From gas to green: a panel data analysis of heat pump adoption in 19 European countries

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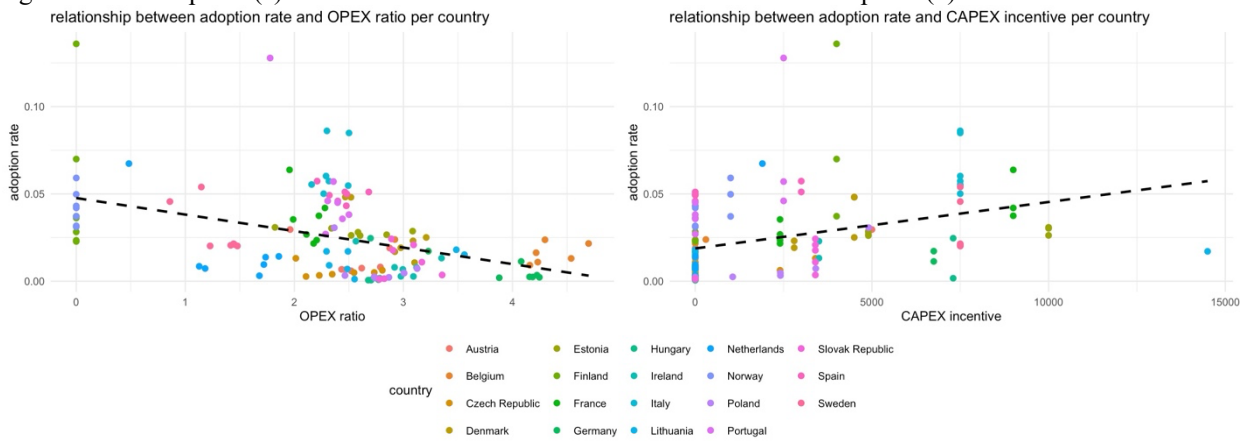
Overview

This study investigates the economic and environmental factors influencing household adoption of heat pumps across nineteen European countries from 2016 to 2022. Recognizing that economic barriers are a significant obstacle to the large-scale deployment of this green technology (Decker & Menrad, 2015; Hast et al., 2016; Rosenow et al., 2022), we focus on the role of financial incentives in driving household investment decisions. Specifically, this work examines the extent to which policymakers can encourage heat pump adoption by improving the electricity-to-previous-fuel price ratio (a proxy for expected operational expenses, OPEX) and reducing investment costs through CAPEX incentives.

Using panel data, we analyze the impact of these financial factors alongside macroeconomic indicators such as GDP and climatic variables like the number of cold weather days. We expect to find a positive relationship between the financial attractiveness of installing a heat pump and adoption rates, as preliminary scatter plots suggest (see Fig. 1).

Fig. 1 panel (a) panel (b)



Methods

The dataset contains panel data for nineteen European countries over seven years, compiled by Nowak & Westring, (2023). In the initial phase of this work, we employed static models to examine the factors driving heat pump adoption rates. Specifically, we used a two-way fixed effects estimator to focus on the effectiveness of financial drivers. This model includes country and year fixed effects to control for unobservable heterogeneity. Key explanatory variables include the electricity-to-gas price ratio and the introduction of heat pump-supporting CAPEX incentives. The results from the two-way fixed effects model were compared with those from separate estimations using only time-fixed or country-fixed effects, as well as with the pooled OLS estimator.

To address discrepancies between the trends observed in scatter plots and the results from static models, we plan to extend the analysis using dynamic models in the next phase of the work. A dynamic panel data approach, employing the Generalized Method of Moments (GMM), will be used to account for potential endogeneity in lagged adoption rates and explanatory variables. Additionally, interaction terms will be introduced to examine nuanced relationships, such as the potential for CAPEX incentives to have a stronger impact in lower-GDP countries and for climatic variables, such as cold weather days, to amplify the effects of both OPEX and CAPEX incentives.

Results

In the first phase of this work, the two-way fixed effects model did not yield significant results for the relationship between financial drivers (OPEX and CAPEX) and heat pump adoption rates. This lack of significance appears to stem from limited within-country variation in OPEX and CAPEX variables, as confirmed by country-specific plots. These plots indicate that variations in adoption rates are primarily driven by between-country differences, which the two-way fixed effects model excludes. For instance, countries with consistently low electricity-to-gas (E-G) price ratios tend to have higher heat pump adoption rates, while within-country fluctuations in E-G ratios do not significantly

influence adoption. This suggests that heat pump adoption is more strongly associated with stable, long-term favorable conditions than with short-term or uncertain changes.
By contrast, the time-fixed effects model produced low but significant results for both OPEX and CAPEX. The electricity-to-gas price ratio had an estimated effect of −0.0085, indicating that a higher E-G ratio somewhat reduces heat pump adoption rates. CAPEX incentives had an estimated effect of 1.07×10^{-6}, indicating a slightly positive relation between higher investment incentives and adoption rates.
In the next phase of this research, we aim to refine the OPEX proxy by accounting for the diversity of heating sources across countries, thereby reducing measurement errors and improving estimate precision. The results of this refined estimate will show us how households respond differently to financial incentives depending on their existing heating infrastructure. For instance, households transitioning from inefficient electric systems may benefit more from operational savings, while those switching from gas or oil heating might require larger financial incentives to offset upfront costs. Dynamic panel models incorporating lagged variables will be used to capture the persistence of adoption behaviors and the cumulative effects of financial drivers.

Conclusions

Preliminary findings indicate that household decisions to adopt heat pumps are influenced by both financial and practical factors. While financial drivers such as payback time and operational costs play a significant role, practical considerations – such as the availability of schooled heat pump installors, or the heat pump readiness of dwellings – should not be neglected.
Thus, to speed up the adoption of heat pumps, we need a thoughtful approach that pairs financial incentives with solutions to practical challenges and regional differences, ensuring that decarbonization efforts are both effective and accessible.

References

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