrimental effects in those areas thus leading to a rebalancing of the differences between the different areas.

Conversely, the demand regression does not provide significant results. The most plausible underlying justification is that, given the relatively short duration of the incentive, the possibility of looking for an old property in order to exploit the incentive has not been perceived as a profitable path to pursue.

The results allow this paper to provide some possible channels of transmission on the level of prices. The shortage in the supply of new properties has resulted in a relative increase in the most expensive areas thereby leading to increased unaffordability. This effect was mitigated in the least expensive areas due to the incentives of the Superbonus. Hence, despite the inefficient distribution of resources across areas (north, south, and center) and asset class (apartments vs detached units), the effect on the housing market has shown a positive return in terms of welfare redistribution.

Furthermore, the shortage of building companies and the inability of the financial sector to provide a smooth system for credit transfer and invoice discount solutions have generated a customer selection mechanism that may have a downward bias in the estimates of all regressions. Hence, the avoidance of such malfunctions could have, on one hand, reduced the inefficiencies in the distribution of the resources and, on the other, amplified the beneficial aspects mediated by the housing market movements.

In order to quantify the magnitude of these effects, Figures 7, 8, and 9 show, respectively, the average predicted values[15] of the relative price, supply, and demand of new properties at the different deciles of the distribution[16] before and after the implementation of the policy.

To conclude, the empirical evidence shows that the impact of the Superbonus was not limited to the overall improvement of the energy efficiency of buildings but it has also allowed

[15] Tables 4, 6, and 8 provide the numerical overview of the estimates.

[16] The ninth decile of the treatment coincide with the tenth decile of the price distribution due to the way the Treat variable is constructed.

for the reduction of housing wealth inequality. This research sets a lower bound for the possible effects in terms of redistribution since, for the previously mentioned issues, a better planned incentive could have produced much stronger and robust results. For robustness, Tables 9, 11, and 12 in the appendix provide a similar model using Equation 4 to make dynamic estimates. The result shows that the effect of the dummy Superbonus has increased while others have a similar magnitude.

7. Discussion

In the previous section, this research attempts to capture the potential impact of an environmental policy aimed at reducing the energy efficiency of buildings, through a fiscal incentive, on housing and social welfare. The analysis aimed to discern both the direct effects brought about by the policy within and across the Italian regions as well as the indirect effects through an examination of its repercussions on the housing market.

The main findings show that the friction generated by the regulatory restrictions on the credit market and the supply chain have significantly impacted on the mechanisms for which those systems were originally designed. Indeed, the analysis shows how different economic conditions have strongly impacted the ability to access the incentive. Most of the issues derive from the speed of implementation of the maneuver and its short time frame which did not allow for a natural rebalancing of the various markets involved.

These results prompt reflection on the appropriateness and effectiveness of entrusting the management of redistribution and inequality reduction systems to private entities, especially during emergency periods. Indeed, given the market characteristics such as its supply rigidity, the shortage of resources, and time, creditworthiness has played a pivotal role in determining selection criteria by companies based on the creditworthiness of customers.

The real estate industry has been hugely affected by the arrival of the Superbonus in part because the available supply, in a market that was experiencing a moment of crisis, was not sufficient to deal with all the demand. Moreover, the novelty introduced by the regulators has demanded strong managerial capacity within an industry characterized by small businesses and a low level of education. This implied that well-organized companies capable of operating within the legal framework reaped the most significant benefits.

Nevertheless, as provided in Section 5.2, the direct and indirect impact of the Superbonus on the housing market has resulted in a relatively positive effect in terms of social welfare. The relativity depends on the fact that the Superbonus benefited only those who owned property. The direct impact generated by the Superbonus on social welfare is due to the relative number of resources that the less expensive properties have received. Indeed, the overall amount incentivized by the government was independent of the value of single homes and, as a consequence, the relative amount received by households has been inversely proportional to their housing investment. Furthermore, the properties that benefited the most were those in the worst conditions which were much more facilitated in achieving the requirements necessary for the incentive.

As shown in Figures 7, 8, and 9, the above conditions have determined a shift in the demand-supply conditions that have favored lower-value houses. In conclusion, the paper provides some of the possible effects generated by the Superbonus. Although the program has generated many positive results, both from an economic and sustainability perspective, the management of social problems through the use of public resources must be carefully planned, especially if its final management is outsourced to the private market.

This paper marks the initial step in studying this extensive environmental policy and future studies should concentrate on evaluating the consequences of its conclusion.

7.1 Implications

The results provide an overview of the impact of the Superbonus policy. While providing an overall idea of the most relevant incentives proposed by a single government in Europe over the last 20 years, it highlights potential underlying mechanisms that policy makers and firms should consider in future policy decisions and actions.

In this context, the incentives in the form of tax credit can lead to a suboptimal allocation of resources both from an energy perspective and in terms of welfare thus negatively impacting aspects related to social sustainability. From a welfare perspective, the paper also shows that such a policy can affect the demand-supply equilibrium condition in the housing market. This is primarily due to the short duration of the incentive which has congested the sectors involved; similar effects have also occurred in the labor market and in the supply of goods needed for the construction industry in general.

From a research perspective, this study contributes to the literature on the effects of environmental policies. The paper focuses on the spillover effects that can indirectly propagate through the economy, in this case via the housing sector.

7.2 Limitations

The paper suffers from some limitations that may be overcome in future studies examining similar issues in different contexts. The main issue derives from the arrival of the incentives during the Covid-19 pandemic that may have affected the economy and the housing market. More specifically, the research cannot isolate the direct effect of the policy on real estate prices as the pandemic simultaneously shifted consumer preferences, for example increasing the demand for larger homes with green spaces that were suited for remote work. However, the goal of the paper is on the welfare effects that are propagated via the housing sector by investigating the impact on the relative price of new and old housing, by assuming that the impact of the pandemic has not played any role in shifting this relationship.

7.3 Future research

Given the main limitations of the research, future studies could attempt to directly assess the impact of environmental policies in the housing market. Housing is the most relevant aspect of households' wealth and represents a significant portion of carbon emissions. For this reason, future policy should be very careful in assessing the effect of environmental policies on housing and households' welfare.

Furthermore, the study does not address the effect the policy's impact on the construction sector. In fact, the policy contributed to inflating all building-related costs, leading to a sudden surge in demand that the supply was unable to meet. Future studies could further explore these aspects by analyzing the impact that the demand bubble generated by the policy has had on the labor market and on companies in the sector that are currently experiencing significant contraction. This would deepen the literature on the indirect effects of environmental policies, contributing significantly to both managerial and policy implications.

8. Conclusion

The paper presents an assessment of the impact on households' welfare of a government tax incentive aimed at enhancing the energy efficiency of buildings. Specifically, the paper provides an overview of the distribution of the tax incentive and its impact on the housing market across different areas in order to understand the policy's impact in terms of welfare and redistribution. The findings reveal a bidirectional impact: while enhancing energy efficiency the policy has narrowed the price gap between new and old properties in the least expensive areas, potentially reducing wealth inequality. However, the allocation of resources between and across regions has depended on the economic conditions of residents. This paper explains that most of the issues related to the negative effects are due to bureaucratic hurdles and challenges in the practical implementation of the proposed measures. Furthermore, it highlights the forthcoming challenges associated with the government's underestimation of the consequences of this action which places a substantial burden on public resources for the following years. The full economic and environmental returns of these investments remain largely unexplored thus emphasizing the need for future research to assess the final outcomes.

ETHICAL DECLARATIONS

Conflict of Interest

All the authors hereby state that there is no conflict of interest with the content of this article, both in terms of academic and professional capacity. It is to affirm that the work is not submitted anywhere else other than this journal.

Ethical Approval

The entire research process is in line with our institutional research ethics policy. We declare that all ethical standards are met and complied with in true letter and spirit.

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APPENDIX

Figure 6: Policy impact on the relative price for new properties

<Figure 6 comes here>

Figure 6: The graph shows the predicted relative price of new versus old properties, before (blue line) and after (red line) the implementation of the Superbonus, at each level of treatment decile. Following what is previously discussed, treatment decile is equal to [1 - price]. The graph shows that the relative price of new properties decreases after the implementation of the policy only in the least expensive neighborhoods.

Figure 7: Policy impact on the relative supply for new properties

<Figure 7 Comes here>

Figure 7: The graph shows the predicted relative supply of new versus old properties, before (blue line) and after (red line) the implementation of the Superbonus, at each level of treatment decile. Following what is previously discussed, treatment percentile is equal to [1 - price percentile]. The graph shows that the relative supply of new properties decreases after the implementation of the policy, however, the situation is reversed for the least expensive neighborhoods. Housing supply is measured as the number of listings that are added in the reference period.

Figure 8: Policy impact on the relative price for new properties

<Figure 8 comes here>

Figure 8: The graph shows the predicted relative demand of new versus old properties, before (blue line) and after (red line) the implementation of the Superbonus, at each level of treatment decile. Following what is previously discussed, treatment decile is equal to [1 - price]. The graph shows that the overall relative demand for new properties decreases, however, results are robust only in the least expensive areas. Housing demand is measured by the number of requests for information that are sent in the reference period.

HDFE Linear regression
Absorbing 1 HDFE group

Number of obs	=	4,789
F(9, 4779)	=	177.89
Prob > F	=	0.0000
R-squared	=	0.3018
Adj R-squared	=	0.3005
Within R-sq.	=	0.3018
Root MSE	=	0.2781

P_ratio	Coef.	Robust Std.Err.	t	P>t	[95%Conf.	Interval]
Treat	1.212	0.045	26.940	0.000	1.124	1.300
1.Dummy Superbonus	-0.066	0.032	-2.030	0.042	-0.129	-0.002
Dummy*Treat						
Treat						
1	-0.077	0.048	-1.590	0.111	-0.172	0.018
% of old	-0.265	0.089	-2.980	0.003	-0.439	-0.091
% of new	0.256	0.053	4.880	0.000	0.153	0.359
Price growth rate	0.790	0.204	3.880	0.000	0.391	1.190
% of new ads	-0.003	0.000	-6.610	0.000	-0.004	-0.002
% of sale	0.022	0.003	6.610	0.000	0.015	0.028
Average Price	0.000	0.000	10.930	0.000	0.000	0.000
_cons	0.302	0.051	5.970	0.000	0.203	0.401

Table 9: The impact of climate policies and incentives to the Prices in the housing market.
(MWFE estimator converged in 1 iterations)

		Delta-method				
	Margin	Std.Err.	z	P>z	[95%Conf.	Interval]
At dummy_110						
1 0	0.653	0.026	25.040	0.000	0.602	0.705
1 1	0.580	0.034	16.900	0.000	0.513	0.647

2 0	0.775	0.022	35.710	0.000	0.732	0.817
2 1	0.694	0.029	24.070	0.000	0.637	0.750
3 0	0.896	0.017	51.660	0.000	0.862	0.930
3 1	0.807	0.023	34.460	0.000	0.761	0.853
4 0	1.017	0.013	77.720	0.000	0.991	1.043
4 1	0.921	0.018	50.500	0.000	0.885	0.956
5 0	1.138	0.009	125.480	0.000	1.121	1.156
5 1	1.034	0.013	76.760	0.000	1.008	1.060
6 0	1.260	0.006	216.610	0.000	1.248	1.271
6 1	1.148	0.010	117.050	0.000	1.128	1.167
7 0	1.381	0.005	271.670	0.000	1.371	1.391
7 1	1.261	0.009	144.420	0.000	1.244	1.278
8 0	1.502	0.008	196.630	0.000	1.487	1.517
8 1	1.375	0.011	124.520	0.000	1.353	1.396
9 0	1.623	0.011	141.620	0.000	1.601	1.646
9 1	1.488	0.015	97.490	0.000	1.458	1.518

Table 10: Predictive price of new versus old properties, at each treatment decile, before and after the Superbonus. Variables that uniquely identify margins: Treat(dynamic) and dummy Superbonus.

HDFE Linear regression		
Absorbing 1 HDFE group	Number of obs =	4,789
	F(9, 4779) =	54.06
	Prob > F =	0.0000
	R-squared =	0.3104
	Adj R-squared =	0.3091
	Within R-sq. =	0.3104
	Root MSE =	3.2336

S_ratio	Coef.	Robust Std.Err.	t	P>t	[95%Conf.	Interval]
Treat	-0.905	0.424	-2.140	0.033	-1.735	-0.074
1.Dummy Superbonus	-1.021	0.420	-2.430	0.015	-1.844	-0.197
Dummy*Treat						
Treat						
1	1.403	0.607	2.310	0.021	0.213	2.594
% of old	-13.008	0.919	-14.150	0.000	-14.810	-11.206
% of new	17.978	1.502	11.970	0.000	15.033	20.923
Price growth rate	8.894	2.118	4.200	0.000	4.741	13.047
% of new ads	0.066	0.009	7.440	0.000	0.049	0.084
% of sale	0.321	0.047	6.790	0.000	0.228	0.413
Average Price	-0.000	0.000	-4.430	0.000	-0.000	-0.000
_cons	-0.685	0.591	-1.160	0.247	-1.843	0.474

Table 11: The impact of climate policies and incentives to the supply in the housing market. (MWFE estimator converged in 1 iterations)

	Margin	Delta-method Std.Err.	z	P>z	[95%Conf.	Interval]
At dummy 110						
1 0	2.822	0.268	10.550	0.000	2.298	3.347
1 1	1.942	0.405	4.800	0.000	1.149	2.736
2 0	2.732	0.226	12.070	0.000	2.288	3.176
2 1	1.992	0.341	5.850	0.000	1.324	2.660
3 0	2.642	0.186	14.210	0.000	2.277	3.006
3 1	2.042	0.278	7.350	0.000	1.498	2.586
4 0	2.551	0.146	17.440	0.000	2.264	2.838
4 1	2.092	0.216	9.670	0.000	1.668	2.516
5 0	2.461	0.109	22.600	0.000	2.247	2.674
5 1	2.142	0.159	13.460	0.000	1.830	2.454
6 0	2.370	0.077	30.860	0.000	2.220	2.521
6 1	2.192	0.112	19.510	0.000	1.971	2.412
7 0	2.280	0.059	38.380	0.000	2.163	2.396
7 1	2.241	0.093	24.020	0.000	2.058	2.424
8 0	2.189	0.069	31.780	0.000	2.054	2.324
8 1	2.291	0.117	19.660	0.000	2.063	2.520
9 0	2.099	0.098	21.480	0.000	1.907	2.290
9 1	2.341	0.165	14.180	0.000	2.018	2.665

Table 12: Predictive supply of new versus old properties, at each treatment decile, before and after the Superbonus. Variables that uniquely identify margins: Treat(dynamic) and dummy Superbonus.

HDFE Linear regression
Absorbing 1 HDFE group

Number of obs =	4,789
F(9, 4779) =	4.71
Prob > F =	0.0000
R-squared =	0.0079
Adj R-squared =	0.0060
Within R-sq. =	0.0079
Root MSE =	0.9349

D_ratio	Coef.	Robust Std.Err.	t	P>t	[95%Conf.	Interval]
Treat	-0.084	0.197	-0.430	0.669	-0.469	0.301
1.Dummy Superbonus	-0.207	0.106	-1.960	0.050	-0.414	0.000
Dummy*Treat						
Treat						
1	0.111	0.138	0.800	0.424	-0.161	0.382
% of old	0.065	0.311	0.210	0.834	-0.545	0.676
% of new	-0.444	0.165	-2.690	0.007	-0.769	-0.120
Price growth rate	0.266	0.594	0.450	0.654	-0.899	1.432
% of new ads	-0.001	0.001	-0.700	0.485	-0.004	0.002
% of sale	0.038	0.013	2.860	0.004	0.012	0.064
Average Price	-0.000	0.000	-0.690	0.490	-0.000	0.000
_cons	1.234	0.236	5.220	0.000	0.771	1.697

Table 13: The impact of climate policies and incentives to the demand in the housing market.
(MWFE estimator converged in 1 iterations)

	Margin	Delta-method Std.Err.	z	P>z	[95%Conf.	Interval]
At dummy 110						
1 0	1.175	0.116	10.160	0.000	0.949	1.402
1 1	0.979	0.129	7.560	0.000	0.726	1.233
2 0	1.167	0.096	12.110	0.000	0.978	1.356
2 1	0.982	0.110	8.910	0.000	0.766	1.198
3 0	1.158	0.077	15.000	0.000	1.007	1.310
3 1	0.985	0.091	10.800	0.000	0.806	1.163

4 0	1.150	0.058	19.690	0.000	1.036	1.265
4 1	0.987	0.072	13.640	0.000	0.845	1.129
5 0	1.142	0.040	28.250	0.000	1.062	1.221
5 1	0.990	0.054	18.280	0.000	0.884	1.096
6 0	1.133	0.025	45.270	0.000	1.084	1.182
6 1	0.993	0.037	26.600	0.000	0.919	1.066
7 0	1.125	0.020	56.800	0.000	1.086	1.164
7 1	0.995	0.025	39.940	0.000	0.946	1.044
8 0	1.116	0.031	36.600	0.000	1.057	1.176
8 1	0.998	0.025	40.160	0.000	0.949	1.047
9 0	1.108	0.047	23.400	0.000	1.015	1.201
9 1	1.001	0.037	26.920	0.000	0.928	1.073

Table 14: Predictive demand of new versus old properties, at each treatment decile, before and after the Superbonus. Variables that uniquely identify margins: Treat (dynamic) dummy 110.

Variance inflation factor

	With interaction		Without interaction	
	VIF	1/VIF	VIF	1/VIF
Treat	4.331	.231	4.543	.22
Dummy Superbonus	14.624	.068	4.055	.247
Dummy*Treat	14.03	.071		
% of old	1.184	.845	1.392	.718
% of new	1.151	.869	1.331	.752
Price growth rate	1.021	.979	1.287	.777
% of new ads	1.288	.776	1.184	.845
% of sale	1.334	.75	1.15	.869
Average Price	4.56	.219	1.02	.981
Mean VIF	**4.836**	**.**	**1.995**	**.**

Table 15: VIF test on relative price, supply, and demand regression

The variance inflation test was conducted in order to control for potential multicollinearity issue. Despite difference-in-difference model with interaction treatment created some source of multicollinearity by construction of the interactions term, the test does not highlight potential issues. The test was conducted on the dynamic interaction terms so as to search for potential sources of multicollinearity not directly induced by the model construction. However, this does not allow for completely removing the induced multicollinearity which still persists within the estimates. Nevertheless, the multicollinearity between the individual terms shows no trace of potential sources of endogeneity. Indeed, the only variable exceeding the test is the interaction variable. Furthermore, for all regression, both in the dynamic and static equation, the standard error is relatively small and the confidence intervals do not show any risk of reversal correlation leading to the conclusion that the results confirm the implications of the proposed model.

	Delta	p-value	Delta	p-value	Delta	p-value
	6.427	0.000	10.253	0.000	6.506	0.000
adj.	7.065	0.000	11.256	0.000	7.142	0.000

Table 16: Testing for slope heterogeneity (Pesaran, Yamagata. 2008. Journal of Econometrics)
H0: slope coefficients are homogenous
Variables partialled out: constant

The null hypothesis of slope homogeneity is rejected. The test for slope heterogeneity confirms the finding of several variation across cross-sectoral units. This is in line with previous literature, as discussed in Chapter 2, and the main hypothesis of the paper. Indeed, the impact of the policy in the housing market is supposed to be different across the different areas due to the relative cost of refurbishment.

Variables:	**CD-test**	**p-value**	**Mean ρ**	**Mean abs(ρ)**
Price	19.552	0.000	0.04	0.19

Variables:	**CD-test**	**p-value**	**Mean ρ**	**Mean abs(ρ)**
Supply	1.212	0.225	0.00	0.19
Demand	5.093	0.000	0.01	0.20
Treat	218.939	0.000	0.40	0.44
Dummy Superbonus	421.769	0.000	0.82	0.82
% of old	12.621	0.000	0.02	0.26
% of new	0.342	0.732	0.00	0.29
Price growth rate	10.334	0.000	0.02	0.19
% of new ads	237.635	0.000	0.44	0.48
% of sale	159.205	0.000	0.29	0.40
Average Price	355.857	0.000	0.67	0.71

Table 15: Cross sectional dependence
Panelvar: id
Timevar: wave

Notes: Under the null hypothesis of cross-section independence, CD ~ N(0,1) P-values close to zero indicate data are correlated across panel groups.

Cross-sectional dependence highlights that common trends have been affecting the housing market. The results are somehow trivial considering that the impact of a policy in the city of Milan is being investigated; as a matter of fact, all neighborhoods will be affected by similar trends that originated at city level. In addition to policy there could be many other factors that simultaneously influence the trends of different neighborhoods. However, robustness tests have been introduced to check potential sources of bias in the model.

Additional robustness test:

HDFE Linear regression Number of obs = 4,789
Absorbing 1 HDFE group F(9, 133) = 54.21
Statistics robust to heteroskedasticity Prob > F = 0.0000
R-squared = 0.3369
Adj R-squared = 0.3314
Within R-sq. = 0.2063
Number of clusters (id) = 134 Root MSE = 0.2719
(Std. Err. adjusted for 134 clusters in id)

		Robust				
P_ratio	Coef.	Std.Err.	t	P>t	[95%Conf.	Interval]
Treat	1.187	0.088	13.520	0.000	1.013	1.361
Dummy Superbonus	-0.033	0.034	-0.960	0.337	-0.100	0.034
Dummy*Treat						
1	-0.104	0.052	-2.010	0.046	-0.206	-0.002
% of old	-0.127	0.122	-1.040	0.302	-0.369	0.115
% of new	0.325	0.076	4.260	0.000	0.174	0.476
Price growth rate	0.792	0.198	4.000	0.000	0.401	1.184
% of new ads	-0.002	0.000	-4.720	0.000	-0.003	-0.001
% of sale	0.011	0.005	2.260	0.026	0.001	0.021
Average Price	0.000	0.000	3.820	0.000	0.000	0.000
_cons	0.355	0.083	4.290	0.000	0.192	0.519

Absorbed degrees of freedom:

Absorbed FE	Categories	- Redundant	= Num. Coefs
V_ric_id_macro	32	0	32

Table 16: Price equation – clustered standard errors and macro-area fixed affect (MWFE estimator converged in 1 iterations)

Note: Clustered standard errors are included in the regression so as to account for multicollinearity and reduce potential sources of bias. Furthermore, they allow one to deal with cross-sectional dependence. The results deriving from the main regression confirm the original findings. Furthermore, the model included macro-area[17] fixed effect. This will allow to control for potential omitted variable bias which has not been taken into account from the other control originally included in the model.

P_ratio	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Treat	1.166	.082	14.19	0	1.005	1.328	***
Dummy Superbonus	-.021	.034	-0.63	.527	-.087	.045	
Dummy*Treat 1	-.125	.053	-2.38	.017	-.228	-.022	**
% of old	-.177	.119	-1.49	.137	-.41	.056	
% of new	.204	.08	2.55	.011	.047	.36	**
Price growth rate	.804	.192	4.18	0	.427	1.181	***
% of new ads	-.002	0	-4.80	0	-.003	-.001	***
% of sale	.015	.006	2.41	.016	.003	.026	**
Average Price	0	0	5.14	0	0	0	***
Constant	.403	.083	4.85	0	.24	.565	***
Constant	-2.632	.116	.b	.b	.	.	
Constant	-2.632	.116	.b	.b	.	.	
Constant	-1.335	.037	.b	.b	.	.	

Mean dependent var	1.363	SD dependent var	0.332
Number of obs	4789	Chi-square	547.932
Prob > chi2	0.000	Akaike crit. (AIC)	1060.353

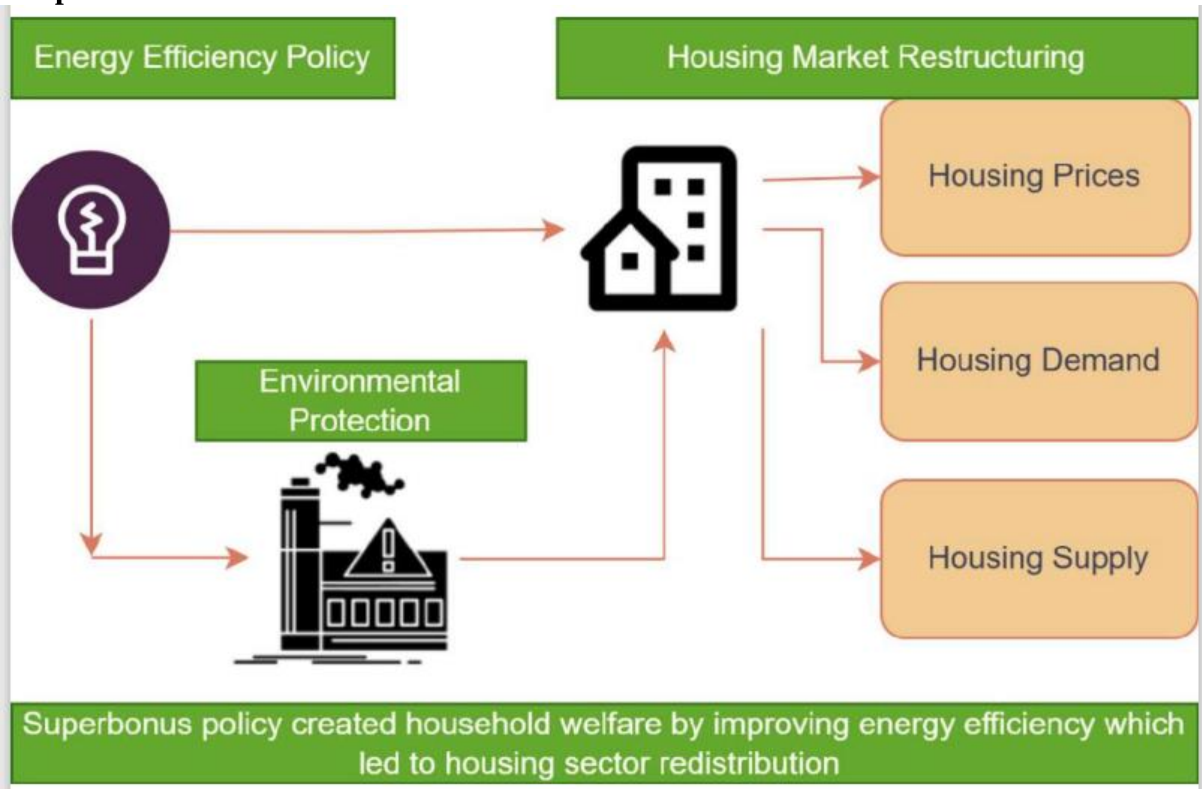
*** *p*<.01, ** *p*<.05, * *p*<.1

Table 17: Mixed effect regression

Note: The table provides Mixed Effects model regression that combines both fixed and random effects. The random effects adjust the intercepts (and potentially slopes) to account for unobserved heterogeneity at different levels. Since random effects allow to take into account for unobserved heterogeneity across clusters (in this case micro and macro areas in the city of Milan) it is particularly useful, as a robustness test, to show that the interaction variable preserve the same coefficient and statistical significance after accounting for other potential sources of heterogeneity in the relationship between the predictors and the outcome variable across groups.

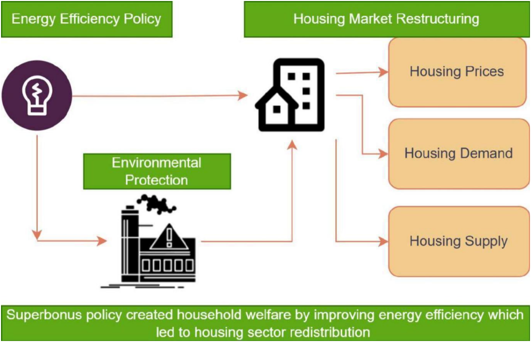
[17] Macro-area includes, on average, five micro areas which are the subject of this analysis (id).

Graphical abstract

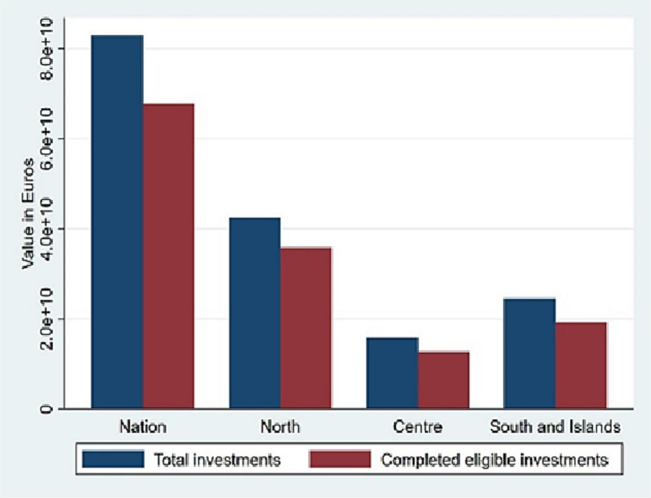


Highlights:

1. Superbouns were introduced in 2020 to improve housing energy efficiency in Italy.
2. Difference approach was used in HDFE estimator at a neighborhood level.
3. Superbonus increased housing prices by 16.1%, supply by 19.8% and demand by 12.3%.
4. Housing energy efficiency policy had led to housing redevelopment for environment.

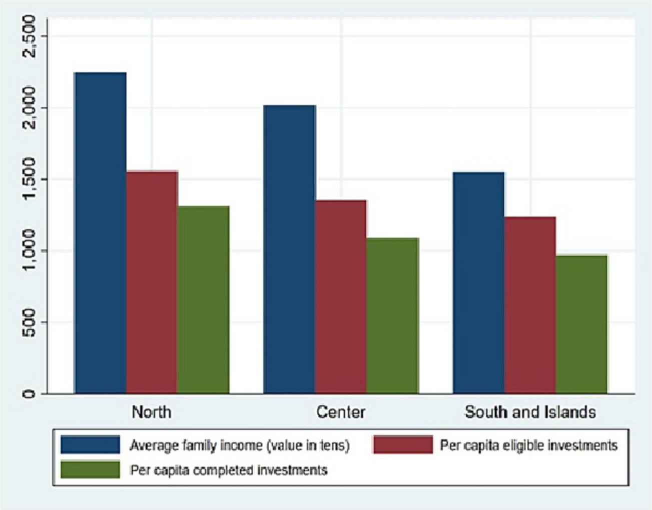


Graphics Abstract



Value in Euros
0
2.0e+10
4.0e+10
6.0e+10
8.0e+10
Nation
North
Centre
South and Islands
Total investments
Completed eligible investments

Figure 1



2,500
2,000
1,500
1,000
500
0
North
Center
South and Islands
Average family income (value in tens)
Per capita eligible investments
Per capita completed investments

Figure 2

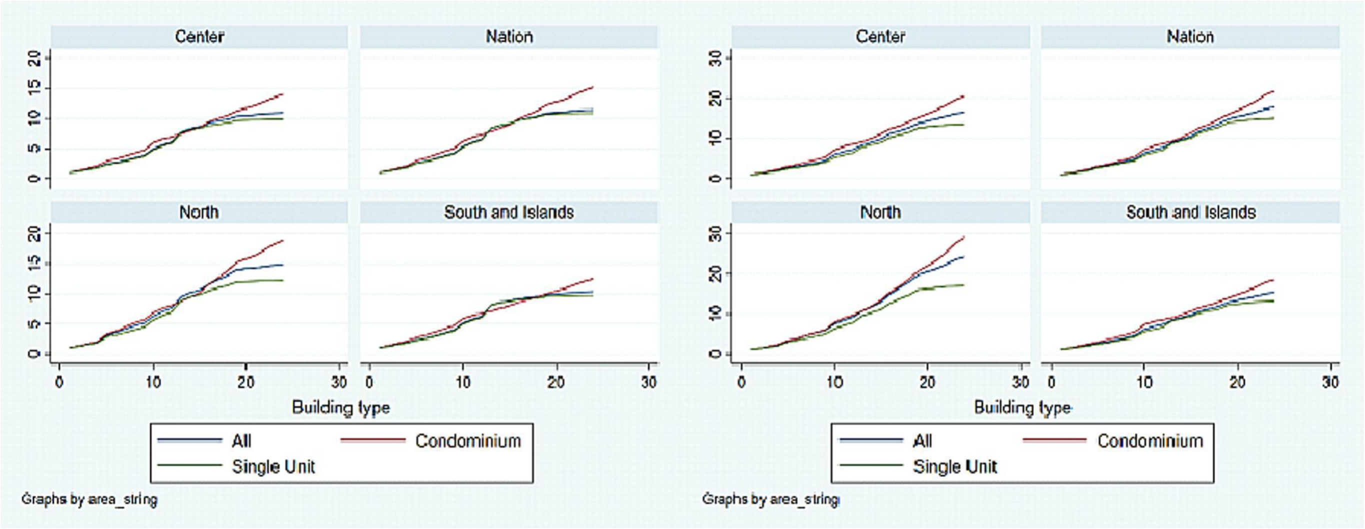

Center
Nation
North
South and Islands
Building type
All
Condominium
Single Unit
Graphs by area_string
Center
Nation
North
South and Islands
Building type
All
Condominium
Single Unit
Graphs by area_string

Figure 3

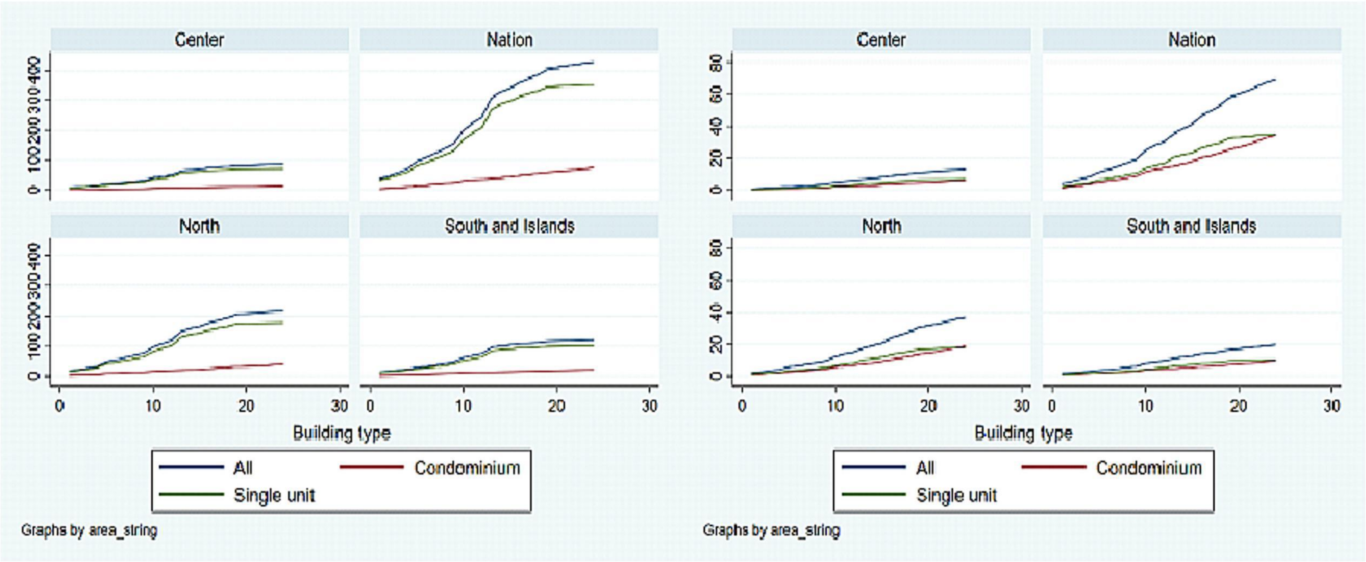

Center
Nation
North
South and Islands
0
100
200
300
400
0
20
40
60
80
0
10
20
30
Building type
All
Condominium
Single unit
Graphs by area_string

Figure 4

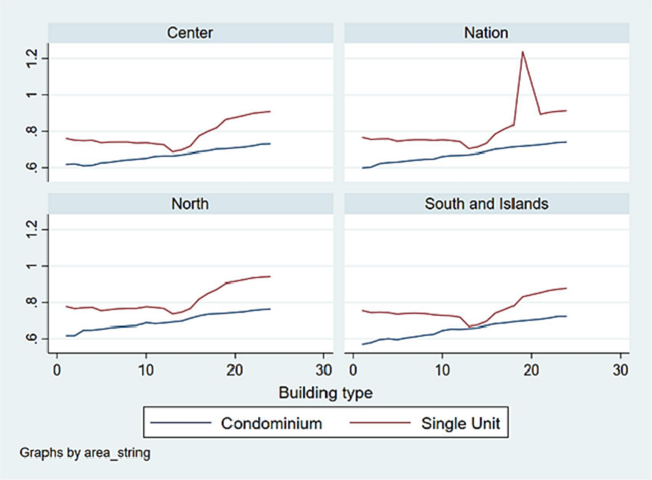
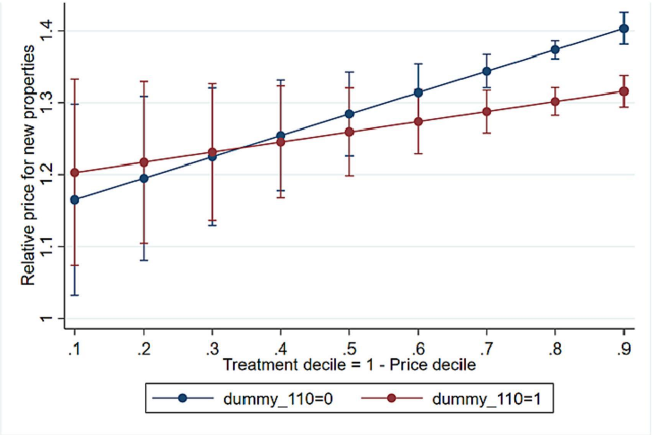
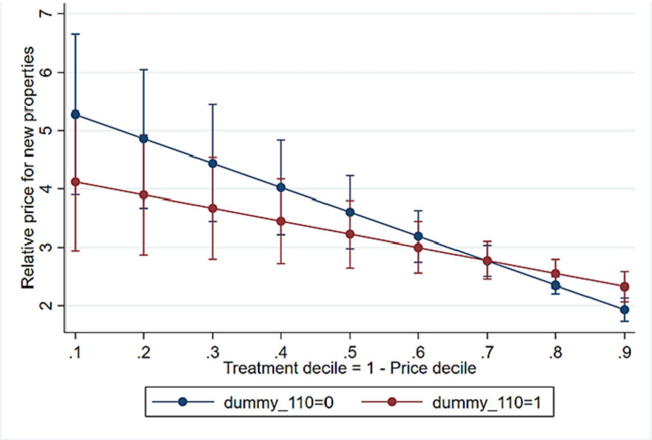

Center
Nation
North
South and Islands
1.2
1
.8
.6
0
10
20
30
Building type
Condominium
Single Unit
Graphs by area_string

Figure 5



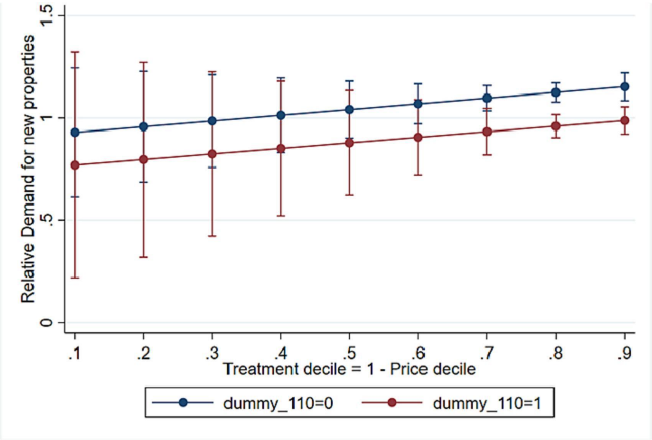
Relative price for new properties
1
1.1
1.2
1.3
1.4
.1
.2
.3
.4
.5
.6
.7
.8
.9
Treatment decile = 1 - Price decile
dummy_110=0
dummy_110=1

Figure 6



Relative price for new properties
2
3
4
5
6
7
.1
.2
.3
.4
.5
.6
.7
.8
.9
Treatment decile = 1 - Price decile
dummy_110=0
dummy_110=1

Figure 7



Relative Demand for new properties
0
.5
1
1.5
.1
.2
.3
.4
.5
.6
.7
.8
.9
Treatment decile = 1 - Price decile
dummy_110=0
dummy_110=1

Figure 8