# The Impact of Housing Quality on Health and Labor Market Outcomes: The German Reunification

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**Abstract**

Environmental hazards such as ambient air pollution and extreme temperatures have a significant impact on individuals' health and generate massive economic costs in industrialized countries. However, individuals spend on average 90% of their time indoors reducing their exposure to outdoor hazards. While economist and policy makers are certain that the provision of decent housing should lead to increased health and well-being, empirical evidence is largely missing or based on small scale experiments on poor households in developing countries. This paper studies the massive renovation wave in East Germany in the aftermath of the German reunification to contribute population-representative evidence on the impact of improved housing conditions on occupants' health and labour market outcomes in industrialized countries. During the 90s, the German government implemented several programs to modernize the East German housing portfolio. The largest program spent a total of €40 billion and renovated 3.6 million dwellings in East Germany. Using the German Socio-Economic Panel (SOEP) and applying an event study approach exploiting the exogenous variation in the exact timing of the renovation, we find that a major renovation of a dwelling significantly improves tenants' health outcomes, with no effect on labor market prospects. Sensitivity analysis with respect to time-varying unobserved factors confirm the robustness of the results.

**Keywords:** Housing quality, renovation program, health, labor market outcomes.
**JEL codes:** H54, I18, R38.

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# 1 Introduction

Human health and well-being are closely linked to environmental conditions. Pollution or extreme temperatures have been associated with increases in mortality rates, sick leave, school absences and ultimately health care costs (for a review, see for example Zivin and Neidell, 2013). While most of our understanding on how living environmental conditions affect health relies on outdoor measures, the average individual in industrialized countries spends over 90 percent of her time indoors. Indoor environmental conditions can differ dramatically from outdoors. Good insulation or heating systems can prevent individuals from being exposed to extreme temperatures, or good insulation from outdoor noise or pollution. Moreover, deficient, overcrowded dwellings have fueled the spread of diseases, and deterioration of mental and physical health of their occupants. Slum clearance, sanitation or provision of low-rent housing are just some examples of public health policy measures devoted to ensure healthy living standards in Western countries. While economist and policy makers are certain that the provision of decent housing should lead to increased health and well-being, the evidence on how indoor environmental conditions affect our health is rather scarce, mostly based on small-scale interventions and in developing countries where settings are often not applicable to the average dwelling in industrialized countries (e.g. cementing sandy floors or upgrading coal cooking stoves, see Cattaneo et al., 2009; Hanna et al., 2016).

This study contributes to this literature by providing, for the first time, evidence of a population wide upgrade in indoor living conditions using the largest renovation wave in modern history not precedented by a war or natural disaster. In fact, we consider the case of the German reunification and exploit the large renovation wave in East Germany in the 90s to learn about the impact of housing quality on occupants' health and labour market outcomes in industrialized countries. At the time of reunification, the conditions of the Eastern German housing portfolio was severely deficient, partly lacking basic amenities such as indoor toilets or modern heating systems. The German Federal Ministry of Transport, Building and Housing judged the East German housing portfolio in 1990 as the oldest real estate substance within developed, industrialized countries, with 52% of the dwelling constructed before 1945 (vs. 29% in West Germany), 40% of apartment buildings massively damaged and 11% were uninhabitable. The German government devoted significant financial resources to bring the housing portfolio in East Germany to western standards, providing subsidized loans and tax credits to the real estate industry to modernize existing and create new dwellings. Thereby, the main program, the *KfW-Wohnraum-Modernisierungsprogram*, allocated a total of €40 billion and renovated 3.6 million dwellings in East Germany (about 50 percent of existing dwellings). In addition, the reunification removed restrictive access to building materials and resources, which was a major cause for the poor housing conditions in the former German Democratic Republic. As a result, the significant gap in housing conditions between East and West Germany has been mostly removed at the end of the 20th century. We will exploit this exceptional period of renovations to generate exogenous variation in the probability to receive a renovation to estimate the causal impact of improved housing quality on occupants' health and labour market outcomes.

We use the German Socio-Economic Panel Study (SOEP) and apply an event study approach including individual and year fixed effects to explore the effects of reporting a major renovation of the dwelling on occupants' living conditions, health and labour market outcomes. We restrict the analysis to tenants in East Germany in the period right after the reunification, 1992-2002, where most of renovations of dwellings were executed as triggered by the general need for renovation of the East German housing portfolio and large governmental support. Given these sample restrictions and conditional on the individual fixed effects, we argue that the remaining variation in the probability to receive a renovation as a tenant is exogenous given the large renovation wave during this time-period. The results of a falsification test within the event study approach as well as other sensitivity tests (including specification tests as well as an alternative IV strategy) support the validity of the identifying assumption.

In a first step, we show that reporting a renovation significantly reduces the probability to report that the dwelling is in need for renovation. This is a key finding because it (i) first suggest a high consistency and reliability of the data (measurement error), and (ii) second confirms a real impact of the treatment on the quality of the dwelling which is a necessary condition in order to being able to identify impacts on health outcomes. Based on this finding, we proceed with estimating the impact on health outcomes and find a significant improvement in objective health status of the tenants as reflected by a reduction in days sick leave. The effect heterogeneity analysis shows that the positive health effects are driven by women. Female tenants receiving a renovation report higher subjective health as well as a reduction in hospital visits and days sick leave, while we find no significant effects for men. We further show for women that the reduction in days of sick leave associated with the renovation is larger in cold years. This evidence suggests that women are more vulnerable with respect to housing conditions, and a major renovation apparently improves their health significantly. Finally, we do not find support that the positive health effects translate into improved labor market outcomes as suggested by the economic literature (Currie and Madrian, 1999; Stephens and Desmond Toohey, 2018).

This paper is organized as follows: Section 2 summarizes the key literature related to environmental conditions on health. Section 3 describes the housing conditions in East Germany at the time of the reunification and explains the governmental renovation programs in the 90s to modernize the East German real estate sector and its outcome. Section 4 presents the data used for the empirical analysis, describes the estimation sample and defines the variables of interest. Section 5 explains the estimation strategy including a discussion on the justification of the identifying assumptions. Section 6 presents the results and Section 7 concludes.

## 2 Literature

Environmental conditions play a crucial role in shaping human health and well being. Air pollution or extreme temperatures cause serious damages to human cardiovascular or respiratory systems. An increasing body of large-scale quasi-experimental studies has documented significant societal costs associated with such hazards in the form of mortality rates, demand for health care services, and lower life satisfaction. In particular, sharp variations in air pollution has been related to significant increases in infant mortality rates (Currie and Neidell, 2005), (low) birth weights (Currie and Neidell, 2005), school absence (Currie et al., 2009) hours of sick leave (Hanna and Oliva, 2015), and respiratory and heart-related hospital admissions (Schlenker and Walker, 2016) even at relatively moderate levels. Similarly, extreme temperatures and its effects on cardiovascular systems are associated with mortality rates and health status along a variety of health measures (Deschênes and Greenstone, 2011; Deschenes, 2014; Barreca et al., 2016).

The exposure to harsh environmental condition affects individual well-being beyond their health. Exposure to extremely hot temperatures or air pollution during testing time has been associated with intimidate drops in average scores of young adults (Ebenstein et al., 2016; Park, 2017). Similarly, sharp variations in air pollution has been associated with drops in labour performance in a variety of economic sectors, such as agriculture (Zivin and Neidell, 2012), pear packers (Chang et al., 2016a), call centres (Chang et al., 2016b), or individual investor behaviour (Meyer and Pagel, 2017). These estimates cover both blue-collar and white-collar sectors and multiple areas of the world such as the U.S., Europe or China.

Individuals or households do not necessarily remain passive towards the environmental hazards, but take multiple actions to avoid or reduce their exposure to health-detrimental environmental conditions. Housing is a key instrument for people to protect themselves against environmental hazards. Evidence from housing markets shows that households are willing to pay a premium to live in neighborhoods with cleaner air or to stay away from different sources of air pollution such as toxic plants Chay and Greenstone (2005); Currie et al. (2015). In addition, individuals trade outdoor by indoor leisure to reduce their exposure, spending even more time indoors in highly polluted or on extremely hot days (Neidell, 2009; Zivin and Neidell, 2014). Furthermore, the literature provides evidence of the effectiveness in mitigating the death-full impact of such hazards. Barreca et al. (2016) show the spread of air conditioning across US residences was associated with a remarkable decline in the number of deaths linked to extreme temperatures, helping occupants to reduce the exposure.

Most of the existing literature focuses on outdoor or ambient air pollution, traditionally disregarding indoor environments. Surprisingly little is known about the indoor environmental conditions on occupants' health and productivity. The average individual in a Western society spends more than 90 percent of her time indoors, most of it at home (Klepeis et al., 2001). Moreover, the U.S. Environmental Protection Agency (EPA) documents significant differences in pollutant concentrations between indoors and outdoors - up to 5 times higher concentration indoors.

There is a lack of large scale representative quasi-experimental evidence on how housing conditions influence occupants' health and well being. Most of the studies in this are come from the epidemiological literature and is based on small-scale intervention studies linking specific dwelling deficiencies (e.g. mold) to occupant illnesses (e.g. asthma) (for a review of the literature see Thomson et al., 2009). Large scales studies are based on cross national surveys relating the health outcomes of individuals to their housing conditions (WHO, 2007).

Recent quasi-experimental research focusing on primitive housing in developing countries shows a significant impact of improvements in the indoor environment (e.g. flooring or electrification) on occupant health and quality of life. Assigning prefabricated houses improves the well-being of occupants, children's health, and reduces insecurity feelings of slummers in Latin America (Galiani et al., 2017). These papers tend to use existing renovation programs to explore how upgrades in housing conditions translate in better health and cognitive outcomes of the occupants. Cattaneo et al. (2009) explore the health benefits associated with a program cementing dirty floors in rural areas of Mexico, improving the cleanness and reducing the parasites in the houses part of the program. The authors show that significant improvements in mental and physical health of the occupants (i.e. parasites or diarrhoea). Similarly, the reduction in fine particulate matter ($PM_{2.5}$) generated by an electrification program in El Salvador led to significant improvements in the prevalence of acute respiratory infections among children (Barron and Torero, 2017).

However, these settings are hardly applicable to the general building stock in most developed countries (Cattaneo et al., 2009). In this paper, we aim at estimating the change in house conditions in a developed country, with starting conditions of the housing portfolio much closer to the average dwelling in Western societies nowadays. Furthermore, the housing programs explored in the existing evidence targets the poorest and most disadvantage stratus of society, challenging the external validity of the findings to other population groups. In addition, the influence of individuals' behaviour might introduce significant deviations in expected health gains (see for e.g. Hanna et al., 2016). In contrast to previous evidence, we aim to provide population representative evidence exploiting variation in indoor house conditions created by a wave in house renovations generated by a large-scale governmental loan program in East

Germany in the aftermath of the German reunification (1990-2000).

## 3 Institutional setting

On Nov 9, 1989 the Berlin wall came down and shortly afterwards on Oct 3, 1990 Germany was reunited. During the time of separation significant differences evolved in terms of economy, institutions, infrastructure and living conditions. East Germany experienced a massive improvement in these dimensions during the 90s, in particular due to strong financial support by West Germany. Although East Germany still lags significantly behind the West German economy (GDP, worker productivity etc.) at the end of the 20th century, infrastructure and living conditions are almost equalized compared to West Germany (Sinn, 2000).

Focusing on the housing portfolio, it can be stated that the differences between East and West Germany were quite significant at the time of the reunification. The closed planned economy in East Germany highly restricted the access to building materials and resources. In addition, there was limited capacity to maintain older buildings as the focus was on the construction of new industrialized building blocks to satisfy the high demand for dwellings. As a results, the German Federal Ministry of Transport, Building and Housing describes the East German housing portfolio at the time of reunification as the oldest real estate substance within the developed, industrialized countries (Federal Ministry of Transport and Housing, 2000). 52% of the dwelling were constructed before 1945 (vs. 29% in West Germany), where 40% of apartment buildings were massively damaged and 11% were uninhabitable. Table 1 provides a distribution of home amenities between East and West Germany at the time of the reunification. The numbers are based on a survey by the *German Federal Association of Housing Associations and Real Estate Companies* (GdW,*Bundesverband deutscher Wohnungs- und Immobilienunternehmen*) on housing associations and municipal housing companies in 1990 (figures for West Germany refer to 1987).[1] It clearly documents the significant lag of the East German housing portfolio compared to the West. Only 48% of the dwellings had access to a centralized heating system, compared to 75% in the West. Furthermore, it should be particularly emphasized that 26% (21%) of the dwellings did not even have a bathtub or shower (indoor toilet) corresponding to about 800,000 (600,000) dwellings. This implies sanitary issues and increases exposure time of occupants to outdoor conditions. The GdW (1990) concludes that the equipment of East German dwellings lags about 20 years behind the West German standard.

[Insert Table 1 about here]

[1] Housing associations and municipal housing companies owned 3.4 million dwellings which corresponds to ∼50% of all dwellings in East Germany at this time. The numbers are likely to represent an overestimation of the actual housing conditions given that housing associations and municipal housing companies predominately own younger and modernized buildings.

A major policy aim right after the reunification focussed on equalizing living conditions in East and West Germany (Sinn, 2000).[2] Therefore, the German government implemented one of the largest loan programs in history, providing significant financial means to encourage home owners to invest in their properties. The program consisted of reduced interest payments (and eased collateral conditions for public housing associations) and was implemented by the German public bank *KfW* (*Kreditanstalt für Wiederaufbau*). Accordingly, the program was called the *KfW-Wohnraum-Modernisierungsprogram* and its main aim was to incentivize the East German real estate industry to modernize their properties and hence to equalize living conditions in West and East Germany.[3] Between October 1990 and January 2000, a total amount of 79 billion DM (corresponds to 40 billion Euro) was allocated to private and public house owners to renovate existing or create new dwellings. The clear majority of the budget (71%) was used for renovations, while only 7% used to build new dwellings and 22% to increase energy efficiency of dwellings (see Reich, 2000). In total, 3.6 million dwellings have been renovated based on the program which corresponds to about 52% of all existing dwellings in East Germany at the time of the reunification.

In addition to this main program, the German government implemented other policies to stimulate the modernization of housing in East Germany: (i) There was another KfW program particularly focussing on the reduction of $CO_2$ emission providing subsidized loans to improve heating systems and insulation of buildings. It started in 1996 and covered only about 10% of the budget as the *KfW-Wohnraum-Modernisierungsprogram.* (ii) Federal states set up specific programs focussing on heritage-protected buildings, in particular in city centres (iii) In addition to the loan programs, the federal government introduced special tax amortization rules for the modernization and creation of dwellings. It allowed owners to deduct 50% of the expenses from taxation within the first 5 years. Lastly, it should also be mentioned that next to the monetary incentives set by tax rules and loan programs, the reunification abandoned the restricted access to resources (e.g. building material) due to abolishment of the closed planned economy system in the former German Democratic Republic.

As a result, the significant gap in housing conditions between East and West Germany has been mostly removed at the end of the 20th century. The GdW documents that 71% of all dwellings owned by housing associations and municipal housing companies were renovated until the end of 2000, while 24% are still in need for renovation and 5% do not need a renovation

[2] Among other reasons, a vast convergence of living conditions (in terms of wage level, housing etc.) was supposed to reduce the East-West migration. For instance, between Jan 1989 and Jan 1992, about 870,000 East Germans migrated to West Germany which corresponds to 5% of the entire East German population (Burda, 1993). After 1992, the internal migration went down and stabilized at around 140,000 to 180,000 per year.

[3] The subsidy consisted of a reduced interest rate of up to 3%-points below the capital market interest rate and was fixed for 10 years. The maximum amount was 400 Euro/m$^2$ with a maximum maturity of 25 years. Eligible were private an public owners modernizing their dwellings (sanitary installation, doors, windows, heating, insulation, elevators, noise protection, roofs etc) as well as creating new dwellings.

at all (Source: GdW Annual Statistic). Figure 1 shows the improvement of house amenities in East German dwellings over time. In 1998, Eastern dwellings converged to the Western standard with 78% having a centralized heating system. In terms of sanitary instalments, the gap reduced significantly to 92% having a bathtub or shower in the East compared to 98% in the West (GdW, 1999).

[Insert Figure 1 about here]

The massive renovation wave in the East during the 90s is also clearly visible in our estimation dataset (see section 4 for the data description). First of all, Figure 2 shows the share of households reporting a major renovation in their dwelling. For West Germany no change can be seen. The share remains stable around 5% over time. However, for East Germany the share increased from initially 5% in 1991 to its peak of 20% in 1997 and then converged back to West Germany in the mid of 2000s. The delayed start of the renovation wave in 1992 is mainly due to the ongoing privatization process of East German assets (including real estate) in the aftermath of the reunification (see Sinn, 1993, for a documentation of the privatization process after reunification). Ownership of real estate had to be clarified first before investments took place. Similarly, Figure 3 present the percentage of households reporting problems with the conditions of their dwellings. The figure shows a significant gap between living conditions between the East and the West. In early 1990s, the differences in proportion of household reporting their houses was in need for partial renovation between the East and the West was around 20% and the differences in the proportion of households reporting their houses were in need for full renovation was over 10%. The renovation programs implemented in Eastern Germany managed to reduced the gap to almost zero by the beginning of the $XXI$ century.

[Insert Figure 2 and 3 about here]

To sum up, during the first ten years after reunification, East Germany experienced a massive renovation wave of dwellings triggered by access to resources as well as significant governmental funding programs. We will exploit this exceptional period of renovations to generate exogenous variation in the probability to receive a renovation to yield causal identification in the empirical strategy.

## 4 Data and Descriptive Statistics

In order to estimate the causal effect of a major renovation of the dwelling on occupants' health and labour market outcomes, we use the *German Socio-Economic Panel (SOEP).* The SOEP is a yearly population representative longitudinal study of about 11,000 households and 30,000 individuals in Germany (Wagner et al., 2007) and contains detailed information on house conditions and renovations executed in the house over the year. The SOEP also includes extensive information about respondents' health status, and health care utilization, and their and socio economic characteristics.

The SOEP started interviewing German households in 1984, including those living in Western Germany. The inclusion of those households that were living in the region of the former GDR was in 1990, before the monetary and economic reunification were executed. For the analysis, we consider the period right after the reunification, 1992-2000 where most of renovations of dwellings were executed as triggered by the general need for renovation of the East German housing portfolio due to missing maintenance before reunification and large governmental support (see section 3). We include only the individuals that were part of the initial sample of the SOEP in Eastern Germany, since the refreshment of the sample took place in 1998, after most of the renovations were executed. In addition, we exclude the period before 1992 because of the availability of the question on the renovation and to avoid bias due to the ongoing privatization process of the real estate industry (Sinn, 1993). We further restrict the analysis to tenants in East Germany, since for tenants it is likely that the timing and type of renovation is exogenous in this time period, given their initial choice for residence (fixed effect). Finally, we observe 3,906 tenants in East Germany, resulting in 18,170 tenant-year observations.

## 4.1 Dwelling renovations

The definition of our treatment indicator, i.e., whether a household received a major renovation in a certain year, relies on a question on renovation activities that took place in their homes since the last interview. Each household has to categorize the renovation in the dwelling as the following categories: (1) installing a new kitchen, (2) bathroom, (3) heating system, (4) windows or (5) other. [4] In addition, respondents living in rental dwellings have to report whether (1) the respondent or (2) the owner paid for the reported modernization of the dwelling. Finally, every year the individuals have to evaluate the conditions of the maintenance of the house where they live as (1) In good conditions, (2) need for partial renovations, (3) need for full renovation, or (4) ready for demolition.[5]

Out of this information, we define a yearly binary treatment variable which takes the value of one if respondents report a modernization that was part of the targeted renovations in the

[4]The actual wording of the question was (in German): "Haben Sie oder Ihr Vermieter seit Anfang [Jahr] eine dieser Wohnung eine oder mehrere der folgenden Modernisierungen vorgenommen? • Eine Küche eingebaut • Bad, Dusche oder WC innerhalb der Wohnung eingebaut • Zentralheizung oder Etagenheizung eingebaut • Neue Fenster eingebaut • Sonstige größere Maßnahmen "

[5]The actual wording of the question was (in German): Wie beurteilen Sie den Zustand des Hauses, in dem Sie wohnen? • In gutem Zustand • Teilweise renovierungsbedurftig • Ganz renovierungsbedurftig • Abbruchreif

subsidized loan programs (i.e. heating, windows, bathroom or insulation[6]) and was paid by the landlord, and zero otherwise. Moreover, we create a binary outcome variable taking the value of one if the respondent reports that her house is in need for partial or full renovation.

### 4.2 Individual Health

The main focus of this paper is to investigate the impact of house renovations on individual health and well-being. The SOEP includes an extensive questionnaire on respondents' health status and their demand for health care, allowing us to measure the impact of the program on individual health using a range of indicators. Each respondent is asked to evaluate her own current health status on a 5-point Liker scale as: (1) very good, (2) good (3) satisfactory (4) poor (5) bad.[7]

In addition, every year participants are asked to report the number of times they visited the doctor in the three months before the date of the interview, and the number of hospital overnight stays in the year before the interview. Finally, each individual in the sample employed at the moment of the interview is asked to report the number of days that was on sick leave in the year before the interview.

### 4.3 Description of estimation sample

Table 2 shows the distribution of socio-economic characteristics among treated and non-treated households in the first year of our sample (1992), i.e., before renovations part of the governmental programs took place. The table shows no significant differences in age, gender, years of education, income, household members or construction year between the two groups before the renovation program. Similarly, there are no statistically significant differences in average health status or demand for health care between the two groups.

[Insert Table 2 about here]

### 4.4 Preferences for a renovated home

Before discussing the identification strategy, we first investigate individual preferences for upgraded housing quality. It is important to understand the moving pattern in our sample because it might affect the timing of the treatment. In fact, individuals can either receive the treatment (i) by remaining in their current dwelling and waiting until it is renovated, or (ii) by actively selecting into the treatment. This means individuals move to a different dwelling that was already

[6]The SOEP does not ask directly for renovation in the insulation of the building, however we use the category "other major parts of the apartment" as a proxy for such renovations

[7]The actual wording of the question was (in German): Wie wurden Sie Ihren gegenwartigen Gesundheitszustand beschreiben? • Sehr gut • Gut • Zufriedenstellend • Weniger gut • Schlecht

renovated or is going to be renovated in the near future. The selection into treatment might be endogenous and has to be to taken into account in the identification strategy.

In addition to the methodological aspect, the analysis of moving patterns is also interesting from a policy perspective. The literature has identified individual preferences for avoiding environmental health risks in the living environment (see, for example Chay and Greenstone, 2003). It has been shown that individuals are willing to pay a rent or price premium to limit or avoid the exposure to hazards such as air pollutants or lead (Billings and Schnepel, 2017). The question is whether such patterns are also visible in our sample.

To analyze individuals changes in address, rents, and dwelling conditions around the renovation year, we estimate the following regression:

$$Y_{it} = \gamma_i + \theta_t + \sum_{\tau=\tau_{min}}^{\tau_{max}} \lambda_\tau \mathbb{1}(t = t_0 + \tau) + \beta X_{it} + V_{it} \tag{1}$$

where $i$ denotes individuals and $t$ years. We use three different outcomes: $ChangeAddress_{it}$, $Rent_{it}$ and $NeedsRenov_{it}$. $ChangeAddress_{it}$ indicates the year individual $i$ moves to another dwelling in year $t$. In addition to observed socio-economic characteristics $X_{it}$ (income, age, education, working status), we include individual fixed effect ($\gamma_i$) as well as year fixed effects ($\theta_t$) to capture fixed unobserved individual and time characteristics. The variables of interest, $\mathbb{1}(t = t_0 + \tau)$ is a binary variable indicating the year $t_0 + \tau$ before or after the renovation. These effects are measured relative to the year the dwelling experiences the renovation $t_0$ ($\tau = 0$), which is excluded. The main coefficient of interest, $\lambda_\tau$, represents the effect of experiencing a renovation event in year $t_0$ on the probability of moving $\tau$ years later (or previously, for $\tau < 0$). Thus, the coefficients $\lambda_\tau$ reflect to what extent individuals' decisions to change address are influenced by the renovations. We consider a time window of 3 years before ($\tau_{min} = -3$) and after the renovation ($\tau_{max} = 3$).

[Insert Table 3 about here]

Column (1) in table 3 presents the changes in the probability of changing address in the years before and after experiencing a renovation in our sample period. The table indicates no existence of a selection of individuals into renovated houses, as indicated by the lack of significant (and positive) coefficients associated with the years prior to the renovation ($\tau < 0$)). In the years after the moving, the results indicate a marginal reduction in the probability to change address.

Similarly, we explore the concurrence of a renovation with a change in address, rent or dwelling conditions using the following empirical model:

$$Y_{it} = \alpha_i + \theta_t + \mu \mathbb{1}(t = t_0) + \beta X_{it} + V_{it} \tag{2}$$

where $\mathbb{1}(t = t_0)$ describes the occurrence of a renovation in the dwelling of individual $i$ in year $t$. The results presented in column (2) in Table 3 indicate that the individuals in our sample are not significantly more likely to report changes in address the year the renovation takes place in the apartment.

In addition, we investigate the changes in the rent associated with the renovation event. Here, $Rent_{it}$ describes the rent per square meter of the dwelling where individual $i$ lives in year $t$. In column (3) of Table 3, we explore the changes in rents in the year of renovation. We observed a positive change in the renovation year. The higher willingness to pay for the dwelling in the renovation year, along with the lack of sorting out of renovated apartment. This suggest that individuals do not select out of the renovation due to a potential increase in rents. Furthermore, individuals did not face economically significant increases in their rent after the move (0.22 Euro per $m^2$). Similarly, official reports indicate that due to subsidy payments to the real estate sector in the 90s in East Germany, the additional premium on the rent for modernized dwellings only amounted to 0.64 Euro per $m^2$ (Harris, 1998).

Finally, we examine whether the reported renovation indeed led to a significant improvement in living conditions. This is a necessary condition to hold in order (i) to show the consistency of the data and hence the reliability of the renovation information, and (ii) to have any meaningful impact on the relevant health outcomes considered in the analysis. We estimate Equation 1 where $NeedsRenov_{it}$ is defined as a dummy variable taking the value of one if the respondent $i$ reports that her house is in need for partial or full renovation in year $t$.

Column (4) in Table 3 presents the estimated change in dwelling conditions associated with the renovation, as described by the probability of assessing the current dwelling as 'in need for partial' or 'full renovation'. In the years immediately before and after the renovation (3 years after the renovation), there is a significant drop in the probability of reporting living in a house that is in need for partial or full renovations. The results indicate the perfect condition of the dwelling (no need for any renovation) sustains for up to 3 years after the renovation.

This evidence confirms consistency and reliability of responses to the questions on the occurrence of renovation and housing conditions. Moreover, it shows a real impact of the treatment on the quality of the dwelling which is a necessary condition in order to being able to identify impacts on health outcomes.

Column (5) in Table 3 displays the estimations of the separate coefficient in Equation 2. The result indicates the existence of a reduction in the probability of reporting the need of a renovation in the exact year of the renovation is completed.

## 5 Empirical Strategy

In order to estimate the causal impact of improved housing conditions due to a major renovation on occupants' health and labour market outcomes, we adopt an event study approach that exploits the temporal variation in the implementation of the renovation wave in East Germany in the 1990s (we adopted the event study approach, increasingly used by different empirical studies in the economics literature, see for example Lafortune et al., 2016). Our strategy is based on the assumption that individuals in our sample living in dwellings non (yet) renovated in a particular year form an useful counterfactual for dwellings that did experience a renovation, after accounting for individual fixed effects and common time trends. The key assumption in our study is that the exact timing of the renovation cannot be altered by the tenants considered in our sample and therefore is as good as random.

The main regression model estimates the effect of a renovation on the outcome variables for the period after the renovation takes place, using the following equation:

$$Y_{ijt} = \alpha_i + \theta_t + \lambda \mathbb{1}(t < t^*_{ij}) + \delta \mathbb{1}(t > t^*_{ij}) + \beta X_{ijt} + V_{ijt} \tag{3}$$

where $i$ denotes individuals living in dwelling $j$ in year $t$; $Y_{ijt}$ describes the outcome variables considered in the study. We discuss our particular measures in the next section. $\alpha_i$ and $\theta_t$ represent the individual and year fixed effects, respectively. The term $\mathbb{1}(t > t^*_{ij})$ represents a binary variable taking the value one if $t$ is larger than $t^*_{ij}$ which is the year before the renovation of individual $i$'s dwelling $j$ occurred; and is set to zero the period before the renovation and for individuals whose dwellings are never renovated during the study period. Figure 4 illustrates the exact timing of the empirical model. The coefficient $\delta$ describes the change in the outcome following the renovation event, relative to the year $t^*_{ij}$, which is excluded. We consider a time window of 3 years before and after the renovation. $X_{ijt}$ contains a set of time-varying socio-economic characteristics, i.e., income, age (and age square), education, ratio household members per room, occupational status and working hours. Standard errors are clustered at the household level.

[Insert Figure 4 about here]

Including $\mathbb{1}(t < t^*_{ij})$ allows for a falsification test for our identifying assumption that the exact timing of the treatment is random. If event timing is non-random this would imply that treated individuals differ from non-treated independent of the treatment. In this regard, $\lambda$ identifies the change in outcome variables between treated individuals in the years before treatment and non-treated individuals in these years. Therefore, $\lambda = 0$ would support the validity of the identifying assumption (random timing of treatment), and exclude any anticipation effects of the treatment. In fact, we find that $\lambda$ equals zero for all health and labor market outcomes.

In addition, we estimate a more flexible model where we do not impose the functional form in the pre and post trends to be linear:

$$Y_{ijt} = \alpha_i + \theta_t + \sum_{\tau=-2}^{-1} \lambda_\tau \mathbb{1}(t = t^*_{ij} + \tau) + \sum_{\tau=1}^{3} \delta_\tau \mathbb{1}(t = t^*_{ij} + \tau) + \beta X_{ijt} + V_{ijt} \tag{4}$$

Equation 4 is identical to our main estimating equation (eq. 3), except that we replace the single indicator variables for the pre ($\mathbb{1}(t < t^*_{ij})$) and the post trend ($\mathbb{1}(t > t^*_{ij})$) with a set of indicators $\mathbb{1}(t = t^*_{ij} + \tau)$ indicating the years before and after the reference year $t^*_{ij}$. For instance, $t^*_{ij} + 1$ indicates the first year right after the renovation (see Figure 4). The effects described by $\delta_\tau$ measure the effect of the renovation on outcomes $\tau$ years later, relative to the reference year $t^*_{ij}$ (which is excluded).

By applying a fixed effect approach, the model controls for selection into renovation based on unobserved but fixed individual characteristics. In order to yield causal estimates, this requires that there are no other time-varying unobserved factors which are jointly correlated with the selection into renovation and outcome variables. This implies that conditional on the individual fixed effects, i.e., tenants' choice for their residence, the exact timing of the renovation must be exogenous. We argue that this assumption is particularly plausible in our observation period given the massive renovation wave in East Germany as triggered by governmental support in the aftermath of the reunification as described in Section 3. The clear majority of dwellings was in need for renovation at the time of reunification and were renovated during the first ten years thereafter. Figure 2 clearly shows the exceptional increase in the probability to receive a renovation in East Germany in the 90s compared to West German citizens. It has also to be emphasized that the governmental financial support to renovate was paid to the owner who actually determines the need and timing of renovations. These settings in the 90s in East Germany make it likely that the exact timing of the renovation is as good as random for tenants. This is supported by the estimation results where we find that $\lambda$ equals zero for all health and labor market outcomes which we interpret as a very strong indication that our identifying assumption holds (see the discussion on the falsification test with equation 3 above).

However, there might be still concerns about potential threats to our identification strategy which are discussed in the following. The first point addresses the potential existence of time-variant unobserved individual characteristics. Individuals could self-select into the renovation by moving into dwellings that are planned to be renovated in the near future. Section 4.4 indicates a lack of significant changes in moving patterns around the renovation. However, in order to avoid that systematic movers bias our results, we only include in our estimation sample the years the individual is living in the exact dwelling that got renovated as part of the renovation wave.

Another concern with respect to time-variant unobserved individual characteristics might be that, for instance, tenants have power to influence the owner's renovation decision as this might be correlated with our outcome variables and hence bias the results. However, this is unlikely to occur given that 91% of tenants in East Germany live in buildings with three or more apartments usually operated by larger housing associations or municipal housing companies (German Federal Statistical Office, 2003). This yields some anonymity in the relationship between tenants and owners reducing the potential influence of tenants on the renovation decision of dwelling owners.

Third, there might be time-varying unobserved regional factors simultaneously affecting the probability to receive a renovation and the outcome variables. For instance, it might be the case that renovations in a certain region coincide with an overall regional investment in infrastructure, e.g., hospitals, roads, public transport etc. We include additional time-varying regional control variables in the empirical model to show the robustness of our results in this regard (see section 6.5).

# 6 Results

In this section we report the estimated effects using the empirical model as defined in Equation 3 on several outcome variables. In a first step, we provide evidence on the health effects of the renovations as reflected by the subjective health status, days sick leave and the demand for health care (doctor visits, hospital overnight stay) of tenants. Second, we aim to investigate whether the health effects also translate into differences in labour market outcomes as suggested by the economic literature (Currie and Madrian, 1999; Stephens and Desmond Toohey, 2018). Third, we consider effect heterogeneity with respect to gender, and explore the role of outside weather conditions as a potential mechanism for the health effects. To test the sensitivity of our results with respect to potential violations of the underlying assumptions (in particular with respect to time-variant unobserved factors), we provide the results of several specification tests as well as implement an alternative instrumental variable strategy in Section 6.5.

## 6.1 Effects of renovation program on subjective well being and health outcomes

This section contains our main results with respect to the impact of a renovation on tenants' well being and health outcomes. We use a wide set of satisfaction and health outcomes as provided by the data. Life satisfaction is measured by a 10-point Likert scale, where 0 denotes not satisfied and 10 very satisfied with life today. Health status is measured by a 10-point Liker scale, a measure of self-assessed health status and days on sick leave, and health care demand is based on the hospital overnight stays and visits to the general practitioner.

Column (1) and (2) in Table 4 describes changes in life satisfaction and health satisfaction. The results indicate no major changes in the satisfaction of individuals around the renovation event.

[Insert Table 4 about here]

Column (3) in Table 4 describes the changes in self-assessed health status, measured by a 5-point Likert scale where level 1 reflects very good and 5 poor. The results indicate no major changes in the perceived health status of individuals. Column (4) in Table 4 shows the changes in the probability of individuals' reporting bad or poor health before and after the renovation of their dwellings. The renovation event was not followed by a significant drop in the probability of reporting bad or poor health in the next three years.

Column (5), (6) and (7) in Table 4 show the effect of renovations on doctor visits, hospital visits and days of sick leave respectively. The table suggests that while the number of hospital visits and hospital visits were not affected, there is a significant drop in the years after the renovation. The individuals reported a significantly 1.8 lower number of days on sick leave after the renovation.

Table 5 shows the estimated coefficients for $\lambda_\tau$ and $\delta_\tau$ based on Equation 4, measuring the changes in health outcomes around the renovation event. The results are similar to those presented in Table 4, except that the significant effect on days sick leave disappears.

[Insert Table 5 about here]

### 6.2 Effects of renovation program on labor market outcomes

Table 6 presents the results of the effect of the renovation wave on labor market outcomes. The results indicate the absence of significant effects on the individuals' probability of being employed, the number of hours worked and the probability of being unemployed.

[Insert Table 6 about here]

### 6.3 Gender differences

Table 8 shows the differences in the estimated parameters from eq. 4 for the subsample of women and men differently. The results indicate that while there are no major differences in the perceived dwelling conditions between men and women (column (1) and (2)), there are differences in the objective indicators of health status. Column (6) shows a significant drop in the visits to the doctor in the years following the house renovation for women. Similarly, column (8) in Table 8 shows a drop in the number of days on sick leave the first year after the renovation of 1.6.

[Insert Table 8 about here]

### 6.4 Extreme temperatures and renovation wave

There is an increasing number of quasi-experimental studies that show the damaging effects of extreme temperatures on human health (see, for example, Deschenes, 2014). The exposure to extremely high or low temperature led to peaks in mortality and morbidity in recent history, via cardiovascular or respiratory failures (Barnett et al., 2012). Humans have developed different sources of adapting to extreme temperature environment, housing modification being one of the most effective sources over the past century. For instance, an new set of empirical evidence shows that the expansion of air conditioning in the residential building environment has been a major factor of damaging effects of heat waves (Barreca et al., 2016).

As figure 1 shows, the renovation wave increased the penetration of heating systems in East Germany after the reunification. The wave improve the protection of households in East against extremely cold temperatures. We estimate the following empirical model to explore the potential drop in the damage associated with cold temperatures associated with the renovation wave:

$$Y_{ijt} = \alpha_i + \delta \mathbb{1}(t > t_i^*) + \mu WinterTemp_{ijt} + \gamma \mathbb{1}(t > t_i^*) * WinterTemp_{ijt} + \beta X_{ijt} + \quad (5)$$

Where $WinterTemp_{ijt}$ describes the average winter temperature experienced by individual i in year t. To construct the annual measures of weather ($WinterTemp_{ijt}$) from the daily records of the Global Historical Climatology Network (GHCN). We select weather stations that have no missing records in any given year. The station-level data are then aggregated to the county level by taking a simple average of all the measurements from the selected stations that are located in a county. [8] For the construction of $WinterTemp_{ijt}$, we compute the average of the daily minimum in the winter season.

Table 9 presents the estimation results of the empirical model presented in section . Column (1)-(3) present the estimation results for the number of doctor visits for the full sample, Column (4)-(6) display the results for the number of hospital visits; and finally Column (7)-(9) display the results for the number of days on sick leave. Each model is estimated for the full sample, only women and only men sample, respectively.

The results suggest that the extreme temperatures have no impact on the number of GP visits, are positively associated with the number of visits to the hospital of both, men and women; and are unrelated to the number of days of sick leave. The estimates of the interaction between the average winter temperature and the renovation wave indicator (i.e. $\gamma$) suggest that the save in days of sick leave associated with the renovation is larger in cold years only for women.

### 6.5 Robustness Analysis

Using individual fixed effect analysis to estimate causal treatment effects requires the assumption that the endogenous selection into treatment (renovation) is based on unobserved but fixed individual characteristics. In Section 5, we argue that this is a valid assumption in our case due to the large scale renovation wave in East Germany after reunification (see Section 3). Although the baseline empirical model controls for time-varying individual characteristics such

[8] 95 percent of the counties only have 1 station, with a maximum of 5 stations for the county of Berlin

as income, age, education, ratio household members per room and working status, there might be still concerns that other time-varying but unobserved factors exist which are jointly correlated with the treatment and outcome variables, resulting in biased fixed effect results. For instance, (although unlikely) tenants' power to influence owners' decision to renovate might alter over time, or it might be the case that regional confounding factors such as parallel investments in health infrastructure coincide with treatment probabilities. The existence of such factors would violate the identifying assumption. In order to test the sensitivity of our results with respect to time-varying but unobserved confounding factors, we (i) first additionally include time-varying regional control variables in our empirical model, and (ii) second re-estimate our results using an alternative instrumental variable approach. In addition to overcoming the issue of time-varying unobserved factors, the IV strategy also addresses another typical concern with fixed effect analysis which is the sensitivity with respect to measurement error (due to self-reporting of the treatment variable). Although, we already provide evidence suggesting consistency and reliability of the data in Section 4.4, the IV strategy provides an additional prove whether measurement error significantly affects the results. Both strategies suggest robustness of our findings.

### 6.5.1 Time-varying regional characteristics

In a first step, we test the sensitivity of our results with respect to the existence of regional time-varying unobserved factors jointly correlated with the treatment and the outcome variables. Therefore, we include additional regional control variables $W_{ct}$ in our main regression model (see Equation 3). The regional indicators are measured on a yearly basis for each county $c$.[9] Given that we are concerned about parallel regional developments which might be jointly correlated with the treatment indicator and the outcome variables, such as investment programs in health infrastructure, environmental or economic regional development, we include the following control variables: population density, immigration and emigration rates, access to health facilities (regional density of general practitioners and hospitals), tax revenues, unemployment rate and labour market participation, and sales in construction sector. Unfortunately, the regional indicators are only available from 1995 onwards restricting the observation window from 1995 to 2002 (which is the main reason why we do not include $W_{ct}$ in the main regression analysis).

[Table tbc]

First results indicate the robustness of our main results. This makes us confident that time-variant regional unobserved confounding factors do not play a major role and more importantly, are not inducing a bias in our main results.

[9] East Germany consists of 77 counties based on the regional classification in 2012 (which we apply in our empirical analysis).

### 6.5.2 Alternative IV estimation

As a second robustness analysis, we apply an instrumental variable (IV) approach in order to learn about the sensitivity of our results with respect to a potential violation of the fixed effect assumption, in particular with respect to the existence of time-varying (individual) unobserved factors. In contrast to the previous exercise where we include additional regional control variables, the IV strategy follows a fundamentally different identification by generating explicit exogenous variation (as induced by the instrument) in the treatment variable. Given the validity of the instrument, the IV approach generates a quasi-experimental situation yielding a clear causal interpretation of the estimated coefficient. However, one has to be caution with directly comparing the IV results with those estimated based on the FE approach. This is because the IV strategy will identify local average treatment effects (LATE), i.e., the effect on those who take the treatment because of the variation in the instrument. In contrast, the FE approach yields average treatment effects for the entire population. Therefore, a difference in the estimated treatment effects using an IV approach or FE regression does not necessarily lead to the conclusion that the FE approach fails to identify causal treatment effects. Nevertheless, the IV results can be used as an indication to assess the reliability of the FE regression results, in the sense, that although the size of the effects might differ, they should not lead to completely different conclusions. This has to be kept in mind when interpreting the IV results, and in particular comparing them to our main FE regression results.

The instrumental variable approach exploits regional variation in the roll-out of the largest governmental loan program (*KfW-Wohnraum-Modernisierungsprogramm*, KfW program hereafter) in East Germany in the aftermath of the German reunification (see Section 3 for details). This variation is used as an instrumental variable for the individual probability to experience a major renovation (treatment). In order to identify the effects of this intervention, we take advantage of the regional variability in the implementation of the program (see Figure A in the Appendix). We have access to yearly loan take-up within the KfW program for counties in East Germany in the period 1992-2000 (Source: KfW). Based on this information, we construct the instrument $Z_{ct}$ as the yearly amount of the subsidy per inhabitant in county $c$:

$$Z_{ct} = Subsidy_{ct}/population_{ct} \tag{6}$$

[Insert Figure A.1 about here]

Given the scope and impact of the program, we argue that the instrument affects the individual probability to report a major renovation of their own dwelling. Tenants who live in a county with a relatively high loan intensity in a certain year are more likely to experience a renovation compared to tenants living in a county with a low intensity. The first stage results strongly support the relevance of the instrument. Furthermore, we do include county fixed effects in order to take potential endogenous selection of counties into account. Therefore, we use within county variation over time to identify the causal parameters. In such a setting, we argue that the exact timing of the renovation can be assumed to be exogenous to the tenant. Assuming validity of the instrument, we estimate the causal local average treatment effect $\delta$ using the two-stage least squares estimator (2-SLS, e.g. Angrist and Krueger, 1991):

$$Renov_{ijt} = \alpha_1 + \gamma_1 Z_{ct-2} + \gamma_2 Z_{ct-2}^2 + \beta_1 X_{ijt} + \eta_j + U_{ijt} \tag{7}$$

$$Y_{ijt} = \alpha_2 + \delta \hat{Renov}_{ijt} + \beta_2 X_{ijt} + \eta_j + V_{ijt} \tag{8}$$

where $Renov_{ijt}$ indicates whether individual $i$ living in dwelling $j$ at year $t$ reports a major renovation or not. $X_{ijt}$ denotes individual characteristics, $\eta_j$ county fixed effects and $Y_{ijt}$ the outcome variables. The instrument $Z_{ct-2}$ is used with two lags because of the time gap between loan approval and actual implementation of the renovation. In addition to the level of the instrument, we include a squared term $Z_{ct-2}^2$ to allow for a non-linear relationship between the instrument and the treatment indicator.

[Table tbc]

First results confirm the existence of the first stage, and show also positive health effects in the second stage.

# 7 Conclusion

There is extensive evidence on how outdoor environmental hazards lead to increase in mortality, ill health, and health care costs. However, the average individual in a modern society spends 90% of the time indoors, and the indoor environmental conditions can differ significantly to outdoors. The current evidence on how the indoor environmental conditions affect human health and well-being mainly relies on small scale intervention studies that are hardly applicable to the average dwelling in an OECD country.

We study the massive renovation wave in East Germany in the aftermath of the German reunification to contribute population-representative evidence on the impact of improved housing conditions on occupants' health and labour market outcomes in industrialized countries.

We use individual household panel data (SOEP) to explore the effect of the program on individual living conditions and health outcomes of Eastern Germans. Applying an event study approach including individual and year fixed effect, we observe a significant improvement in housing conditions and objective health status of the tenants as reflected by a reduction in days sick leave. In addition, we show that the positive health effects associated with a renovation are driven by women. Female tenants receiving a renovation report higher subjective health as well as a reduction in hospital visits and days sick leave, while we find no significant effects for men. We further show for women that the reduction in days of sick leave associated with the renovation is larger in cold years. Therefore, it seems that women are more vulnerable with respect to housing conditions, and a major renovation apparently improves their health significantly. Finally, we do not find indication that the positive health effects translate into improved labor market outcomes. Sensitivity tests confirm the robustness of our results with respect to the underlying assumptions.

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## Tables and Figures

Table 1: Home amenities in German dwellings at reunification in 1990

| | West Germany | East Germany |
|---|---|---|
| Central heating system | 75 | 48 |
| Centralized warm water system | 55 | 36 |
| Bathtub or shower | 97 | 74 |
| Indoor toilet | 98 | 79 |

*Source:* GdW Gesamtverband der deutschen Wohnungswirtschaft.
*Note:* Numbers are in percentages and based on a survey on housing associations and municipal housing companies in 1990 (figures for West Germany refer to 1987). They operate 3.4 million dwellings which corresponds to ∼50% of all dwellings in East Germany at this time.

Table 2: Descriptive statistics treated and non-treated households in the first year of the sample (1992)

| | Non Renovated ($N = 2152$) | Renovated ($N = 1754$) | p-value |
|---|---|---|---|
| Individual and household characteristics | | | |
| Years of education | 11.97 | 11.90 | 0.38 |
| Household income (in Euro/month) | 1353.13 | 1329.44 | 0.27 |
| Household members | 3.05 | 2.84 | 0.00 |
| Age of respondent | 42.27 | 42.77 | 0.40 |
| Female (1=yes) | 0.45 | 0.48 | 0.27 |
| Working (1 = yes) | 0.60 | 0.60 | 0.61 |
| Labor Income (in log) | 781.04 | 769.71 | 0.53 |
| Dwelling Characteristics | | | |
| Construction year | 1960.93 | 1959.25 | 0.23 |
| Monthly rent (in €) | 125.62 | 118.44 | 0.00 |
| In need for renovation (1=yes) | 0.77 | 0.78 | 0.23 |
| Health Outcomes | | | |
| Current health (from 1 very good to 5 poor) | 2.36 | 2.37 | 0.62 |
| Days sick leave | 7.14 | 7.86 | 0.53 |
| Doctor visits last three months | 2.12 | 2.29 | 0.16 |
| Number visits hospital | 1.16 | 1.28 | 0.79 |

*Note:* The table shows descriptive statistics for treated and non-treated individuals who are observable at the beginning of our observation window in 1992. P-value is based on a t-test on equal means.

Table 3: Change in address, rent per square meter and living conditions around the renovation

| | (1) Change Address (1=Yes) | (2) Change Address (1=Yes) | (3) Rent per sqm. | (4) Rent per sqm. | (5) Needs renov. (1=Yes) | (6) Needs renov. (1=Yes) |
|---|---|---|---|---|---|---|
| House Renovated$_{t_0}$ | | 0.00507 | | 0.228*** | | -0.149*** |
| | | (0.00494) | | (0.0390) | | (0.0148) |
| Year (1=Yes)$_{t_0+1}$ | -0.00977 | | 0.268*** | | -0.124*** | |
| | (0.00839) | | (0.0604) | | (0.0199) | |
| Year (1=Yes)$_{t_0+2}$ | -0.0180** | | 0.246*** | | -0.137*** | |
| | (0.00730) | | (0.0772) | | (0.0222) | |
| Year (1=Yes)$_{t_0+3}$ | -0.0114 | | 0.142 | | -0.126*** | |
| | (0.00775) | | (0.0923) | | (0.0271) | |
| Year (1=Yes)$_{t_0-1}$ | -0.00227 | | -0.329*** | | 0.204*** | |
| | (0.00717) | | (0.0578) | | (0.0213) | |
| Year (1=Yes)$_{t_0-2}$ | -0.000499 | | -0.301*** | | 0.158*** | |
| | (0.00815) | | (0.0653) | | (0.0270) | |
| Year (1=Yes)$_{t_0-3}$ | -0.00321 | | -0.291*** | | 0.167*** | |
| | (0.00751) | | (0.0760) | | (0.0279) | |
| Observations | 15,491 | 18,170 | 15,057 | 17,669 | 15,347 | 18,015 |
| Indivudal Fixed Effects | YES | YES | YES | YES | YES | YES |
| Year Fixed Effects | YES | YES | YES | YES | YES | YES |

*Note:* */**/*** indicate statistically significance at the 10%/5%/1%-level. Standard errors are in parentheses and clustered at the household level.

Table 4: Effect renovations on health outcomes in years before and after renovation

| | (1) Sat Living Today | (2) Satisfaction Health | (3) Current Health | (4) Bad Health (1=Yes) | (5) GP Visits | (6) Hospital Visits | (7) Days on Sick Leave |
|---|---|---|---|---|---|---|---|
| Post Renovation (1=Yes) | -0.0539 | -0.0276 | 0.00557 | -0.00219 | -0.0844 | -0.00739 | -1.834** |
| | (0.0508) | (0.0504) | (0.0230) | (0.0106) | (0.120) | (0.0539) | (0.840) |
| Pre Renovation (1=Yes) | -0.0258 | -0.0144 | 0.00747 | -0.0117 | -0.177 | -0.104 | -0.340 |
| | (0.0661) | (0.0637) | (0.0276) | (0.0133) | (0.156) | (0.0741) | (0.929) |
| Observations | 14,858 | 14,860 | 13,165 | 13,165 | 10,891 | 12,456 | 12,608 |
| Individual FE | YES | YES | YES | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Controls YES | YES | YES | YES | YES | YES | YES | YES |

*Note:* */**/*** indicate statistically significance at the 10%/5%/1%-level. Standard errors are in parentheses and clustered at the household level.

Table 5: Effect renovations on health outcomes in years before and after renovation

| | (1) Sat Living Today | (2) Satisfaction Health | (3) Current Health | (4) GP Visits | (5) Hospital Visits | (6) Days on Sick Leave |
|---|---|---|---|---|---|---|
| Year $t^* + 1$ (1=Yes) | -0.0123 | 0.0232 | 0.00139 | 0.127 | -0.0314 | -0.609 |
| | (0.0528) | (0.0544) | (0.0234) | (0.143) | (0.0552) | (0.909) |
| Year $t^* + 2$ (1=Yes) | -0.0315 | -0.0211 | 0.00578 | 0.142 | -0.0747 | -0.697 |
| | (0.0613) | (0.0679) | (0.0280) | (0.187) | (0.0722) | (0.905) |
| Year $t^* + 3$ (1=Yes) | -0.0955 | 0.00675 | 0.0546 | -0.0407 | 0.0648 | 0.111 |
| | (0.0778) | (0.0816) | (0.0332) | (0.163) | (0.0966) | (1.139) |
| Year $t^* - 1$ (1=Yes) | -0.00306 | -0.0351 | 0.0291 | -0.0968 | -0.0889 | 0.196 |
| | (0.0712) | (0.0654) | (0.0299) | (0.171) | (0.0739) | (0.905) |
| Year $t^* - 2$ (1=Yes) | -0.00974 | 0.0325 | -0.0326 | -0.0263 | -0.158 | 0.761 |
| | (0.0853) | (0.0895) | (0.0371) | (0.172) | (0.121) | (1.200) |
| Observations | 14,858 | 14,860 | 13,165 | 11,452 | 13,014 | 13,169 |
| Year FE | YES | YES | YES | YES | YES | YES |
| Controls YES | YES | YES | YES | YES | YES | YES |
| Indivudal FE | YES | YES | YES | YES | YES | YES |

*Note:* */**/*** indicate statistically significance at the 10%/5%/1%-level. Standard errors are in parentheses and clustered at the household level.

Table 6: Labor market outcomes

| | (1) Working (1=Yes) | (2) Hours Work per Week | (3) Unemployed (1=Yes) |
|---|---|---|---|
| Post Renovation (1=Yes) | 0.0140 | 0.484 | -0.00710 |
| | (0.0118) | (0.495) | (0.0129) |
| Pre Renovation (1=Yes) | 0.000771 | 0.491 | -0.00919 |
| | (0.0143) | (0.625) | (0.0156) |
| Observations | | | |
| Controls | 12,889 | 12,605 | 8,874 |
| Year FE | YES | YES | YES |
| Controls YES | YES | YES | YES |
| Indivudal FE | YES | YES | YES |

*Note:* */**/*** indicate statistically significance at the 10%/5%/1%-level. Standard errors are in parentheses and clustered at the household level.

Table 7: Effect renovation wave on percieved dwelling conditions and subjective wellbeing by gender

| | (1) Sat Living Today | (2) Satisfaction Health | (3) Current Health | (4) Bad Health (1=Yes) | (5) GP Visits | (6) Hospital Visits | (7) Days on Sick Leave |
|---|---|---|---|---|---|---|---|
| Post Renovation (1=Yes) | -0.033 | -0.069 | 0.042 | 0.007 | 0.053 | 0.059 | -0.133 |
| | (0.063) | (0.067) | (0.030) | (0.013) | (0.152) | (0.063) | (1.073) |
| Post Renovation (1=Yes) | -0.039 | 0.077 | -0.067* | -0.017 | -0.256 | -0.125 | -3.173** |
| * Female (1=Yes) | (0.066) | (0.085) | (0.037) | (0.015) | (0.192) | (0.095) | (1.316) |
| Observations | 14,297 | 14,303 | 12,605 | 12,605 | 10,891 | 12,456 | 12,608 |
| Controls | YES | YES | YES | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Pre trends YES | YES | YES | YES | YES | YES | YES | YES |
| Controls YES | YES | YES | YES | YES | YES | YES | YES |

*Note:* */**/*** indicate statistically significance at the 10%/5%/1%-level. Standard errors are in parentheses and clustered at the household level.

Table 8: Effect renovation wave on objective health measures by gender

| | (1) Needs Renov. (1=Yes) Male | (2) Needs Renov. (1=Yes) Female | (3) Doctor Visits male | (4) Doctor Visits Female | (5) Hospital Visits Male | (6) Hospital Visits Female | (7) Days on Sick Leave Male | (8) Days on Sick Leave Female |
|---|---|---|---|---|---|---|---|---|
| Year t (1=Yes) | -0.0539** | -0.0651*** | 0.152 | 0.0747 | 0.115 | -0.175** | 0.623 | -1.608* |
| | (0.0229) | (0.0207) | (0.203) | (0.191) | (0.0746) | (0.0780) | (1.625) | (0.920) |
| Year t+1 (1=Yes) | -0.0711*** | -0.0678*** | 0.179 | 0.0673 | 0.0464 | -0.191* | -0.734 | -0.558 |
| | (0.0273) | (0.0231) | (0.189) | (0.296) | (0.0807) | (0.102) | (1.385) | (1.193) |
| Year t+2 (1=Yes) | -0.0433 | -0.0399 | 0.162 | -0.239 | 0.120 | -0.00312 | 0.438 | -0.123 |
| | (0.0332) | (0.0270) | (0.201) | (0.233) | (0.101) | (0.150) | -1,772 | (1.664) |
| Year t-2 (1=Yes) | 0.161*** | 0.182*** | 0.109 | -0.264 | -0.135 | -0.0267 | -1.395 | 1.673 |
| | (0.0263) | (0.0222) | (0.261) | (0.223) | (0.0882) | (0.112) | (0.992) | (1.446) |
| Year t-3 (1=Yes) | 0.106*** | 0.115*** | 0.371* | -0.338 | -0.139 | -0.146 | -0.363 | 1.752 |
| | (0.0327) | (0.0289) | (0.210) | (0.293) | (0.151) | (0.179) | (1.429) | (1.789) |
| Observations | 6,913 | 7,865 | 5,348 | 6,104 | 6,096 | 6,918 | 6,159 | 7,010 |
| Controls | YES | YES | YES | YES | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES | YES | YES | YES | YES |
| Controls YES | YES | YES | YES | YES | YES | YES | YES | YES |

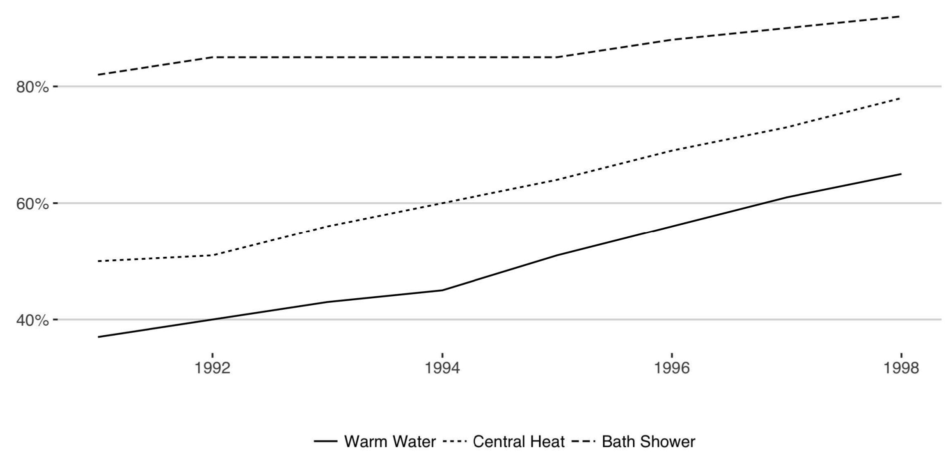
*Note:* */**/*** indicate statistically significance at the 10%/5%/1%-level. Standard errors are in parentheses and clustered at the household level.

Table 9: Winter temperature, renovation wave and health conditions

| | (1) Doctor Visits Full sample | (2) Doctor Visits male | (3) Doctor Visits Female | (4) Hospital Visits Full sample | (5) Hospital Visits Male | (6) Hospital Visits Female | (7) Days on Sick Leave Full sample | (8) Days on Sick Leave Male | (9) Days on Sick Leave Female |
|---|---|---|---|---|---|---|---|---|---|
| Post Renovation | 0.039 | 0.041 | 0.030 | 0.035 | 0.039 | 0.0481 | -1.664* | -1.667 | -1.633 |
| | (0.196 ) | (0.212) | (0.293) | (0.064) | (0.096) | (0.079) | (0.939) | (1.217) | (1.403) |
| Temp. Winter | -0.006 | -0.055 | 0.039 | 0.077*** | 0.064*** | 0.082*** | -0.083 | -0.476 | 0.226 |
| | ( 0.043) | ( 0.053) | (0.061) | (0.014) | (0.023) | (0.020) | (0.189) | (0.301) | (0.266) |
| Post Renovation | -0.116 | -0.093 | -0.142 | 0.003 | -0.043 | 0.045 | -0.322 | 0.578 | -1.048** |
| * Temp. Winter | (0.084) | (0.142) | (0.095) | (0.025) | (0.042) | (0.027) | ( 0.347) | (0.522) | (0.480) |
| Observations | 6036 | 2782 | 3254 | 6937 | 3208 | 3729 | 7004 | 3236 | 3768 |
| Controls | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Year FE | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Controls YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |

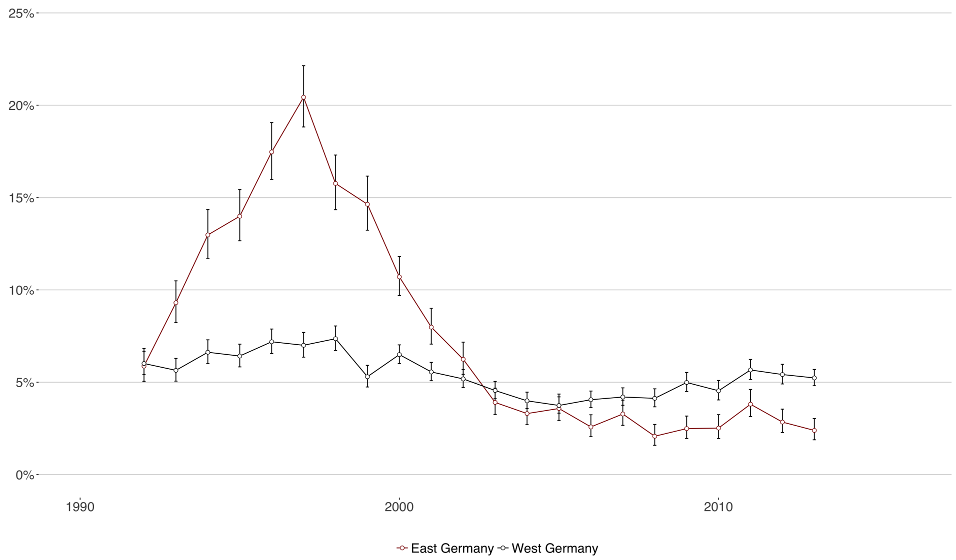
*Note:* */**/*** indicate statistically significance at the 10%/5%/1%-level. Standard errors are in parentheses and clustered at the household level.

Figure 1: Home amenities in East German dwellings over time



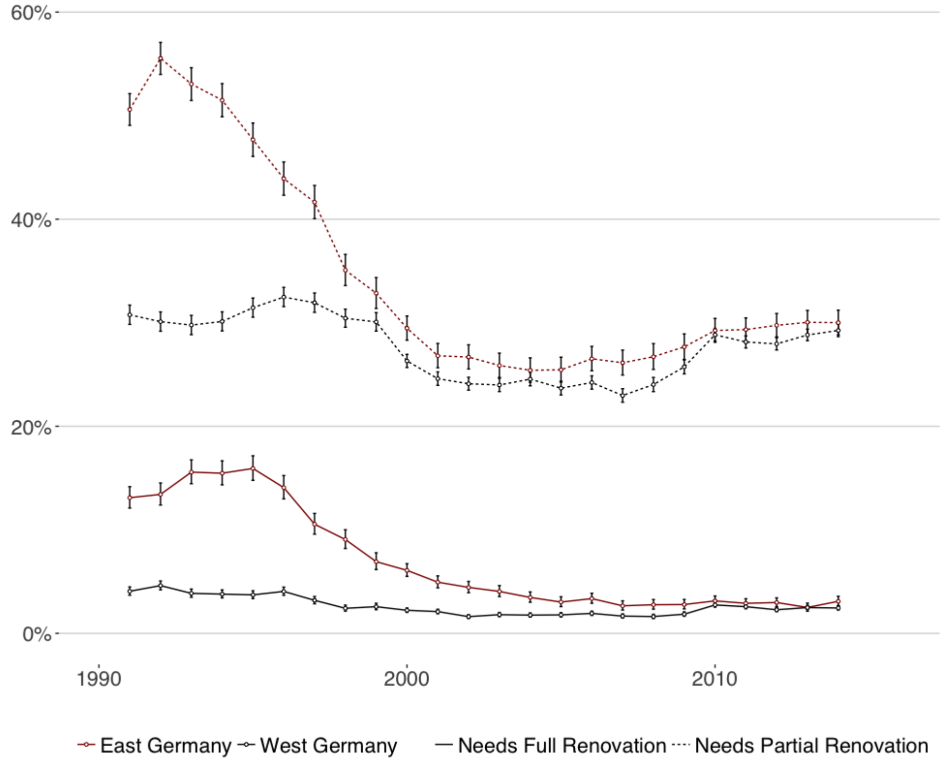

*Source:* GdW (1999).
*Note:* Numbers are based on a survey on housing associations and municipal housing companies.

Figure 2: Percentage of households reporting a renovation in Eastern and Western Germany



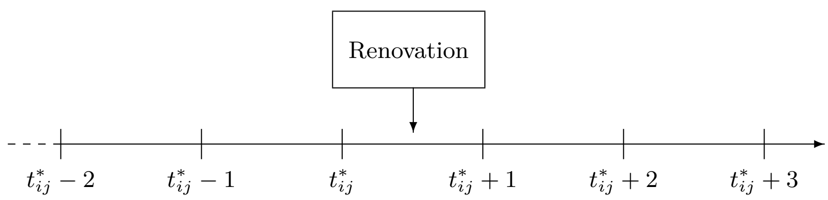

*Source:* SOEP, own calucations.

Figure 3: Percentage of households reporting in a dwelling in need for partial or full renovation in Eastern and Western Germany



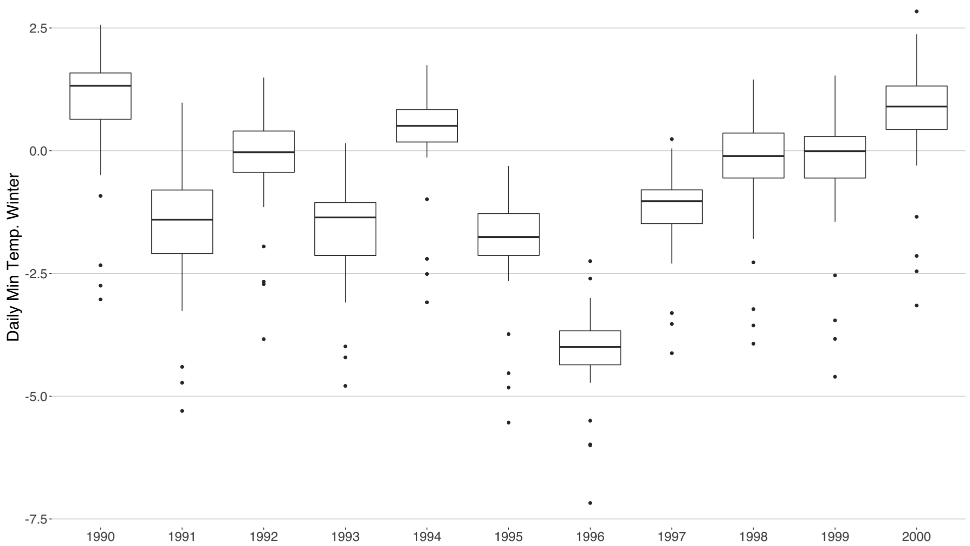

*Source:* SOEP, own calucations.

Figure 4: Timing of the empirical model




*Note:* The figure illustrates the exact timing of the empirical model.

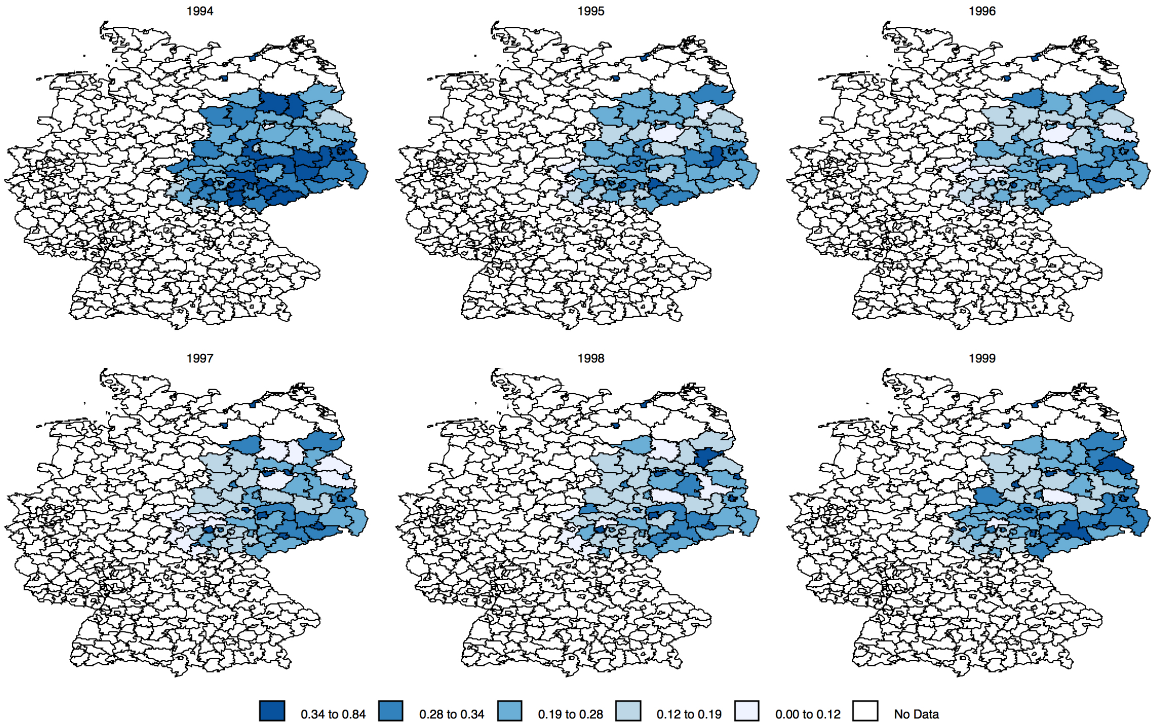
Figure 5: Daily temperatures in Eastern Germany during the sample period




*Source:* NOAA, own calucations.

# A Appendix

Figure A.1: Distribution Loan Take-up per Inhabitant Across Counties over Years of the Program




Note: Distribution of loan take-up per inhabitant in years 1992 and 1993 omitted for space limitations (available upon request).