AN ECONOMETRICS ANALYSIS OF RESIDENTIAL ENERGY DEMAND FOR HEAT PUMPS: LESSONS FROM INTERNATIONAL EXPERIENCE

Sophia Kokoni

Surrey Energy Economics Centre, Centre for the Environment and Sustainability, University of Surrey

Outline

- Introduction
- Background
- Methods
- Results
- Conclusions

Introduction

Residential sector:

- The 4th most greenhouse gas intensive sector in the EU (followed by energy supply, industry and transport)
- Buildings: 40% energy consumption and 36% CO_2 emissions
- 35% of the EU stock is more than 50 years old
- 75% is energy inefficient
- Very low renovation rate 0.4-1.2% / year
- Emissions: 731 $mtCO_2equ.$ in 1990, 575 $mtCO_2equ.$ in 2016

Introduction

The EU legislation context

- The Energy Efficiency Directive
- Energy Performance of Buildings Directive
- Smart Financing for Smart Buildings Initiative in 2016

Introduction

Decarbonisation through electrification can:

- Increase energy efficiency
- Reduce energy consumption
- Reduce emissions
- Reduce energy bills

Background

Definition:

Heat pump is a device that extracts heat from a source of low temperature and it transfers it to a receptor of higher temperature. The low temperature source can be ambient air, the ground, ground water and other water bodies such as lakes, oceans and rivers. The usual receptors are indoors spaces e.g. a house (served by an individual unit) or whole buildings (served by a collective unit).

Background

Technical aspects

- Heat pumps are the reverse fridge
- Heat pumps work with electricity
- Renewable systems when SPF ≥ 2.5
- Desirable SPFs ≥ 3

Background

- Ground source and air source heat pumps are the two main types
- Heat pumps work more efficiently in well–insulated spaces
- The efficiency of a heat pump is measured by the coefficient of performance (COP) which is the ratio of the energy output (useful energy going to the receptor) to the energy input (heat from the source)

$$\text{COP} = \frac{\text{Energy output}}{\text{Energy input}} \text{ ,}$$

e.g. COP = 3 means that for one unit of energy input we get 3 units of energy as an outcome.

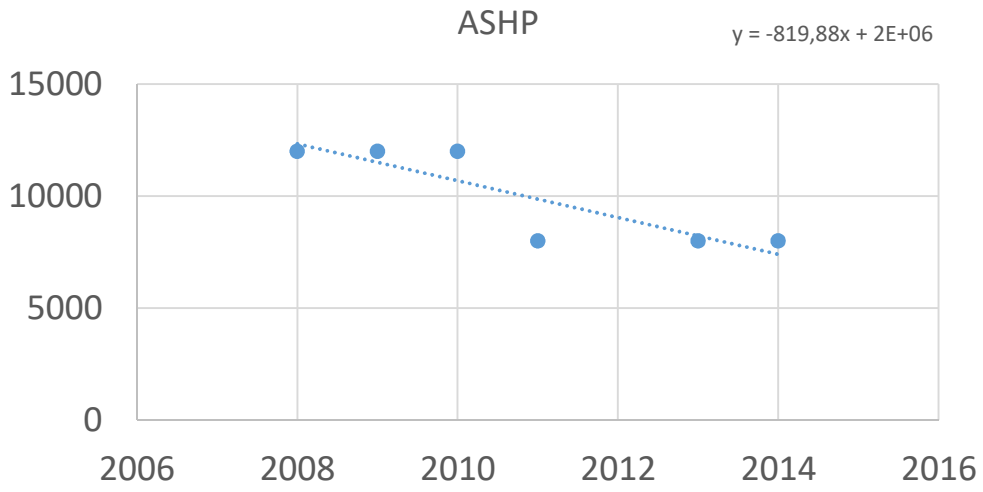
Background

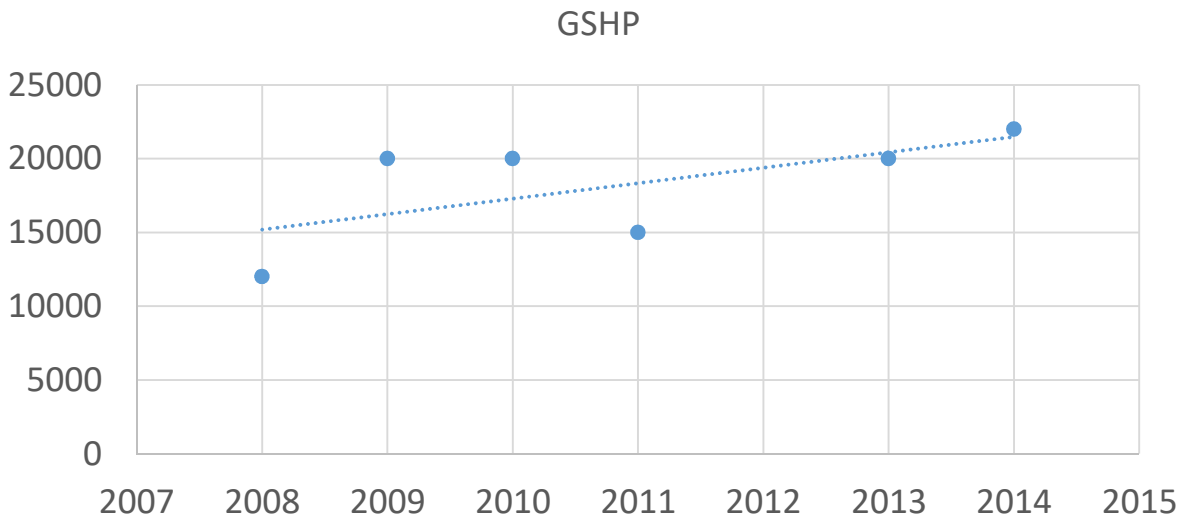
Markets

- Austria, Sweden and Switzerland the most developed markets
- Finland, France, Germany and Norway: fast growing
- United Kingdom: lacking behind. It's the youngest market (2000-2017)

Background

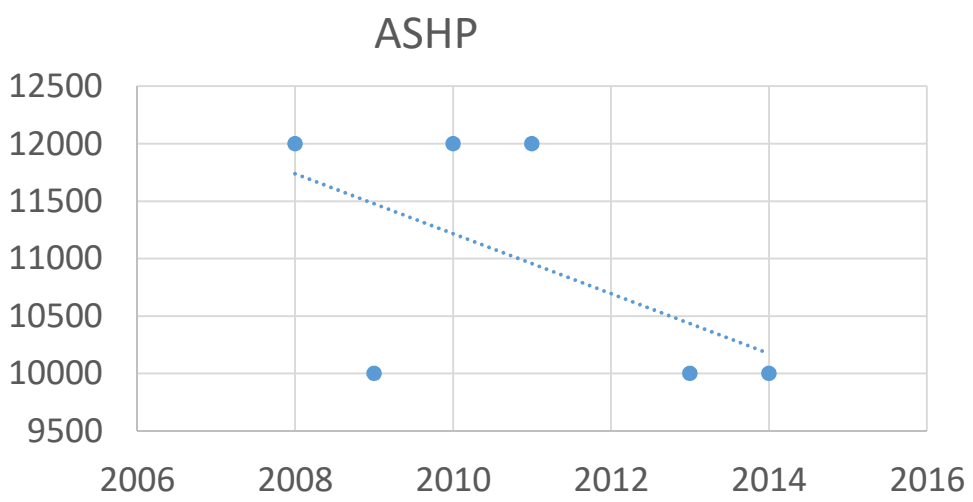
Capital cost (€): Finland

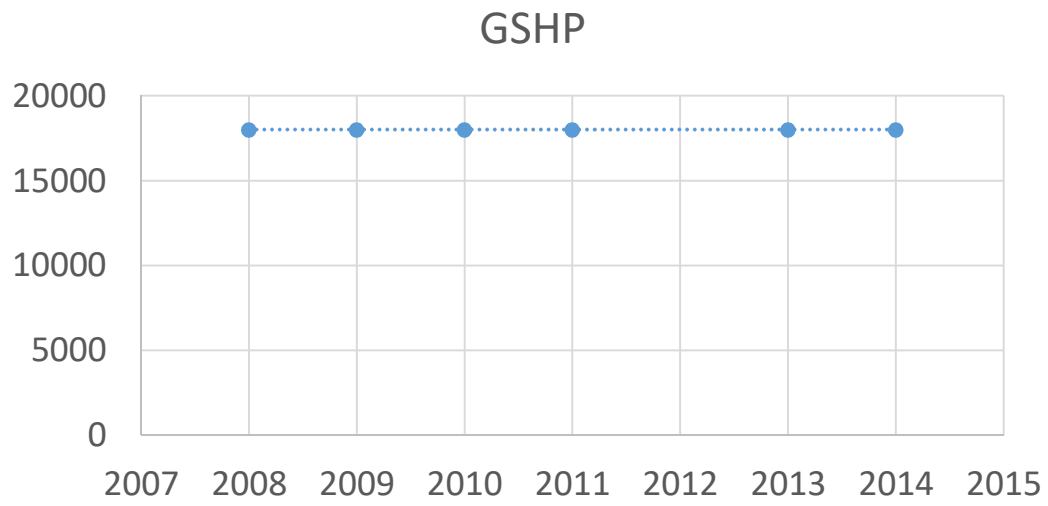




Background

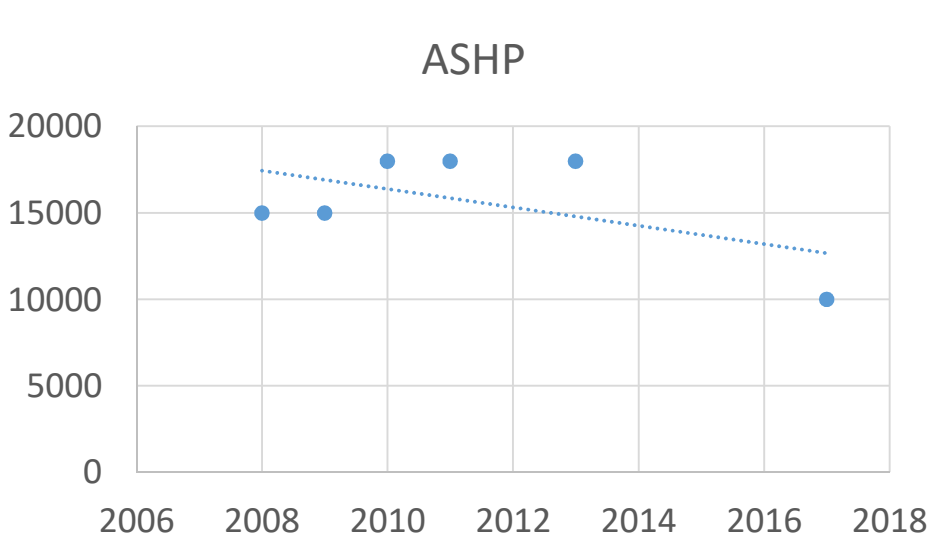
Capital cost (€): France

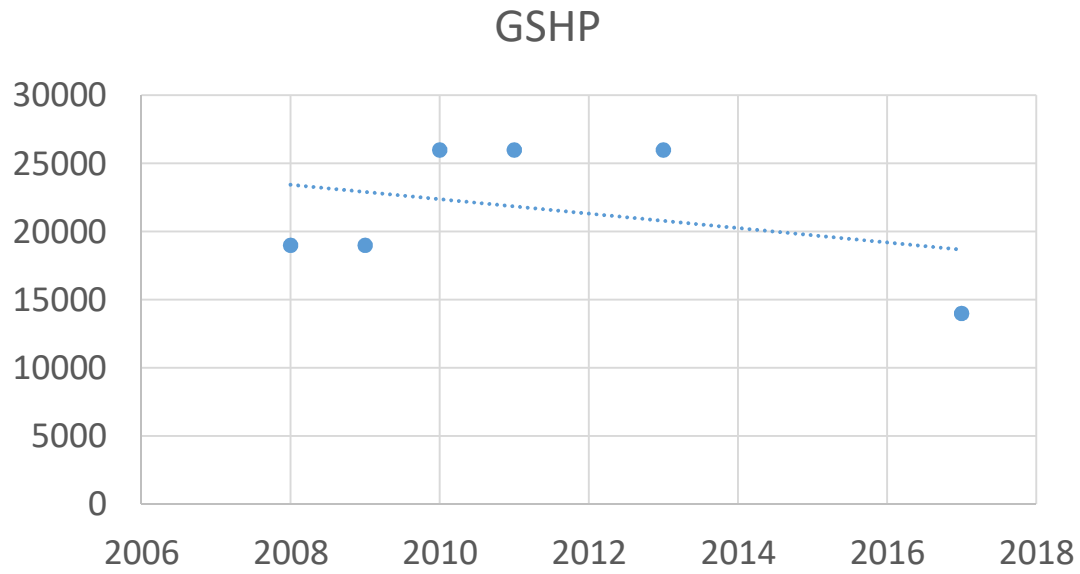




Background

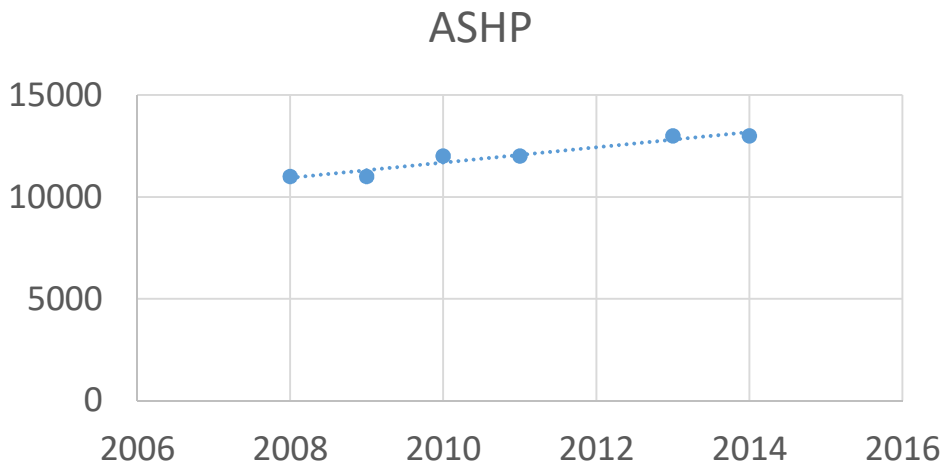
Capital cost (€): Germany

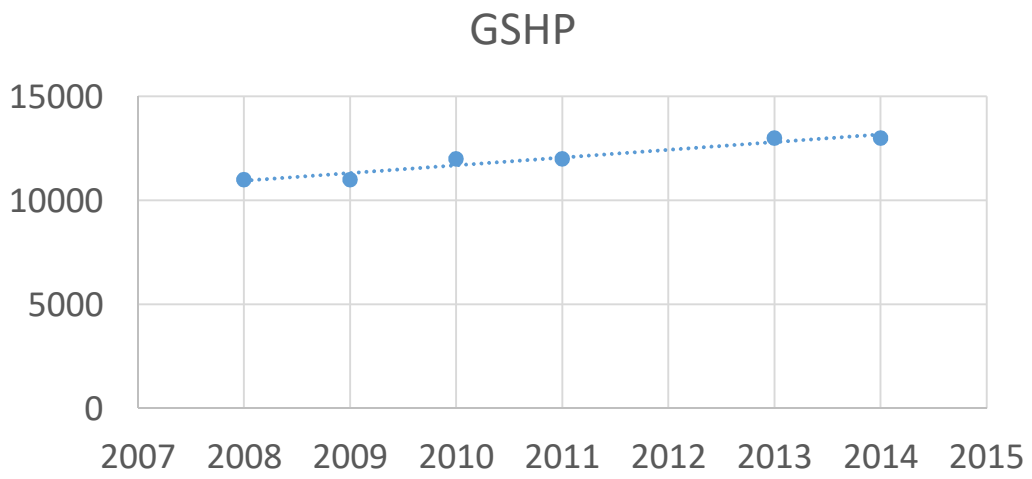




Background

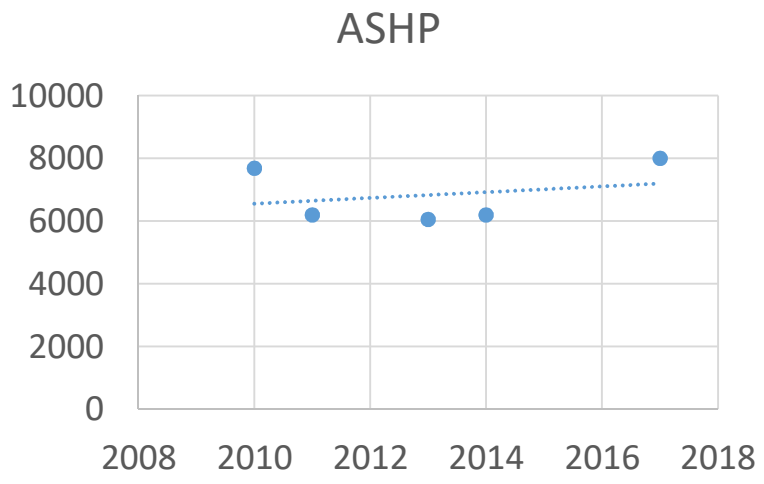
Capital cost (€): Sweden

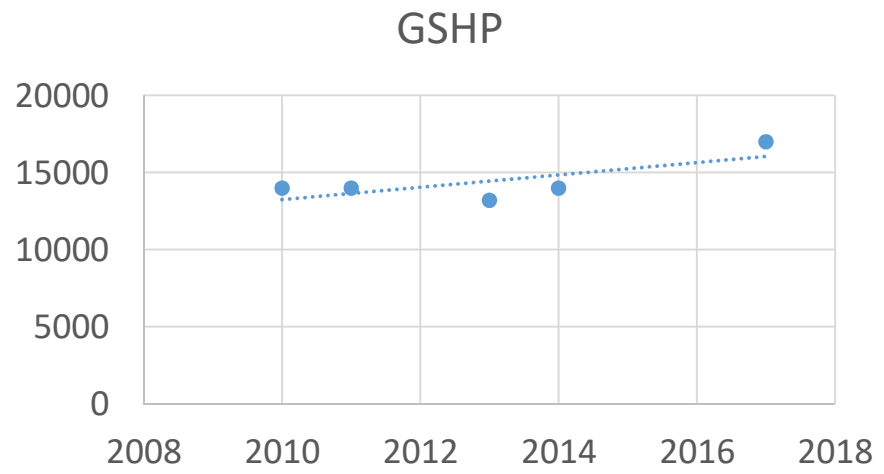




Background

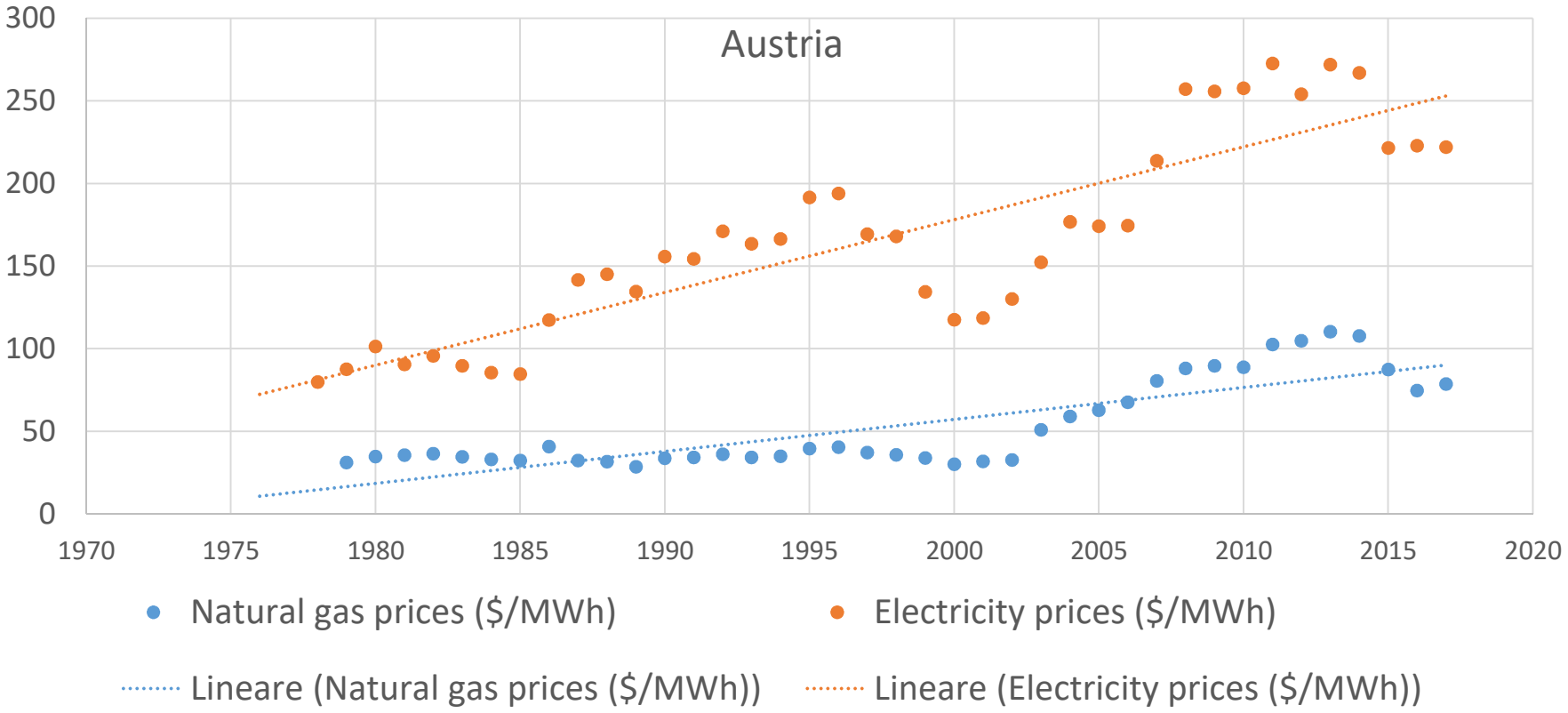
Capital cost (€): United Kingdom





Background

Energy prices



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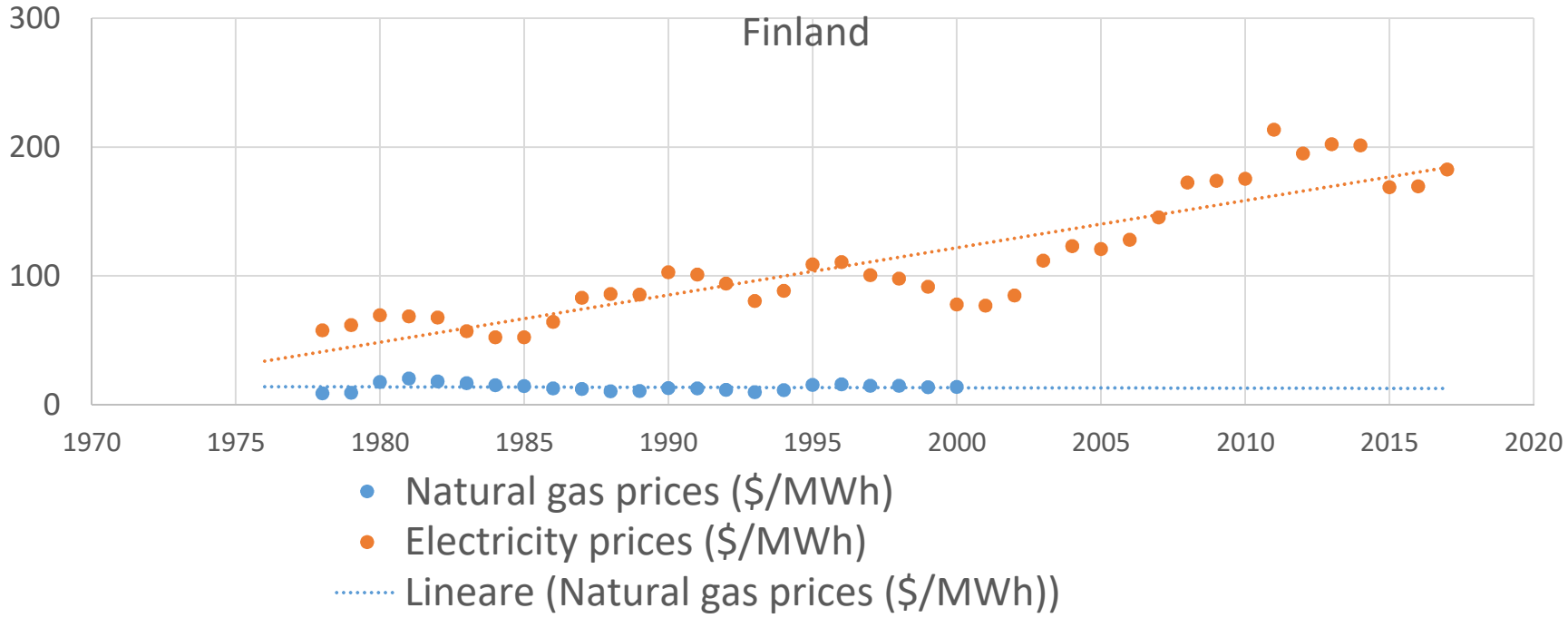

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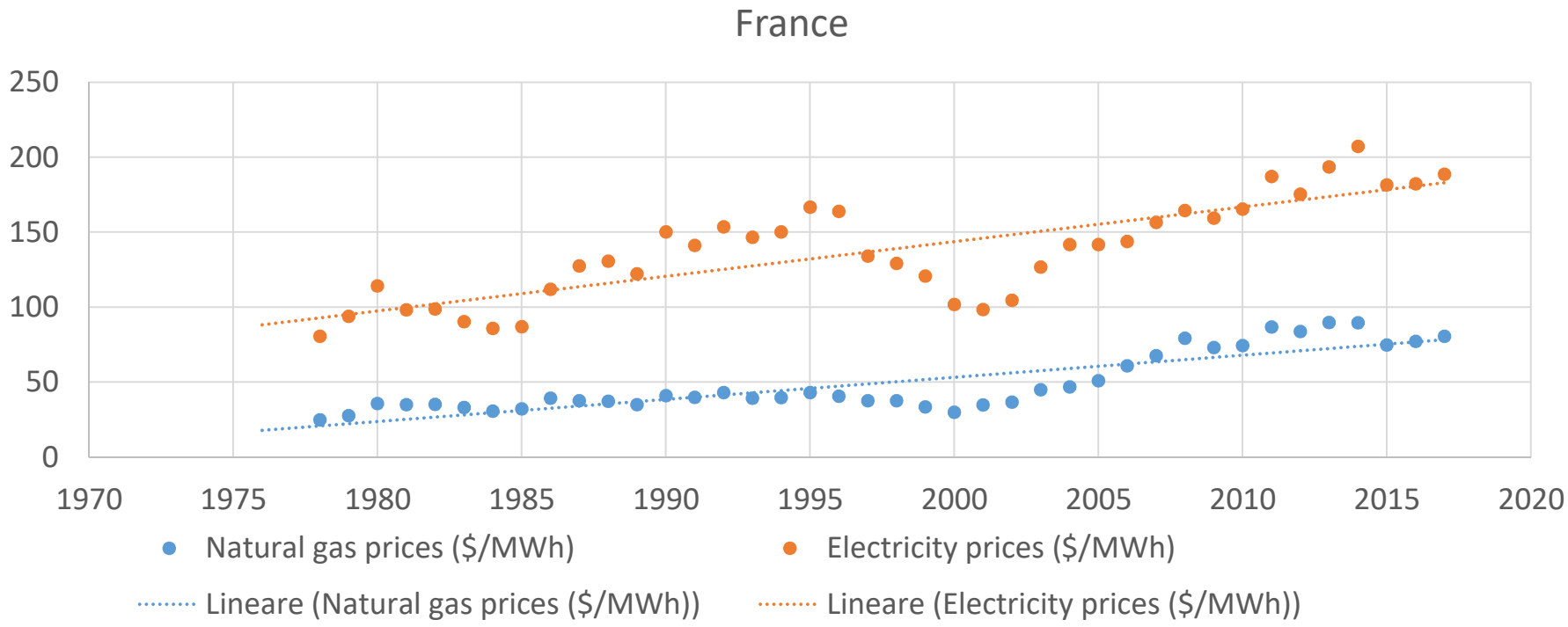

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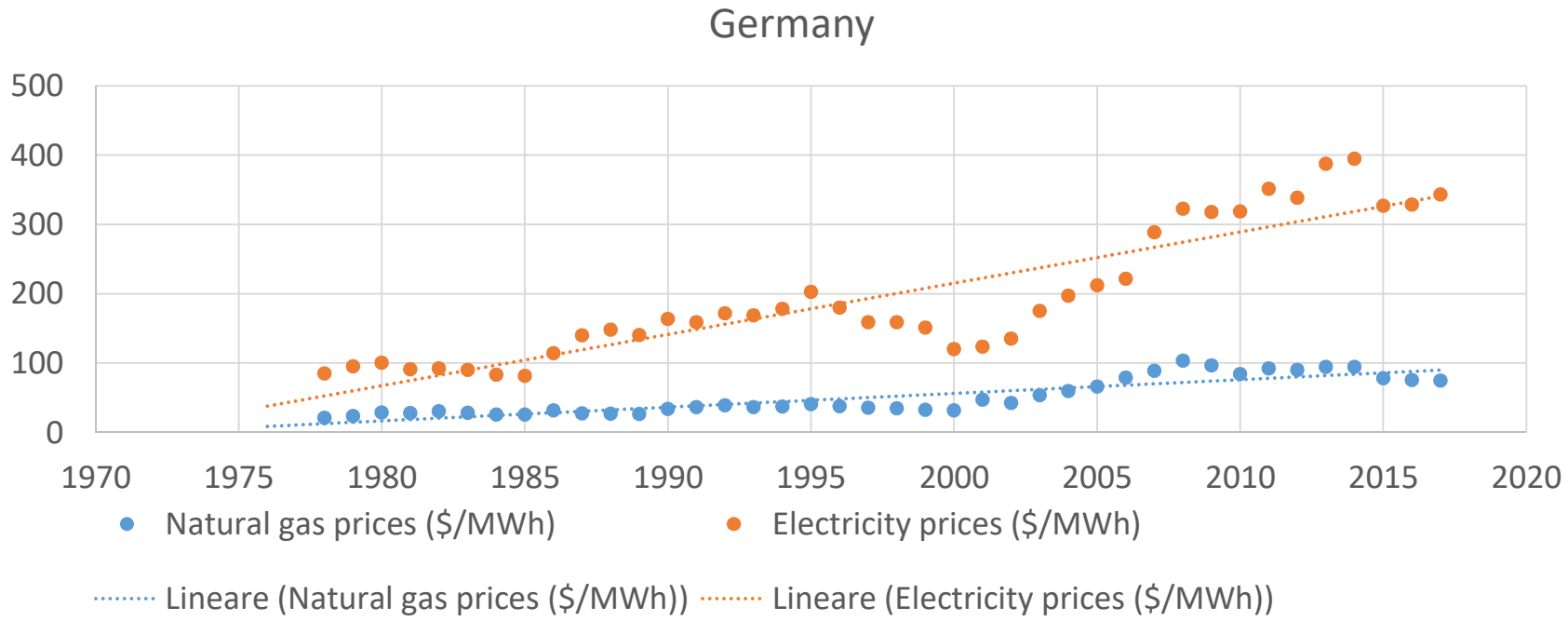

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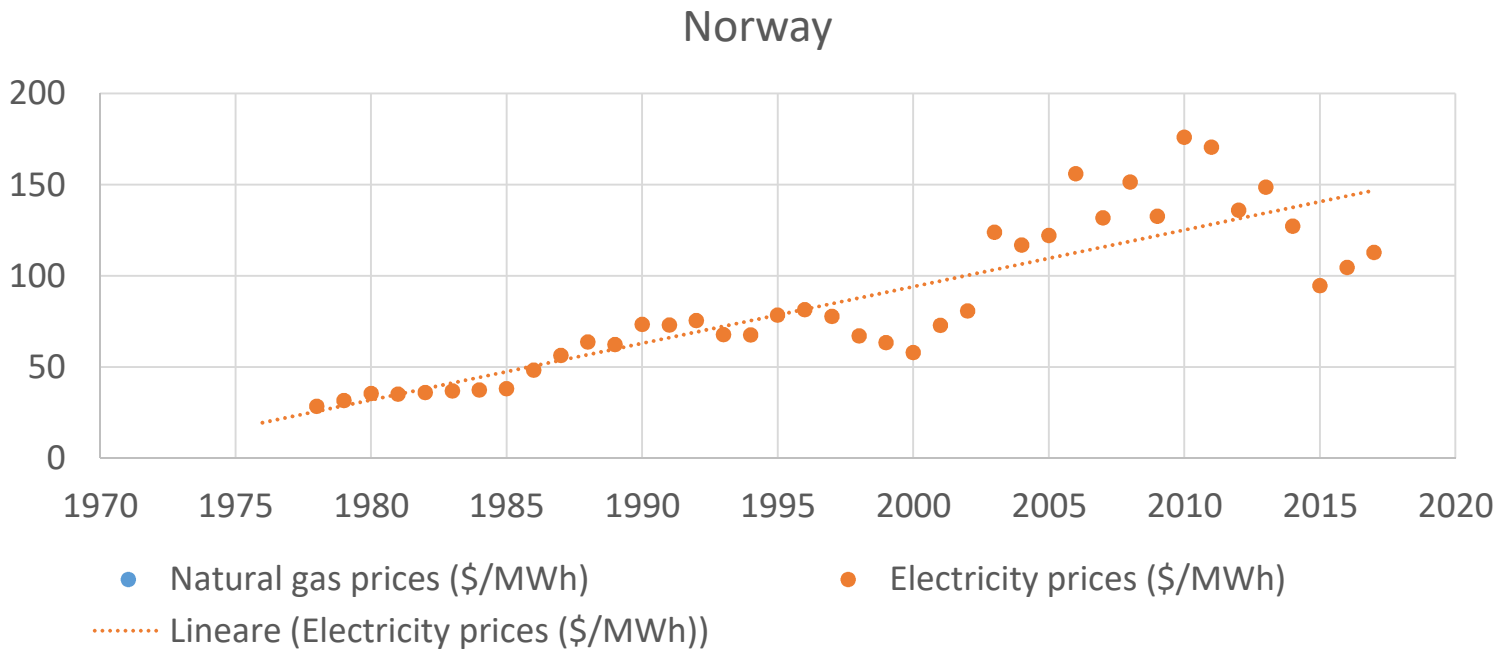

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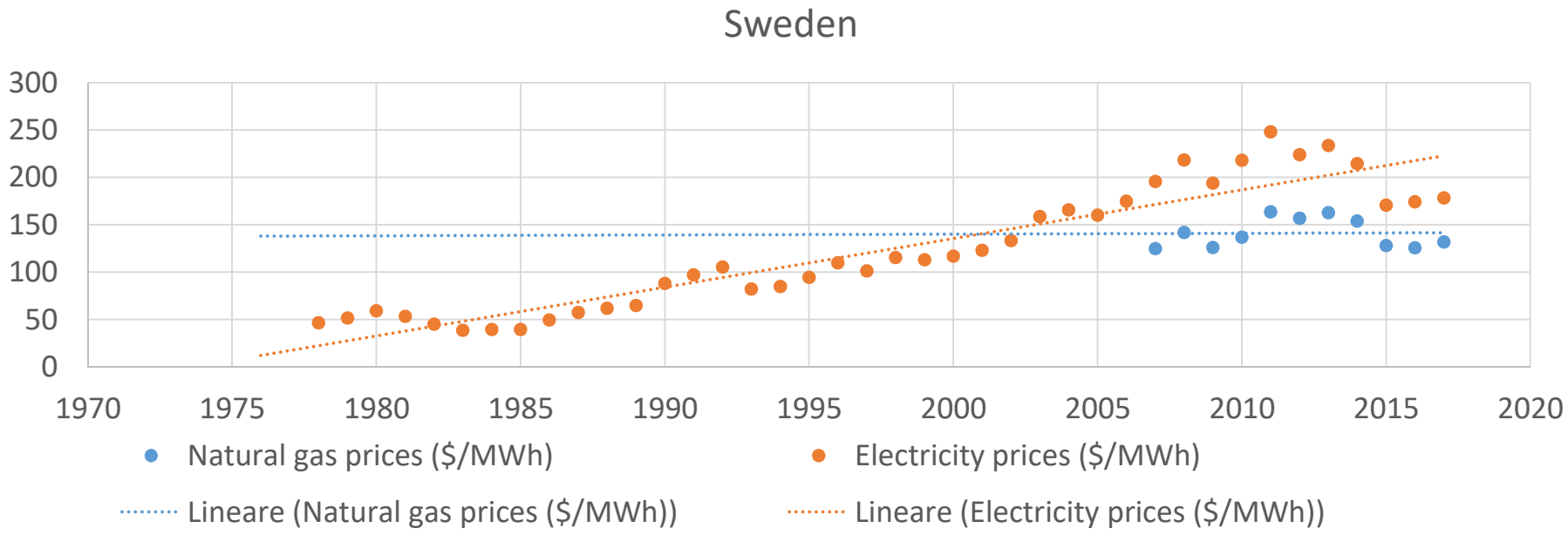

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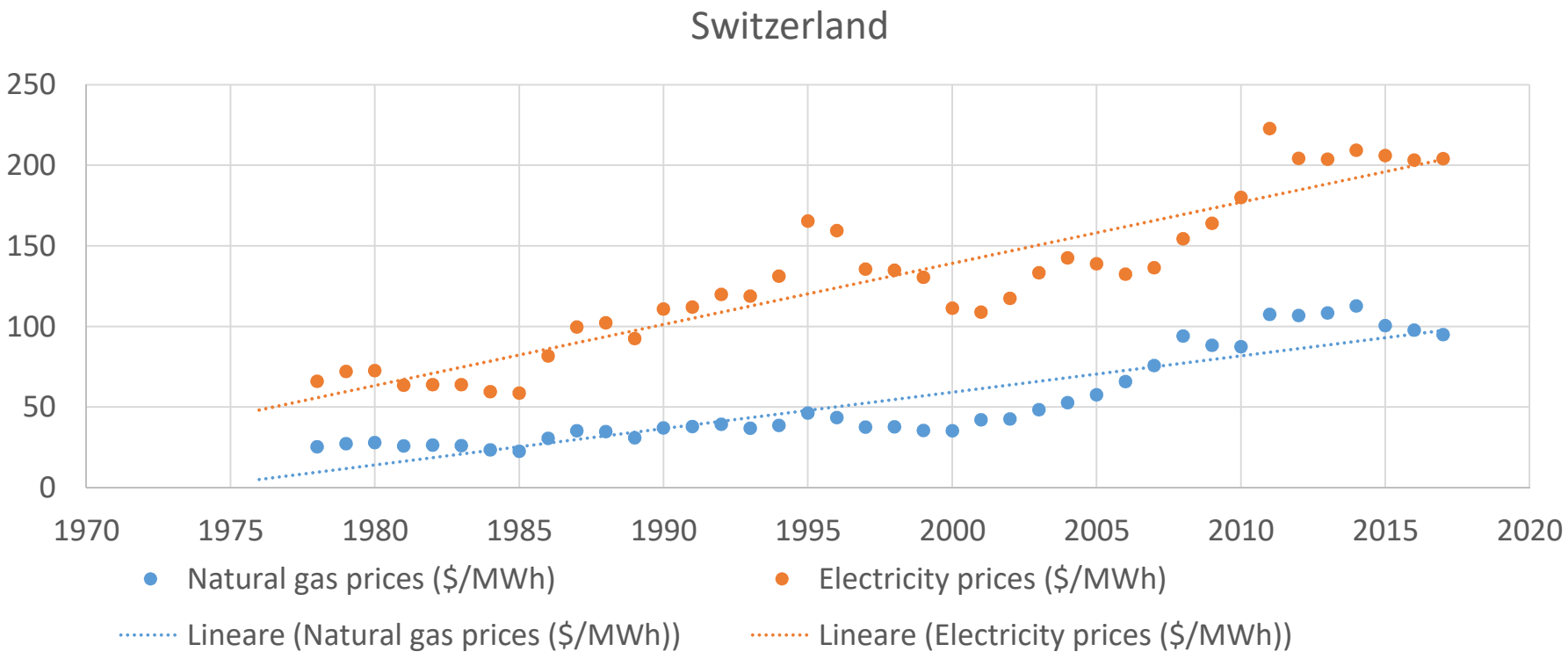

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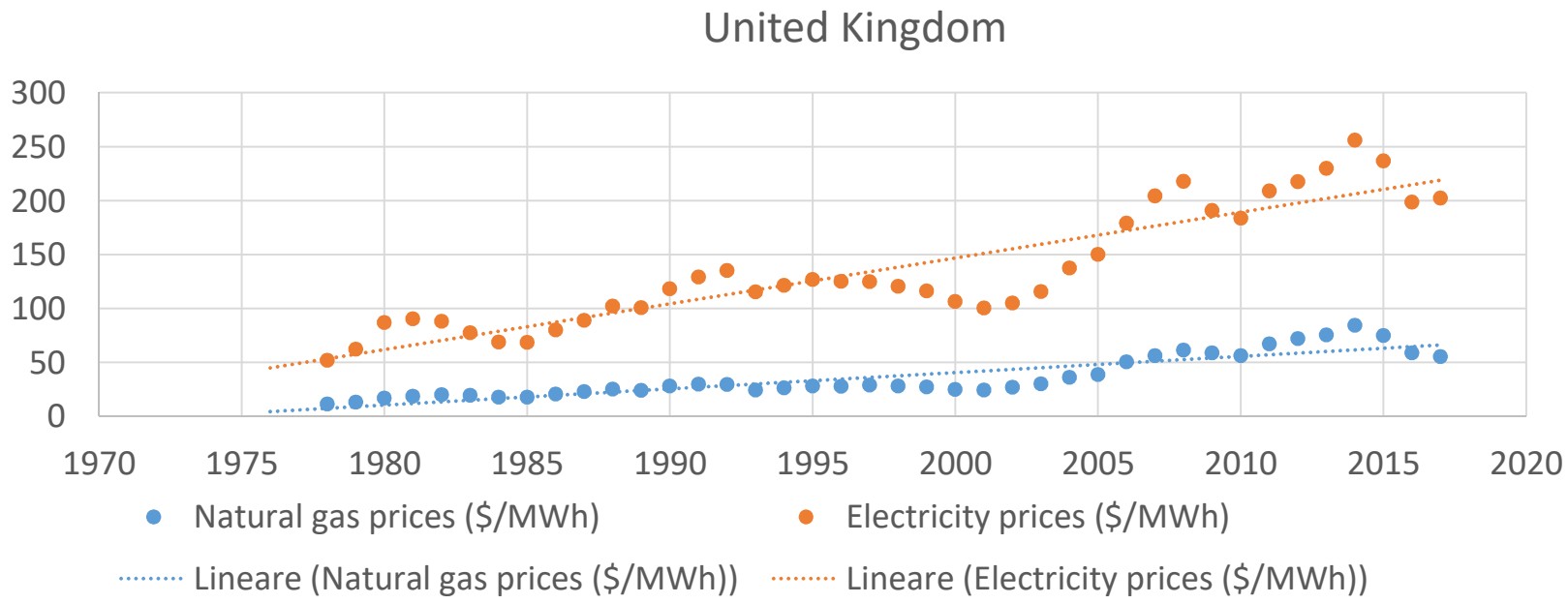

Methods

Econometrics model

Methods

Econometrics model

- Why? In order to analyse the factors that have contributed to stimulate the heat pump markets in a number of countries in Europe
- Panel data model for the period 1976-2017
- Austria, Finland, Norway, Switzerland, Sweden, Germany, France and the UK. These countries have been chosen for two reasons: first because they have well-developed markets and second because they represent two regions with different climatic conditions, population size, socio-economic and macroeconomic characteristics
- Variables: Y is the number of heat pump sales and X variables are: : natural gas and electricity prices, household consumption expenditure, CO_2 emissions, heating degree days – no consistent data on the capital cost of heat pumps
- Log-log model

Methods

Model specification: 3-step model:

a) $Y_{it} = a_0 + a_1X_{1t} + a_2X_{2t} + a_3X_{3t} + a_4X_{4t} + a_5X_{5t} + a_6X_{6t} + c_i + u_t$

- Y = Number of heat pumps sold annually
- i = Austria, Finland, Germany, France, Norway, Sweden and Switzerland
- t = 1,2, 3, … , 41
- X_1 = Natural gas price
- X_2 = Electricity price
- X_3 = Overall consumer expenditure
- X_4 = HDD (heating degree days)
- X_5 = CO_2 emissions
- X_6 = Capital cost for heat pumps
- c_i = Unobserved effects
- u = Error term

Methods

b) $Y_{it} = a_0 + a_1X_{1t} + a_2X_{2t} + a_3X_{3t} + a_4X_{4t} + a_5X_{5t} + a_6X_{6t} + a_6D$

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- X_3 = Overall consumer expenditure
- X_4 = HDD (heating degree days)
- X_5 = CO_2 emissions
- X_6 = Capital cost for heat pumps
- D = Policy (any type e.g. capital cost subsidy, running cost subsidy, information campaign etc.)
- c_i = Unobserved effects
- u = Error term

Methods

c) $Y_{it} = a_0 + a_1X_{1t} + a_2X_{2t} + a_3X_{3t} + a_4X_{4t} + a_5X_{5t} + a_6X_{6t} + a_6D_1 + a_7D_2 + c_i + u_t$,

- Y = Number of heat pumps sold annually
- i = Austria, Finland, Germany, France, Norway, Sweden and Switzerland
- t = 1,2, 3, … , 41
- X_1 = Natural gas price
- X_2 = Electricity price
- X_3 = Overall consumer expenditure
- X_4 = HDD (heating degree days)
- X_5 = CO_2 emissions
- X_6 = Capital cost for heat pumps
- D_1 = Capital cost subsidy dummy variable: subsidy = 1 and no subsidy = 0
- D_2 = Running cost subsidy dummy variable: subsidy = 1 ad no subsidy = 0
- c_i = Unobserved effects
- u = Error term

Methods

- **Data:**

Macroeconomic, socioeconomic, market and physical data

- **Sources:**

International Energy Agency

Organisation for the Economic Cooperation and Development

World Bank

European Environment Agency

European Heat Pump Association, individual companies, national heat pump associations

- **Software :** Stata

Results

1st stage model:

Fixed effects model (after applying the Haussmann test)

Variable	Coefficient
Gas price	2.721**
Electricity price	-2.017**
HDD	-0.612**
CO2	0.34**
Population	9.872*
Consumer expenditure	-3.475**

Results

2nd stage model:

Variable	Coefficient
Gas price	2.479***
Electricity price	-1.622**
HDD	-0.586
CO2	0.368***
Population	9.901
Consumer expenditure	-2.337
Policy	0.544**

Results

2nd stage model: including country effect

Variables	Coefficient
Gas price	2.479***
Electricity price	-1.622
HDD	-0.586
CO2	0.368***
Population	9.901
Consumer expenditure	-2.337

Results

- 2nd stage model: effect of policy on each country's sales

Country	Coefficient
Finland	2.713
France	2.883**
Germany	2.609**
Norway	-
Sweden	1.976**
Switzerland	1.067**
United Kingdom	1.099

Conclusions

- Natural gas prices have significant and positive relationship with heat pump sales
- Electricity prices have significant and negative relationship with heat pump sales
- Consumer expenditure has significant and negative relationship with heat pump sales
- CO2 emissions have significant and positive relationship with heat pump sales
- Policy has significant and positive relationship with heat pump sales

Conclusions

- The same conclusions are valid when we look at each country separately
- Policy implementation has had the highest impact on France's and Germany's heat pump sales

Next step

Estimate and evaluate the role of different types of policies for each country:

- Research and development
- Information campaign
- Capital cost subsidy
- Running cost subsidy
- Tax allowances

Thank you!