Estimating the effect of the Iberian exception mechanism on different inflation categories for Spain and Portugal†

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Abstract

This study employs synthetic control methods to estimate the effect of the Iberian exception on wholesale electricity prices as well as a series of inflation categories, for both Spain and Portugal. This unique research strategy allows us to gain valuable insights from EU electricity markets in a time of growing calls for reform. In particular, we determine that the intervention achieved a 54% reduction in the raw price of electricity in both countries, with almost identical results. When considering the impact of the policy on inflation, the difference between the two countries is striking; On one hand, Spain achieved a reduction of more than 3% in the overall price level, which can be traced down to a 20% decline in energy inflation; By contrast, the effect on Portugal's inflation is undetectable. We argue that this divergence is explained by the different retail market structures in each country. While the regulated tariff in Spain is directly indexed by wholesale prices, there is no direct link between wholesale and retail prices for Portugal in the short term. Furthermore, the high concentration of market share among a few retail firms explains why the policy intervention did not have an effect on Portugal's CPI in the medium term either.

keywords: Iberian exception mechanism, day-ahead auction, EU electricity markets, inflation, synthetic controls, permutation inference

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List of abbreviations

ACER Agency for the Cooperation of Energy Regulators. 5

ATE Average treatment effect. 19, 22–28, 30

CACM GL Capacity Allocation and Congestion Management Guideline. 6–8, 16, 19

CCR Capacity Calculation Region. 9

CP00 Overall CPI. 23, 24, 27, 28

CP00xNRG Overall CPI excluding energy. 27–30

CPI Consumer Price Index. 1, 2, 20, 22, 24, 26, 27, 31, 32, 34

DAA Day-ahead auction price. 21, 22, 24, 27–30, 32

DSO Distribution System Operator. 3

EC European Commission. 11, 12, 15, 32, 33

EDP Energias de Portugal. 10

ENTSO-E European Network of Transmission System Operators for Electricity. 5, 21

EU European Union. 1–7, 11, 13–16, 19, 33

FOOD Food, alcohol and tobacco CPI. 25, 28, 30

GD Goods only CPI. 24, 25, 28–30

GDP Gross Domestic Product. 14

IbEx Iberian Exception mechanism. Not to be confused with the IBEX 35 stock market index. 12, 13, 15, 16, 19–27, 30–33

IGD Industrial goods CPI. 25, 26, 28, 30, 31

IGDxNRG Non-energy industrial goods CPI. 26, 28, 30

kW Kilowatt. 9, 32

LNG Liquefied natural gas. 11, 15

MIBEL Iberian Electricity Market. 8–11, 13, 16, 21, 22, 31, 32, 42

MIBGAS Iberian Gas Market. 12

MWh Megawatt-hour. 6, 11, 12, 14, 15, 20, 22, 31, 33

NEMO Nominated Electricity Market Operator. 8

NRA National Regulatory Authority. 5

NRG Energy CPI. 26–30, 32

OLS Ordinary Least Squares. 41

OMIE Iberian Market Operator, Spanish center. 8

OMIP Iberian Market Operator, Portuguese center. 8

PVPC Voluntary price for the small consumer. 9, 21, 31, 32, 34

REE Red Eléctrica de España. 9

REN Redes Energéticas Nacionais. 10

RMSPE Root mean squared predictive error. 17, 19, 28–30

SC Synthetic control. 16–29, 31

SDAC Single Day-ahead Coupling. 8, 9, 19

SERV Services only CPI. 24, 28, 30

SMEs Small and mid-sized enterprises. 14

TPA Third-party access. 5

TSO Transmission System Operator. 3–6, 8–10

TTF Title Transfer Facility. 11, 15

VAT Value added tax. 14

1 Introduction

As economic activity began to pick up following the COVID-19 recession, global supply chains became overwhelmed after months of slowdown. This asymmetry between supply and demand quickly began to put pressure on prices across the world, to which central banks responded almost unanimously by raising interest rates. The effectiveness of this strategy in tackling the root cause of this inflation, *i.e.* disruption of global supply chains and unprecedented private profits, is questionable at best. Nevertheless, it is already taking a toll on employment and purchasing power. In an already tense environment, Russian troops invaded Ukraine as the rest of the world watched in disbelief. The conflict rapidly developed into a humanitarian tragedy for thousands of Ukrainians and Russians alike, although its ramifications can be felt worldwide. The EU found itself in an awkward position, at odds between its role as the region's peacekeeper and its reliance on Russian gas. For over a year now, countries across the block have been mobilizing to secure alternative gas sources and reconfigure their energy mix.

The energy crisis is forcing policymakers in the EU to rapidly activate policy mechanisms to shield households and businesses from soaring prices. Whether through tax reductions and exemptions, direct transfers and subsidies, or even an EU-wide cap on profits in the energy sector, the amount and variety of policy arrangements in such a short period are remarkable. Among the different policies implemented since the crisis started, the correction mechanism in the Iberian wholesale electricity market stands out as one of a kind. By directly targeting the windfall profits that non-gas energy generators enjoy under the current price-setting mechanism in wholesale electricity markets across the EU, this policy intervention has earned the title of the Iberian exception mechanism.

The uniqueness of this arrangement creates a natural experiment, as Spain and Portugal operate under new rules while the rest of the Union continues to follow the directives in place. This setting can be exploited not only to determine whether the policy is succeeding in bringing electricity prices down but also to gain deeper insights from the EU electricity market design in a time of growing calls for reform. This study employs synthetic control methods to estimate the effect of the Iberian exception on wholesale electricity prices as well as a series of inflation categories, for both Spain and Portugal.

To the best of our knowledge, the research strategy developed in this paper has not been applied in the context of the Iberian exception, allowing us to draw a unique perspective on the issue at hand. In particular, we determine that the intervention achieved a 54% reduction in the raw price of electricity in both Spain and Portugal. When considering the impact of the policy on inflation, the difference between the two countries is striking; on one hand, Spain achieved a reduction of more than 3% in the overall price level which can be traced down to a decline in energy inflation between 20 and 25%; by contrast, the effect on Portugal's inflation is undetectable. We argue that this divergence is explained by the different retail market structures in each country. While the regulated tariff in Spain is directly indexed by wholesale prices, there is no direct link between wholesale and retail prices in the short term for Portugal. Furthermore, the high concentration of market share among a few retail firms explains why the policy did not have an effect on Portugal's CPI in the medium term either.

The remainder of the paper is structured as follows; Section 2 describes how wholesale electricity markets currently operate in the EU by paying special attention to the liberalization process that the Union's energy sector went through since the 1990s. The Iberian exception mechanism is then presented in the context of the Iberian single market for electricity; Section 3 outlines the synthetic control estimator and devises an inferential strategy which takes into account the latest developments in the field; Section 4 presents the results from estimating the effect of the policy intervention on different price indicators and tests their sensitivity; Section 5 analyzes the results and provides explanations for the differences in the effects of the policy on Spain and Portugal. In addition, it puts the findings of this paper in context with the most recent developments of the energy crisis; Section 6 summarizes the paper and concludes.

2 Institutional setting

2.1 The electric grid

Before we can dive deeper into the inner workings of EU electricity markets, it is important to understand the structure of the electric grid. The electric grid is a network that connects generators of electricity to consumers through the transmission and distribution infrastructure. The grid has two important technical properties which affect the way markets work:

1. Supply and demand of electricity must always be balanced, otherwise system failures will occur.

2. The flow of electricity in the grid cannot be controlled, and follows the path of least resistance such that consumers receive electricity from various sources.

The grid begins with electricity generators (see figure 1), which can be classified depending on their flexibility. For instance, nuclear power plants have very low flexibility because turning them on and off is very costly. As a result, they must operate constantly, producing stable amounts of electricity. Solar and wind power generation technologies have low flexibility because they depend on climatic factors to generate electricity, which given the current state of the technology, cannot be stored at a large scale. Generators that use coal and biomass have medium flexibility, whereas those operating with natural gas and geothermal energy are highly flexible. The most flexible technology is hydro-power, as it can be switched on and off in a few seconds (Erbach, 2016).

[Figure 1 here]

Once the electricity is generated, the transmission network carries it over long distances at high voltages to reduce transmission losses. Transmission is subject to large economies of scale, and due to environmental and efficiency reasons, it is not desirable to duplicate lines. These factors make competition in transmission activities extremely difficult, and grant it natural monopoly status (Pérez-Arriaga, 2013). As a result, Transmission System Operators (TSOs), who are in charge of managing the transmission network in each jurisdiction, have been subject to numerous regulations in the EU since the 1990s. After the electricity goes through the transmission system, Distribution System Operators (DSOs) receive it and distribute it to consumers.

2.2 Reform in the EU electricity sector

In the 1990s, the EU began a process of liberalization and reform of its electricity markets. Before this, most countries in Europe had one vertically integrated firm that dominated every single aspect of electricity, from generation to transmission and distribution. Consumers could only buy their energy from one source, which was usually a state-owned monopolistic firm (Pepermans, 2019).

Over the past thirty years, EU electricity markets have gradually taken shape through the so-called Electricity Directives. The First Electricity Directive (Directive 96/92/EC) was adopted in 1996 and aimed at a slow and partial opening of electricity markets to allow more generators and consumers to negotiate the purchase and sale of electricity. However, it only outlined the minimum steps required for liberalization and thus led to uneven results, with some countries barely achieving the desired reforms and others going well beyond the requirements (Kanellakis et al., 2013). This divergence began to diminish in 2003 with the entrance into force of the Second Electricity Directive (Directive 2003/54/EC), which repealed First Directive and gave Member States shorter deadlines and less freedom to continue to open up their markets (Meeus et al., 2005). With competition established in the internal markets of each Member State, the Third Electricity Directive (Directive 2009/72/EC) was adopted in 2009 to achieve a single electricity market in the EU (Glachant & Ruester, 2014). The latest electricity directive, the Clean Energy Package (Directive 2019/944), was approved in 2019 to push the energy transition forward while continuing to promote the single market through coordination of the different actors involved. On top of the general directions provided by the directives, a series of market codes and guidelines give Member States operational instructions for specific areas of the electric sector (Meeus, 2020).

TSOs constitute the backbone of the electrical grid for which the directives have paid special attention to separate them from generation and distribution activities. The First Directive required vertically integrated firms to keep separate accounts for generation, transmission and supply activities, a process known as unbundling of accounts (Eikeland, 2011). Under the Second Directive, firms operating at different levels of the electrical grid were prompted to legally unbundle their transmission activities from their generating and distribution activities. Finally, the Third Directive required TSOs to be certified by the competent national authority under one of three unbundling models: independent system operator; independent transmission operator; or full ownership unbundling, which became the most common approach in Europe (Meeus, 2020).

In order to introduce competition in the generation and distribution of electricity, access to the transmission system had to be ensured so that new and incumbent market participants could transport their electricity at a reasonable price. In this sense, the

First Directive introduced three third-party access (TPA) models: negotiated TPA allows TSOs to negotiate access to the grid on a case-by-case basis; regulated TPA prompts national regulators to set access prices to the network; and the single buyer model, which involves the creation of a power pool for generators. This pool is then bought every hour by a single agent, usually the system operator (Meeus et al., 2005). Allowing for different tariff regimes in different jurisdictions proved to be an impediment to the single electricity market. In addition, most TSOs opted for the negotiated TPA, often regarded as an opaque process. In this sense, the Second Directive made regulated TPA binding for all (Eikeland, 2011).

The electricity directives also encouraged the creation of regulatory bodies, both at the national and supranational levels. While the First Directive gave freedom to Member States to regulate internally, the Second Directive required the appointment of a National Regulatory Agency (NRA) with the tasks of approving tariffs, acting as a dispute settlement authority and, in cooperation with its European counterparts, developing guidelines for the harmonization of technical markets factors such as cross-border infrastructure and trade (Eikeland, 2011). Furthermore, the Third Directive created the Agency for the Cooperation of Energy Regulators (ACER) to coordinate between national regulatory authorities and mediate cross-border issues. The European Network of Transmission System Operators for Electricity (ENTSO-E) was also established by the TSOs to achieve cooperation among them and develop common commercial and technical standards (Glachant & Ruester, 2014). Since then, the EU has promoted the creation of regional markets as an intermediate step towards an integrated market in Europe. This model was meant to accommodate regional particularities and achieve the involvement of relevant stakeholders to a larger extent than would be possible at the European level (Karan & Kazdağli, 2011).

2.3 Wholesale electricity markets in the EU

With a better understanding of the physical structure of the electrical grid as well as the liberalization and integration process in the EU electricity sector, it is pertinent to describe the functioning of wholesale markets. Wholesale electricity markets differ with respect to the time lapse between trading and physical delivery of the electricity, and according to Acer (2021b), can be divided as follows:

- **Forward markets** allow market participants to trade against possible price fluctuations in spot markets, with trading taking place up to several months before delivery. Forward trading in the EU is governed by the Forward Capacity Allocation Guideline (Regulation 2016/1719).
- **Spot markets** include the intraday and the day-ahead market. Intraday markets allow trading hours to minutes before delivery, whereas day-ahead markets allow trading one day before delivery and serve as the main reference for contracts negotiated in forward markets. Spot markets in the EU are regulated through Regulation 2015/1222, also referred to as the Capacity Allocation and Congestion Management Guideline (CACM GL).
- **Balancing markets** are a special type of market to make sure that supply and demand are always balanced in the electric grid. In order to avoid system failures, TSOs procure balancing services in accordance with the Electricity Balancing Guideline (Regulation 2017/2195).

Day-ahead markets in the EU operate under merit-order auction trading. This mechanism allows market participants to submit bids (demand) and offers (supply) corresponding to price-energy pairs (expressed in €/MWh-MWh) for each delivery period (usually every hour). The market operator then ranks the bids in descending price order, and the offers in ascending price order, resulting in downward-sloping demand and upward-sloping supply curves. The market outcome is defined by the price-energy pair at which the cumulative merit-ordered bids equal the cumulative merit-ordered offers. In this sense, the bids at a price not lower than the outcome price are matched with the offers not higher than the outcome price (Pototschnig, 2013). Figure 2 shows the demand and supply curves resulting from the spot market (dashed), and after balancing operations have been carried out (solid).

[Figure 2 here]

Under merit-order auction trading, the first electricity generators to enter the auction are usually nuclear power plants and renewables such as run-of-river hydropower, wind and solar power plants. As outlined in section 2.1, these sources are the least flexible. Thus, they make the lowest bids to make sure they sell their electricity. On the other hand, fossil-fuel-run facilities, such as combined cycle, cogeneration and thermal power plants, enjoy a degree of flexibility which allows them to enter the auction at higher prices. Finally, Hydropower plants running on stored water are subject to very low marginal costs and can be turned on and off very easily, for which they can also enter the auction at higher prices (Pacce et al., 2021). Given their role in the merit-based auction, the technologies that usually set the market price are known as marginal technologies, whereas nuclear, run-of-river hydropower, wind and solar power plants are referred to as inframarginal technologies.

Taking into account the order in which different technologies enter the auction, we can conclude that the merit-order mechanism benefits inframarginal technologies; their energy is paid at the highest price of all accepted offers, even if they often enter the auction at prices close to, or even below, zero. These "windfall profits" are designed to incentivize renewable generation, as well as the development of evermore efficient technologies. However, for windfall benefits to serve as an incentive towards emission-free and efficient electricity generation, fossil-fuel technologies must still operate. Even if stored-water hydro plants set the auction price, they optimise their yearly production based on opportunity costs: if they empty their water storage to produce electricity today, they will not be able to use this water for electricity production in the future. As such, their opportunity cost is associated with the most expensive technologies, *i.e.* those that use fossil fuels in general, and gas in particular (Acer, 2022). To sum up, wholesale electricity prices in the EU are closely correlated with international gas prices, which has important consequences for the policy intervention that this paper focuses on.

The integration of electricity markets in the EU means that increasing amounts of electricity are moved from one jurisdiction to another in order to meet supply and demand requirements throughout the whole network. Congestion occurs when the transmission capacity is not sufficient to satisfy the demand for transmission services, *i.e.* the electricity generated is not enough to meet the demand indicated by the market outcome (Pototschnig, 2013). Different approaches have been used to deal with congestion in different EU regions over time. However, with the adoption of the CACM GL in 2015, market coupling in day-ahead markets became binding for all Member States to manage congestion. Market coupling grants power exchanges cross-border transmission rights. Power exchanges are trading platforms that promote the trade of electricity between market parties. In this sense, the allocation of cross-border transmission rights is integrated into the clearing of the day-ahead auction that power exchanges organize, instead of through a separate auction (Meeus, 2020).

While power exchanges gradually emerged in most Member States over the past 30 years to organise wholesale trading of electricity, the obligation to abide by market coupling gave them a larger responsibility. The CACM GL prompted each Member State to appoint at least one power exchange in their jurisdiction as a Nominated Electricity Market Operator (NEMO) to coordinate transmission allocation with TSOs. The CACM GL also required the newly appointed NEMOs and TSOs to develop a common proposal for capacity allocation across the Union (Regulation 2015/1222). This joint venture materialized in the Single Day-ahead Coupling (SDAC), which allocates cross-border transmission capacity by coupling day-ahead electricity markets from different regions through a common algorithm, operated by all the NEMOs. As of June 17, 2021, all 27 Member States plus Norway are part of the SDAC, which performs coupling for more than 98% of the electricity consumed across these countries (Entso-e, 2022b).

2.4 The Iberian wholesale electricity market

Spain and Portugal are located in the Iberian Peninsula, in Southwest Europe, only connected to continental Europe with France through the Pyrenees Mountains. These geographical conditions make the Iberian Peninsula an island in terms of electricity transmission with the rest of Europe. Both countries underwent extensive liberalization and reform in their electricity sectors throughout the late 1990s and early 2000s, following the Electricity Directives. In 2004, the governments of Spain and Portugal signed an agreement to develop a single Iberian power market, with the goals of promoting competition among generators, bringing prices down, and providing consumers with more options to obtain their supply of electricity (Ferreira et al., 2007). The agreements materialized in 2007, as the Iberian Electricity Market (MIBEL) was established. MIBEL is divided into the spot market, run by the Spanish Iberian Market Operator (OMIE) and the futures market, managed by the Portuguese Iberian Market Operator (OMIP). In this sense, OMIE is the NEMO that operates in both countries, effectively constituting a monopoly for the wholesale of electricity in the region (Acer, 2021a). Furthermore, MIBEL uses a market coupling algorithm that produces a single price for both countries given no constraints on cross-border interconnection capacity. Since 2018, instances of market splitting –the hours when the price difference between the two countries is equal or greater than 1€– have been lower than 4% (Iea, 2021a).

Spain and Portugal are integrated into the SDAC through the Southwestern Capacity Calculation Region (CCR), which also includes France. This implies that the markets in these three countries cooperate to allocate cross-border transmission of electricity through the common algorithm and the active coordination of the TSOs in each jurisdiction. However, France is also included in the Core CCR, which connects it with Belgium and Germany, as well as the Italy-North CCR, which connects it with Italy (Entso-e, 2022a).

In order to complete the analysis of the institutional environment before the intervention, it is relevant to briefly describe the profiles of Spain and Portugal in terms of electricity generation, transmission and distribution.

2.4.1 Spain

The publicly listed company Red Eléctrica de España (REE) is the designated TSO in Spain, with the tasks of maintaining and developing the grid, coordinating the cross-border flow of electricity and guaranteeing equal access to the transmission system by third parties. The Spanish state must own 10% of REE shares, while other entities may hold no more than 5%. In addition, REE cannot own any shares in companies involved in the generation or supply of electricity or gas. Generation of electricity in Spain is dominated by three main firms (Grupo Endesa, Iberdrola and Naturgy), accounting for about 50% of consumption volume. Consumers may choose to receive their electricity from retail providers at a fixed price, or through a regulated scheme known as the voluntary price for the small consumer (PVPC). The PVPC tariff is directly indexed by MIBEL day-ahead prices and designed for households and firms using up to 10kW of power. Among small consumers, roughly 40% are under the PVPC tariff and the remaining 60% have a contract with a retail provider (Iea, 2021b).

[Figure 3 here]

Figure 3 shows the electricity generated in Spain by source over the last five years. The main sources are gas, nuclear energy, and wind, with solar generation gaining momentum in recent years. Coal-powered electricity has played a significant role historically, although Spain is phasing out of this source, significantly reducing its use since 2019. The red line in figure 3 shows the net balance of cross-border electricity transmission between Spain and its neighbouring countries, *i.e.* Portugal, France, Morocco and Andorra. While Spain has been a net importer of electricity over the past decade, it became a net exporter in late 2021, mostly explained by France's issues meeting its energy demand.

2.4.2 Portugal

Rede Eléctrica Nacional is the certified TSO in Portugal, and it is owned by Redes Energéticas Nacionais (REN), a 100% privately owned company and the second-largest wholesale electricity provider in the country. Portuguese competition authorities have imposed restrictions on the supervisory and administrative boards of REN to prevent them from influencing the operations of the national TSO. Another important player in electricity generation is Energias de Portugal (EDP), a 100% privately owned firm that owns the majority of Portugal's installed generation capacity. Additionally, EDP is the largest wholesale supplier of electricity in the country. The retail market is also dominated by a few companies, with EDP accounting for 64% of consumers and the top four companies (EDP, Endesa, Iberdrola and Galp) providing electricity for 80% of consumers. Overall, the electricity sector in Portugal is highly concentrated among a few private companies. While most consumers in Portugal receive electricity through the retail market, there is also a regulated scheme serving roughly 5% of consumers. Unlike in Spain, the regulated tariff in Portugal is based on MIBEL prices from the previous year (IEA, 2021a).

[Figure 4 here]

Figure 4 shows the electricity generated in Portugal by source over the last five years. Gas and hydro-powered generation dominate the mix, with solar gaining volume over the last two years. Portugal began to phase out coal in 2018, achieving a significant drop in coal-fired generation the year after. The country's largest coal-fired power plant closed in January 2021, and the last remaining plant stopped operating in November of that year (IEA, 2021a). While net exports to Spain fluctuate throughout the year, Portugal has been a net importer of electricity since 2021.

2.5 Policy intervention: The Iberian exception mechanism

As described in section 2.3, the merit-order auction design produces wholesale electricity prices which are highly correlated with international gas prices. Figure 5 highlights this comovement by showing international gas prices –as represented by the month-ahead Title Transfer Facility (TTF) contract– and the day-ahead auction price in six different European regions a year before the intervention came into force.* Note how wholesale electricity is rarely priced below gas futures. Additionally, the OLS coefficients included in the figure indicate that in the Apennine, Central-west, Iberian and Southeast regions, electricity roughly doubles the price of gas on a given day.

[Figure 5 here]

Between the summer and fall of 2021, the supply of gas was unable to meet global demand amid a rebound in economic activity following the COVID-19 recession. Figure 5 shows how electricity prices followed the steady rise in TTF during this time. Towards the end of 2021, a large spike in gas futures was echoed by EU wholesale electricity prices, this time prompted by increasing uncertainty about Russian pipeline gas supplies to continental Europe, even as liquefied natural gas LNG imports recovered (Acer, 2022). The beginning of Russia's invasion of Ukraine between February and March 2022 produced an even larger spike in the TTF, which sent wholesale electricity prices well above 400 €/MWh in all regions, except North. While electricity prices achieved relative stability in the months that followed, they remained around 200 €/MWh, double from a year before.

In this context, the European Commission (EC) encouraged Member States to implement extraordinary measures to prevent soaring energy prices from spreading across the economy. On March 25, 2022, all the EU prime ministers gave Spain and Portugal green light to develop a correction mechanism for MIBEL day-ahead price, given their

*Regional divisions based on Electricity Markets Reports (Ec, 2022c); Apennine peninsula (Italy); Southeast region (Bulgaria, Croatia and Greece); Iberian peninsula (Spain and Portugal), Central-east region (Czechia, Hungary, Poland, Romania, Slovakia and Slovenia); Central-west region (Austria, Belgium, France, Germany, Luxembourg and the Netherlands); and North region (Denmark, Estonia, Finland, Latvia, Lithuania, Sweden and Norway) lack of interconnections with continental Europe. On April 26, the governments of the two countries reached an agreement, which was then passed into legislation in Spain as the Royal Decree-Law 10/2022 on May 13, and in Portugal as the Decree-Law 33/2022 on May 14. Both laws were approved by the EC on June 8 and entered into force on June 14, such that the first day-ahead prices under the mechanism were set for June 15.

The policy intervention, which became known as the Iberian exception mechanism (IbEx), establishes a limit to the price that certain electricity generators can enter the day-ahead auction with. This applies to combined cycle and cogeneration power plants, as well as other gas and coal-fired facilities, although the latter plays a minimal role in the Iberian energy mix. The limit, which we will refer to as the *reference price*, is set under the market price for gas. Inevitably, the IbEx outlines a way to compensate facilities for the losses they would otherwise incur.

The compensation mechanism for gas facilities is designed as follows: The governments of Spain and Portugal agreed to set the *reference price* at 40 €/MWh during the first six months of the intervention, and raise it by an additional 5€/MWh each month during the six months that follow. The *reference price* is compared to a gas *market price*, computed daily as the weighted average of gas futures with maturity ranging between 1 and 3 days before the day under consideration. The *market price* is published every day by the Iberian Gas Market (MIBGAS) before the electricity day-ahead auction begins, such that market participants can submit their bids and offers with this knowledge. The *reference price* is subtracted from the *market price* and divided by the efficiency rate of gas facilities, assumed to be 0.55. As a result, the compensation that gas-firing generators receive is computed through the following formula:

$$Adj_{i,d} = \begin{cases} \left(P_d^{MRKT} - P_d^{REF}\right)\frac{1}{0.55} & \text{if} \quad P_d^{MRKT} > P_d^{REF} \\ 0 & \text{Otherwise} \end{cases} \tag{1}$$

where $Adj_{i,d}$ is the compensation received by facility i on day d, P_d^{MRKT} is the *market price* published by MIBGAS and P_d^{REF} is the *reference price* set by regulators. On days when the *market price* is lower than the *reference price*, the adjustment cost is zero. The top row of figure 6 shows the evolution of the adjustment costs as a function of the *reference* and *market prices* from June 15 to December 31, 2022.

[Figure 6 here]

By limiting the price gas generators can enter the auction with, and covering their losses through a compensation mechanism, the IbEx aims at reducing the windfall profits that inframarginal technologies enjoy under the merit-based order auction design. Furthermore, the policy intends to do so without altering the merit order that would otherwise emerge in the market. In this sense, while the resulting price of gas-generated electricity is indexed by gas market prices, the large markup that inframarginal generators receive is significantly reduced.

The adjustment cost is naturally borne by market agents buying electricity indexed by the day-ahead auction price. Additionally, the IbEx stipulates that the adjustment cost is partly financed through revenues from electricity exports to France. As noted in section 2.1, the flow of electricity cannot be controlled and consumers receive electricity from various sources. In this sense, and while the Iberian mechanism effectively introduces two different prices –one for gas technologies and another one for the rest– it is important for electricity to have a unique price. As a result, the hourly price of electricity under the intervention is computed by taking into account the share of electricity in the grid subject to the adjustment mechanism, as well as electricity exports to France. The bottom of figure 6 shows the daily average MIBEL day-ahead price and the corrected price that results from the IbEx.

2.6 Other measures against the energy crisis in the EU

In addition to Spain and Portugal, most European countries have taken action to address the energy price volatility. This section summarizes the most common policy interventions that different national governments have implemented unilaterally, as well as collectively at the EU level. Unless noted otherwise, all the information that follows is based on the dataset compiled by Sgaravatti et al. (2023), which includes measures used by European countries against energy price inflation between September 2021 and January 2023. In particular, we consider all EU-27 countries plus Norway. This is meant to give a non-exhaustive overview of different measures in order to put the IbEx in its broader context, in preparation for the empirical analysis.

Since the beginning of the energy crisis, governments across Europe have allocated large funds to protect households and firms from soaring prices through direct transfers, subsidies or tax cuts, among others. Some of the countries which have dedicated more funding in terms of share of GDP include Slovakia (9.3%), Germany (7.4%) and Bulgaria (5.7%), whereas Finland (0.6%), Ireland (1.3%) and Sweden (1.3%) are among those who have committed fewer funds.

One of the most widespread measures among the countries considered is a reduction in energy taxes and VATs. All countries except Slovakia have implemented this policy in some form. For instance, Belgium, Germany, the Netherlands and Sweden temporarily introduced reductions in the tax associated with petrol, diesel and other fuels. Other countries like Croatia, Czechia, Finland and Italy approved reductions in electricity and gas VATs, aimed at supporting vulnerable groups, such as households and small and mid-sized enterprises (SMEs).

Another common measure for governments across Europe is to regulate the retail price of electricity. Out of the countries considered, only Finland and Lithuania did not intervene in their retail markets. One of the most prominent examples is France, whose government limited the increase in regulated tariffs to 4% first, and 15% as the surge in prices continued. Estonia launched a "universal service" for electricity in October 2022, allowing households and SMEs to buy power at a fixed price. In December 2022, Czechia's government introduced an indirect cap on the regulated electricity tariff, transferring consumers the excess amount.

Governments across the EU have also made efforts to support vulnerable groups throughout this time, with only Hungary not taking any of such measures. Some of the most notable examples include Austria, Belgium, Denmark and Latvia, whose governments approved monthly direct transfers for low-income households to help them cover energy bills. Romania for its part supported vulnerable consumers via subsidies for energy-efficient house equipment and improvements.

Direct support to businesses has also been a widespread strategy to combat the energy price surge across the EU. In Greece, for instance, subsidies were granted to businesses throughout most of 2022, with the government making transfers to shops, farmers and industries per MWh consumed. In April 2022, Lithuania launched a package to promote energy independence among businesses and public projects through the installation of solar power stations and the replacement of biomass and fossil-fuel boilers with more efficient alternatives. Another example is Norway, whose government covered companies' power costs exceeding 3% of revenue in the first half of 2022.

While individual countries have deployed a variety of strategies to cope with this unprecedented situation, the EC has also promoted multilateral agreements aimed at scaling down electricity demand and limiting profits in the energy sector. In September 2022, the EU energy ministers agreed to reduce the consumption of electricity in each Member State by 10% overall and 5% during peak hours. Concerned with the record-breaking profits for some electricity generators as gas prices soar, a 180 €/MWh cap was set on the revenues of inframarginal generators. Furthermore, given the success of the IbEx, a group of countries began pushing for an EU-wide revision of wholesale electricity markets. An agreement was reached in December 2022, as the Union's energy ministers outlined a temporary market correction mechanism, which is activated if TTF futures exceed 180€/MWh and are 35€ above international LNG prices for 3 consecutive working days. The intervention applies for a year after February 15, 2023 (Ec, 2022a; Ec, 2022b)

Whether through tax cuts, direct transfers to households and businesses or a redistribution of the profits in the energy sector, governments across the EU have made considerable efforts to mitigate this episode of energy-price inflation. The measures outlined above also serve to highlight the uniqueness of the IbEx as the only initiative to tackle surging prices from the source *i.e.*, by amending the price-setting mechanism in the wholesale market. The entrance into force of the EU-wide correction mechanism in February 2023 opens an eight-month window to study the effects of this unusual policy intervention. This setting constitutes a unique opportunity to understand the relationship between EU electricity markets and price dynamics in national economies. The following section develops a framework to estimate the effect of the IbEx on wholesale electricity prices and the overall price level for different categories of goods and services.

3 Methodology

The IbEx presents an ideal natural experiment to study its impact on inflation with causal implications. This is because, while MIBEL day-ahead market has been operating under special circumstances since June 15, all other European markets continue to follow the EU energy directives as well as the CACM GL in their integrity. However, the fact that only two units are treated under this intervention poses the fundamental challenge of finding an explicit counterfactual that can be used to estimate the effect of the policy. Synthetic control (SC) methods (Abadie and Gardeazabal, 2003; Abadie et al., 2010) allow for the estimation of a counterfactual from a pool of control units, based on a set of optimized weights.

3.1 Synthetic controls

Suppose we observe data for $(J+1) \in \mathbb{N}$ units (countries) over a period of time $T \in \mathbb{N}$. Assume that unit J_1 is assigned treatment under a policy intervention at time $T_0 \in (1, T)$, and receives treatment during $T_1 = T - T_0$ periods. The remaining J units remain untreated and therefore make up a donor pool of control units. Let $Y^1_{j,t}$ and $Y^0_{j,t}$ be the outcomes of interest for country $j \in \{1, ..., J+1\}$ at time $t \in \{1, ..., T\}$ under treatment and no treatment, respectively. We are interested in estimating the treatment effect of the policy on the treated, defined as $\alpha_{1,t} = Y^1_{1,t} - Y^0_{1,t}$, for $t \in \{T_0+1, ..., T\}$. Since $Y^1_{1,t}$ is observable, we just need to estimate a counterfactual $Y^0_{1,t}$.

Let $\mathbf{Y_j} = [Y_{j,1}, ..., Y_{j,T_0}]$ be the vector of observed outcomes for unit j in the pre-intervention period, and $\mathbf{X_j}$ a $(K \times 1)$-vector of predictors of $\mathbf{Y_j}$. Furthermore, Let $\mathbf{Y_0} = [\mathbf{Y_2}, ..., \mathbf{Y_{j+1}}]$ be a $(T_0 \times J)$-matrix and $\mathbf{X_0} = [\mathbf{X_2}, ..., \mathbf{X_{j+1}}]$ be a $(K \times J)$-matrix. SC methods produce $\widehat{Y}^0_{1,t} = \sum_{j=2}^{J+1} \widehat{w}_j Y_{j,t}$ for each $t \in \{1, ..., T\}$, which is an estimator for $Y^0_{1,t}$. $\widehat{\mathbf{W}}(\mathbf{V}) = [\widehat{w}_2, ..., \widehat{w}_{j+1}]$ is a vector of weights assigned to each country in the donor pool, and the solution to the minimization problem:

$$\widehat{\mathbf{W}}(\mathbf{V}) = \underset{\mathbf{W} \in \mathcal{W}}{\arg\min} \left(\mathbf{X_1} - \mathbf{X_0} \cdot \mathbf{W}\right)' \mathbf{V} \left(\mathbf{X_1} - \mathbf{X_0} \cdot \mathbf{W}\right) \tag{2}$$

where $\mathcal{W} = \left\{\mathbf{W} = [w_2, ..., w_{j+1}]' \in \mathbb{R}^j \text{ and } \sum_{j=2}^{J+1} w_j = 1\right\}$, *i.e.* no control unit receives a weight smaller than zero, and the sum of all weights must equal one. Furthermore,

$\mathbf{V}$ is estimated through the minimization problem:

$$\widehat{\mathbf{V}} = \underset{\mathbf{V} \in \mathcal{V}}{\arg\min} \left(\mathbf{Y_1} - \mathbf{Y_0} \cdot \widehat{\mathbf{W}}(\mathbf{V})\right)' \left(\mathbf{Y_1} - \mathbf{Y_0} \cdot \widehat{\mathbf{W}}(\mathbf{V})\right) \tag{3}$$

where $\mathcal{V}$ is a diagonal $(K \times K)$-matrix whose trace equals one, *i.e.* no predictor receives a weight smaller than zero, and the sum of all weights must equal one. In this sense, $\widehat{\mathbf{W}}$ measures the importance of each control unit towards the SC, and $\widehat{\mathbf{V}}$ measures the importance of each predictor towards the SC (Firpo and Possebom, 2018; Cunningham, 2021).

3.2 Inference

Traditionally, inference in the context of SC methods has been conducted through a permutation-like test based on placebo effects (Abadie et al., 2010). The test is performed by estimating an SC for each unit in the donor pool. The post-to-pre-treatment ratio of root mean squared predictive error (RMSPE) is then computed for all units to obtain a distribution of placebo effects. RMSPE ratios are ranked in descending order and a p-value is assigned to each unit by diving its rank over the sample size. Finally, the null hypothesis of no effect can be rejected if the treated country's p-value is below a specified level of significance. Ando and Sävje (2013) show that in many settings this test violates the fundamental condition that requires RMSPE ratios to be *iid* under the null. As a result, RMSPE ratios can be both uninformative and misleading depending on the particular circumstances surrounding each SC study. Taking this into account, it is appropriate to consider more robust ways to conduct inference.

Chernozhukov et al. (2021) develop an alternative approach in the context of SCs. Consider the following reformulation of the potential outcomes problem:

$$\left.\begin{array}{l} Y^0_{1,t} = \widehat{Y}^0_{1,t} + u_t \\ Y^1_{1,t} = \widehat{Y}^0_{1,t} + \theta_t + u_t \end{array}\right| \quad E(u_t) = 0, \quad t = 1, ..., T \tag{4}$$

where θ_0 is a fixed policy effect sequence with $\theta_t = 0$ for $t > T_0$. Finally, u_t is either *iid* or a stationary and weakly dependent sequence of error terms. The goal is to test a hypothesis about the fixed policy effect sequence in the post-intervention period,

$H_0 : \theta = \theta_0$, where $\theta = [\theta_{T_0+1}, ..., \theta_T]'$ is a postulated policy effect trajectory. Following this, the data can be rewritten under the null as $\mathbf{Z}(\theta_0) = (Z_1, ..., Z_T)'$, where

$$Z_t = \begin{cases} \left[Y^0_{1,t}, Y^0_{2,t}, ..., Y^0_{J+1,t}, X'_{1,t}, ..., X'_{J+1,t}\right]', & t \leq T_0 \\ \left[Y^1_{1,t} - \theta^0_t, Y^0_{2,t}, ..., Y^0_{J+1,t}, X'_{1,t}, ..., X'_{J+1,t}\right]', & t > T_0 \end{cases} \tag{5}$$

We obtain $\widehat{Y}^0_{1,t}$ using $\mathbf{Z}(\theta_0)$ via SCs and estimate the residuals by rearranging (4) as $\widehat{u} = [\widehat{u}_1, ..., \widehat{u}_T] = Y^1_{1,t}$ - $\widehat{Y}^0_{1,t}$ for $1 \leq t \leq T$. The identifying assumption requires u_t to be invariant under the intervention. Furthermore, consider the test statistic $S = \sum_{t=T_0+1}^{T} |\widehat{u}_t|$. Chernozhukov et al. (2021) propose two methods of computing p-values from this test statistic. Firstly, *moving block* or *mb* permutations consist of iteratively taking ordered blocks of residuals of size T_1, *i.e.* $[\widehat{u}_1, ..., \widehat{u}_{T_1}]$, $[\widehat{u}_2, ..., \widehat{u}_{T_1+1}]$, ..., $[\widehat{u}_{T-T_1+1}, ..., \widehat{u}_T]$. For each of these blocks, we compute the absolute sum of post-treatment errors and store them in vector S^{mb} of size $(T \times 1)$, such that $S^{mb}_n = \sum_{t=n}^{n+T_1-1} |\widehat{u}_t|$. p-values are then computed as follows:

$$\widehat{p}_{mb} = \frac{1}{T}\left(\sum_{n=1}^{T}\left\{S^{mb}_n \geq S\right\}\right) \tag{6}$$

The second method is referred to as *iid* permutations and similarly, requires computing the absolute sum of post-treatment errors by iteratively taking blocks of residuals of size T_1. In this case, however, residuals are resampled without replacement a given number of permutations N_p. The result for each permutation is stored in vector S^{iid} of size $(N_p \times 1)$, and the p-value is computed as the share of S^{idd} that is larger than or equal to the test statistic S, through the following formula:

$$\widehat{p}_{idd} = \frac{1}{N_p - 1}\left(1 + \sum_{n=1}^{N_p}\left\{S^{idd}_n \geq S\right\}\right) \tag{7}$$

These two methods are advantageous in small-sample settings because $\widehat{Y}^0_{1,t}$ is estimated under the null hypothesis. Notice that while the order of the residuals matters for *mb* permutations and the size of S^{mb} is determined by T, the size of S^{idd} is unconstrained, making *iid* permutations better-suited for precise p-value computations. Throughout the paper, the focus will be on testing the null hypothesis that the intervention had no effect:

$$H_0 : \theta_t = 0, \quad t > T_0 \tag{8}$$

To determine whether we can reject the null, the .05 threshold will be used. Additionally, p-values below .01 offer further support whereas those below .1 will be indicative of limited significance. However, we encourage readers to critically judge the credibility of the results beyond conventional levels of significance by carefully assessing the information provided. While we mainly consider p-values obtained via *iid* with 5,000 permutations for hypothesis testing, the results will be contrasted through *iid* with 1,000 and 10,000 permutations, as well as through *mb* permutations and RMSPE ratios. In addition, 90% confidence intervals for θ_t in the post-treatment period are computed via test inversion as described by Chernozhukov et al. (2021). These confidence intervals are included when reporting ATEs and accompany the plots showing the gap between observed and synthetic trends.

3.3 Data and specifications

The present study employs SC methods to estimate the effect of the IbEx on a series of price outcome variables.[†] For the donor pool of control units, we initially consider EU-27 countries plus Norway, as they all operate under the EU Electricity Directives and the CACM GL, and engage in market coupling through the SDAC. Cyprus and Malta are removed from the donor pool because they do not operate a wholesale electricity market of their own. Furthermore, the case of France is characterized by particularities which should be assessed carefully. As noted in section 2.5, the adjustment costs of the IbEx are partly financed through electricity exports to France. In this sense, it has been purchasing electricity from Spain at a corrected price since the beginning of the intervention. While France is well-connected with the rest of Europe and imports electricity from several countries other than Spain, we cannot rule out the possibility that the IbEx had an impact on the country's price level (Schlecht et al., 2022). Taking this into account, France is also removed from the control units. As a result, the analysis is carried out with 23 countries in the donor pool.

[†]The estimation of SC units is done in `R` using the `limSolve::lsei()` function (Soetaert et al., 2009). Computation of p-values via the *iid* and *mb* permutations, as well as of confidence intervals is done with the `scinference` package (Wuthrich, 2021).

The treatment effect is estimated for each country separately *i.e.*, Portugal is removed from the analysis to estimate an SC unit for Spain, and vice versa. First, the effect of the IbEx is estimated on wholesale electricity prices, for which we use the monthly average corrected day-ahead series for Spain and Portugal (OMIE, 2022b), and the monthly average day-ahead series for the countries in the donor pool (ENERGY-CHARTS, 2022) as outcome variables. Once we determine the effect on the raw price per MWh, we explore the impact of the policy on the overall price level. As mentioned in section 2.6, most countries in the donor pool implemented tax cuts in some form as a response to the energy crisis. To isolate the effect of the IbEx on inflation, we use different CPI categories at constant tax rates as outcome variables (EUROSTAT, 2018). We begin with the most general category, the overall index including all goods and services, and work our way through increasingly specific categories. Figure 7 shows the eight CPI categories considered in this study and the relationship between them. For instance, the overall index is composed of the goods-only and the services-only categories. Furthermore, the goods-only category results from combining the food-alcohol-tobacco index with the industrial-goods index. In turn, the industrial-goods index is composed of the energy index and the non-energy-industrial-goods index, which are at the most specific level considered here. Another way to conceptualise the overall index is as a combination of the energy index and the overall index excluding energy.

[Figure 7 here]

While SC methods have emerged over the last two decades as an easy-to-implement, yet powerful method to estimate treatment effects in natural experiments, there is a considerable lack of guidance on how to choose predictor variables. KAUL et al. (2016) show that using other covariates in addition to all pre-treatment outcome lags renders the former irrelevant in terms of $\widehat{\mathbf{V}}$. FERMAN et al. (2020) contribute to this line of research by providing recommendations to limit the possibilities for specification searching in the context of SC methods. While different SC specifications can generate different estimates, they show that different specifications will lead to asymptotically equivalent SC estimators as long as the number of pre-treatment lags used as predictors goes to infinity with T_0. Accordingly, they argue that specifications including all pre-treatment outcome lags as predictors satisfy the asymptotic equivalence condition. This specification is also advantageous because it minimizes the root mean square error in the pre-treatment period and it is not subject to arbitrary decisions regarding predictor selection. Following these insights, all the estimates presented in this paper result from specifications that include all pre-treatment outcome lags as predictors.

As this discussion illustrates, the choice of T_0 is also an important decision when applying SC methods. While the literature does not provide much guidance on this decision, several authors suggest that T_0 should be large compared to T_1 (Firpo and Possebom, 2018; Ferman et al., 2020). Taking this into account, this study considers three different time specifications A, B, and C, with $T_0^A = 48$, $T_0^B = 72$ and $T_0^C = 96$ months. Equivalently, four, six and eight years before the IbEx came into force. Furthermore, $T_1^* = 6$ in all three specifications.[‡] Another issue to consider is the fact that the intervention began on June 15, 2022, for which observations on this month fall on both sides of the treatment assignment. In order to isolate the effect of the IbEx, only full-month intervention periods are considered, such that the pre-intervention period goes up to May 2022, and the post-intervention period begins on July 2022. Figure 8 summarizes the three time specifications considered in this study.

[Figure 8 here]

Several authors have estimated the effect of the IbEx on MIBEL wholesale prices as well as the price paid by consumers under the PVPC tariff in Spain by estimating counterfactuals through different approaches (see for instance Schlecht et al., 2022, Hidalgo-Pérez et al., 2022, or Icae, 2022). However, no research goes beyond electricity markets to determine whether the intervention had an impact on the overall price level and its different categories. Furthermore, this study estimates the effects of the IbEx on both Spain and Portugal, which will allow us to identify whether the policy affected each country differently. These contributions make the present study unique in its approach, and render the conclusions drawn relevant towards evidence-based policy evaluation.

[‡] A series of considerations must be noted concerning the estimation of the effect of the IbEx on DAA. Firstly, the ENTSO-E only makes day-ahead auction price data available from January 2015 onward. As a result, specification C can only go up to 89 pre-treatment periods for this outcome. Furthermore, Ireland's day-ahead auction price data are subject to inconsistencies, for which this country is removed from the donor pool to estimate the effect on outcome DAA. Finally, day-ahead auction data for Bulgaria and Croatia are not available before October 2016 and October 2017 respectively, for which they are not included in the donor pool for specifications B and C.

4 Results

This section outlines the results from estimating the effect of the IbEx on wholesale electricity prices as well as eight CPI categories. The replication files for these results can be found in the following GitHub repository.

4.1 Day-ahead auction price

In order to determine whether the IbEx was successful in reducing the day-ahead price of electricity (DAA), we estimate an SC unit for Spain and Portugal using this variable as the outcome. Figure 9 summarizes the results for specification B, with Spain on the left and Portugal on the right. The top row shows the observed and synthetic series between June 2016 and December 2022, whereas the bottom row highlights the differences between them. Furthermore, the beginning of the IbEx is represented by a vertical dashed line on June 2022. Let us first focus on the top row of the figure. Notice how the observed trends for both treated countries are almost identical. This is due to the almost-full convergence in wholesale electricity prices between Spain and Portugal through the common market, MIBEL. Furthermore, both synthetic counterfactuals are able to match the observed trends, including the strong fluctuations in the months before the intervention. As soon as the intervention comes into force, however, the synthetic and observed trends begin to separate for both countries.

[Figure 9 here]

The bottom of the figure shows the effect of the IbEx on DAA for each country, with 90% confidence intervals in the post-treatment period. The largest difference between the observed and counterfactual outcomes occurs in August 2022, with both treated units registering gaps of around 160€/MWh. After the synthetic series recover from this spike, they return to an upward trend in October while the observed trends continue to decline. This indicates that the IbEx was successful in reducing some of the volatility in wholesale markets. In particular, the ATEs between July and December 2022 range between -54.5 and -53.0% for both countries across specifications A through C (see tables 1 and 2). Testing the null of zero effect via *iid* permutations yields p-values below .01 in all specifications, which allows us to reject the null that the IbEx had no effect on the treated at this level of significance (see tables 3 and 4). Once again, the results are very similar for both countries because the outcome of interest is almost identical.

4.2 Inflation

We have now established that the IbEx achieved a large reduction in the raw price of electricity in both Spain and Portugal, as measured by the day-ahead auction price. In this sense, it becomes relevant to determine how much of this reduction spilled over to the overall price level and its different subcategories.

4.2.1 Overall CPI

In order to get a general picture of the effect that the IbEx had on Spain and Portugal's inflation in its first full six months, let us first consider the CP00 index, which includes all items. Figure 10 shows the observed and synthetic series for both treated countries, as well as the gap between them. While Spain's SC unit follows the pre-intervention observed trend closely, the Portuguese SC unit is not able to match all of the seasonal fluctuations. The two treated countries also differ in the post-treatment period; on one hand, Spain's CP00 flattens after the intervention begins, while its synthetic counterfactual continues to follow an upward trend; on the other, and while the gap between them widens, Portugal's observed and synthetic CP00 trends follow the same trajectory.

[Figure 10 here]

The bottom of the figure shows that while the effect of the intervention on Spain's overall inflation could be positive in its first two months, it is unambiguously negative after August 2022. The ATEs between July and December are between -3.6 and -3.1% across the three specifications. While the effect is non-significant in specification A, the resulting p-values in specifications B and C are below .01, for which we can reject the null of no effect at this level of significance. Moving onto Portugal, figure 10 shows how while the effect trends downward, the size of this difference is comparable to the pre-treatment gasps. The resulting ATEs range between -1.3 and -1.2%, although none of the three specifications is statistically significant, for which we cannot rule out the possibility that the intervention had no effect on CP00.

Thus far, we have found similar effects of the IbEx for Spain and Portugal in terms of DAA. While this translated into a reduction of more than 3% in Spain's CP00, no significant effect was found on Portugal's overall inflation. We continue our analysis by estimating the effect of the intervention on subcategories of the CP00 index.

4.2.2 Goods vs services

The most straightforward subdivision of CP00 is among goods (GD) and services (SERV). Figure 11 shows the results from estimating SC units for Spain and Portugal, taking goods-only inflation as the outcome of interest. The results are very similar to the ones obtained for CP00, which points to the notion that most items included in the overall CPI are goods, as opposed to services. In the case of Spain, the effect of the policy intervention increases over time, particularly after August. The estimated ATEs range between -5.6 and -4.7%. Furthermore, we can reject the null of no effect at the .05 level in specification C. Similarly to CP00, the gap between Portugal's observed and synthetic GD series in the post-treatment period is negative, although comparable in size to the pre-treatment differences. While the resulting ATEs are between -2.0 and -0.6%, none of the specifications yields significant estimates.

[Figure 11 here]

Figure 12 summarizes the effect of the IbEx on SERV. While Spain's SC unit is able to match the observed trend closely, the fit of Portugal's SC unit is off throughout the time range under consideration. The resulting ATEs are within -1.0 and -0.7% for Spain, and -2.9 and -2.6% for Portugal. While Spain's estimate in specification C is significant at the .05 level, we cannot reject the null of no effect for Portugal in any of the specifications.

[Figure 12 here]

Putting together the results obtained thus far, we have that the reduction in DAA caused by the IbEx prompted Spain's CP00 to decline by more than 3%. This reduction is mainly explained by a decline in GD of around 5%. While the effect of the policy on Portugal's DAA is comparable to Spain's, its impact on inflation is unclear, as we are unable to reject the null of no effect for CP00, as well as for GD and SERV. Following these insights, we continue our analysis by breaking down the GD category.

4.2.3 Industrial goods vs food items

The goods-only subindex is composed of the industrial goods (IGD) category and the food, tobacco and alcohol (FOOD) category. Figure 13 shows the observed and synthetic IGD trends as well as the difference between them for the two treated countries. Looking at Spain first, the difference between the observed and synthetic series in the post-treatment period is negative and growing over time. Overall, the ATE in the first full six months of the intervention is between -8.8 and -7.6% across specifications. Furthermore, specifications B and C yield significant estimates at the .05 level. The effect of the policy on IGD is not as clear when looking at Portugal. While the SC unit matches the observed trend well throughout most of the pre-treatment period, the two series begin to diverge a year before the intervention. The resulting ATEs range between -4.4 and -3.2%, and while specification C yields limited significance, we fail to reject the null of no effect in the other two specifications.

[Figure 13 here]

Figure 14 outlines the results for both treated countries taking FOOD as the outcome. The ability of Spain's SC unit to match the observed trend is remarkable, both in the pre and post-treatment periods. As a result, the estimated ATEs are very close to zero and range between -0.6 and 0.3%. The associated p-values are all above .05, which is consistent with the ambiguity of these estimates, as we fail to reject the null of no effect. The results for Portugal draw a similar picture, with the synthetic counterfactual following the observed trend closely on both sides of the treatment assignment. A few months before the intervention, however, the two trends begin to diverge, which results in positive ATEs, ranging between 0.8 and 1.4%. Furthermore, we fail to reject the null of no effect in all three specifications.

[Figure 14 here]

These results are consistent with our findings so far. In the case of Spain, the reduction in GD caused by the IbEx is fully explained by a decline in IGD. The impact on Portugal's inflation continues to be undetectable, as we are unable to reject the null of no effect for any of the inflation categories considered up to this point. We continue our analysis by exploring two further categories within the IGD index.

4.2.4 Energy vs non-energy industrial goods

The energy (NRG) and non-energy industrial goods (IGDxNRG) indices combine to form the IGD index. While the former includes electricity, gas and other fuels, the latter is composed of durable, semidurable and nondurable industrial goods. Figure 15 summarizes the results from estimating SC units for Spain and Portugal's NRG. Let us first analyse Spain, shown on the left side of the figure. While the synthetic and the observed trends move jointly in the pre-treatment period, they abruptly diverge as soon as the intervention begins. Even with the SC unit trending downwards after October 2022, the gap between the two series does not shrink, reaching up to 51 index points in December. Overall, the ATE ranges between -26.6 and -20.9%, which is by far the largest effect estimated for any CPI category so far. Specifications B and C yield statistically significant estimates at the .05 and .01 levels, respectively. The results obtained for Portugal are in line with the insights gathered up to this point. The SC unit is able to match the observed trend closely, and while the two series diverge slightly in the post-treatment period, they follow the same inverted double-u pattern. This results in ATEs between 0.5 and 1.4, which indicates that the effect could be well above zero. However, we are unable to reject the null of zero effect for any of the three specifications.

[Figure 15 here]

Next, we estimate the effect of the IbEx on IGDxNRG. Figure 16 shows the observed trends and the estimated SC units for Spain and Portugal, as well as the gap between them. The IGDxNRG series for both countries is characterized by strong seasonal fluctuations, which the SCs are able to match well in both cases. The resulting ATEs are comparable, ranging between -1.5 and -1.2% for Spain and -0.5 and 0.1 for Portugal. Furthermore, testing for the null of no effect results in p-values well above .05 for both countries, for which we cannot rule out the possibility that the IbEx had no effect on IGDxNRG.

[Figure 16 here]

In line with our findings up to this point, we have that the reduction in Spain's IGD achieved by the IbEx was caused by a large reduction in NRG. In turn, the decline in the overall price level of industrial goods is due to a reduction in goods-only inflation, which contributed to alleviating the overall price level as indicated by CP00. The NRG category is specific enough to allow us to draw a connection between the reduction in day-ahead auction price outlined in section 4.1 and the decline in inflation. While we may not continue to break down CPI categories, a relevant exercise at this point is to analyse how much of this reduction in energy items spilled over to non-energy items.

4.2.5 Overall index excluding energy

To complete our analysis of the effect of the IbEx on inflation, we estimate SC units for CP00xNRG, which results from removing NRG items from the CP00 index. Figure 17 displays the results from this estimation. Let us focus on Spain first, which showcases a remarkable pre-treatment match between the observed and synthetic series. This good pre-treatment fit allows for the post-treatment gap to stand out, despite it being not very large in percentage terms. The resulting ATEs are between -1.1 and -0.9%, with specification C yielding significant estimates at the .05 level. We continue by examining Portugal's estimate. While the SC unit follows the observed pre-treatment trend closely, the few fluctuations it misses undermine the size of the post-treatment difference. As a result, the estimated ATEs range between -0.1 and 0.1, for which the effect could be both positive and negative. The fact that no specification yields p-values below 0.8 goes in line with the ambiguity of these estimates.

[Figure 17 here]

4.3 Sensitivity Analysis

Throughout this section, we have found considerable differences between Spain and Portugal in terms of the effect of the IbEx on inflation. Before we explore the reasons behind this divergence, let us analyze the consistency of the estimates across specifications. Spain's ATEs and 90% confidence intervals for all three specifications can be found in table 1 of the appendix. The estimates are stable across specifications, with the only outlier being NRG; while the ATEs for specifications A and B are within one percentage point of each other, the estimate for specification C differs by five percentage points. On the other hand, the confidence intervals are compatible across specifications, for which the divergence in the ATEs should not be a major source of concern. The largest confidence intervals are obtained for outcome variables DAA and

NRG, although they are proportional to the size of the ATEs. One additional insight from table 1 relates to the relationship between the range of the confidence intervals and the number of pre-treatment periods; as T_0 increases, the confidence intervals tend to become narrower for all variables.

In section 3.2 we outlined three different inferential methods in the SC literature; RMSPE ratios, *mb* permutations and *iid* permutations. So far, we have only considered the *iid* method with 5,000 permutations. At this point it is relevant to explore how p-values behave as the number of *iid* permutations changes, as well as in the other two methods. Table 3 shows the resulting p-values for Spain via *iid* with 1,000, 5,000 and 10,000 permutations. Firstly, it is relevant to note that, given the thresholds under consideration, testing the null hypothesis of no effect yields the same results for any given outcome and T_0 across the three *iid* permutations presented in the table. One pattern that stands out is that the size of the p-values tends to decline as T_0 increases for all outcomes, except SERV and FOOD. Overall, the p-values obtained via *iid* permutations are stable and tend to converge as T_0 and the number of permutations increase. This highlights a major advantage of *iid* permutations over other SC inferential methods *i.e.*, resampling allows for more precise p-value computations (Chernozhukov et al., 2021).

Shifting our focus to inference conducted via *mb* permutations, table 5 reports p-values obtained through this method to test the null of no effect for Spain's estimates. The most apparent pattern is that *mb* permutations yield larger p-values than *iid* permutations. This is due to the way in which each of these p-values is computed; while resampling allows for S^{iid} to be large, the size of S^{mb} is determined by T (see equations (6) and (7)). As a result, we can only reject the null of no effect for outcomes DAA and CP00 when using this method. Limited significance is obtained for outcomes GD, IGD and CP00xNRG. Overall, and considering that *mb* permutations yield larger p-values by construction, the two methods produce comparable results. For instance, the largest p-values result from specification A and outcomes IGDxNRG and FOOD in both cases, whereas the smallest arise from specification C and outcome DAA and CP00.

We continue our analysis by looking into table 7, which shows Spain's p-values computed via RMSPE ratios. Conducting inference via this method delivers very different results than the ones obtained so far. For example, the effect on DAA, which is the most powerful as indicated by *iid* and *mb* permutations, is not deemed significant through RMSPE ratios. Furthermore, we are only able to reject the null of zero effect for outcome NRG in specifications A and C. Interestingly, specification B for this outcome yields the largest p-value in the entire table. These examples illustrate the inconsistencies in this method, discussed in section 3.2, and largely contradict the results obtained via *iid* and *mb* permutations.

Computing results for different specifications which vary in terms of T_0 allows us to test the sensitivity of the estimates in the time dimension. To analyze how the results change with respect to the units included in the donor pool, we conduct leave-one-out sensitivity tests (Abadie et al., 2015). This is done by iteratively estimating an SC unit for each of Spain's outcome variables, excluding from the control pool one unit whose assigned weight was non-zero. We are particularly interested in identifying *destabilizing units i.e.*, those that when removed turn a previously non-significant result into significant, and vice versa, using the .05 threshold as a reference. Figure 18 shows the distribution of p-values from testing the null of no effect on Spain's results removing one unit from the donor pool at a time. Furthermore, *destabilizing units* are labelled next to the p-values obtained after removing them from a particular specification. For instance, the results for DAA are very stable, as they are not dependent on individual units being included in $\widehat{\mathbf{W}}$. By contrast, removing Luxembourg or Estonia from specification B for outcome GD turns it significant. Similarly, excluding Italy from the donor pool reverses the significance of specification C for this outcome. More important for our results, outcome NRG is sensitive to whether Luxembourg is included in specifications B and C. In any case, the resulting p-values are well below .1, and specification C without Luxembourg yields a p-value of .0503. Another intriguing result from this test arises from specification C for outcome CP00xNRG. While all the other p-values are below .035, removing Italy from the donor pool results in .866. This indicates a big dependence on this unit and brings into question the evidence pointing to some of the reduction in energy inflation spilling over to non-energy items.

[Figure 18 here]

With a better sense of the sensitivity of Spain's results across the time and unit dimensions as well as through different inferential approaches, we shift our focus to Portugal.

Table 2 reports Portugal's ATEs for the different outcomes and specifications considered in this study. Portugal's estimates are also consistent across specifications, with only GD showing somewhat considerable fluctuations in specification A compared to B and C. The confidence intervals for this outcome, however, are coherent across the three specifications. Contrary to Spain, the size of the confidence intervals remains stable as T_0 increases. Only the results for DAA and GD are characterized by a reduction in the range of the confidence interval as the number of pre-treatment periods grows.

Table 4 shows the resulting p-values for Portugal via *iid* with 1,000, 5,000 and 10,000 permutations. In this case, the p-values do not necessarily decline with T_0, as illustrated by outcomes SERV, FOOD, NRG, IGDxNRG and CP00xNRG. Some of these outcomes even display an inverted U-shape in terms of p-values, with specification B yielding the largest ones. Additionally, outcome GD obtains limited significance in specification C. This provides some evidence that the IbEx had some effect on the goods-only price level. However, the fact that no significant effect was found for other outcomes above or below this category suggests that this finding must be interpreted with caution.

In order to contrast these results, let us analyze Portugal's p-values obtained via *mb* permutations, shown in table 6. Once again, we see a correspondence across the results obtained via *iid* and *mb* permutations; although at different scales, the largest and smallest p-values coincide between the two approaches for the most part. In addition to GD being below .1 in specification C, the estimate for outcome IGD also obtains limited significance. This provides additional support to the notion that the IbEx achieved a reduction in goods-only inflation by lowering the industrial goods index. On the other hand, the p-values for NRG are consistently above .5 in tables 4 and 6, for which we are unable to find a mechanism connecting the reduction in day-ahead prices to that of industrial goods.

Table 8 reports p-values computed via RMSPE ratios for Portugal's estimates. Like what we saw for Spain, DAA is deemed highly insignificant, despite contradicting evidence from *iid* and *mb* permutations, as well as graphically in figure 9. In this sense, we should be careful about relying on RMSPE ratios for inference in this setting.

We conclude by carrying out the leave-one-out sensitivity test for Portugal, whose results are summarized in figure 19. Portugal's results are very stable, with only outcome IGD containing a *destabilizing* unit; removing Finland from all three specifications yields p-values below .05. This, added to the evidence gathered via *iid* and *mb* permutations, points to the notion Portugal's goods-only inflation was reduced by about 2% between June and December 2022. Due to the reasons explained above, we are unable to link this reduction to the IbEx. However, it is reasonable to think that another anti-inflation measure implemented in Portugal around this time is responsible for this effect.

[Figure 19 here]

5 Discussion

In the previous section, SC methods were employed to estimate the effect of the IbEx on the day-ahead auction price as well as a series of CPI categories, for both Spain and Portugal. In terms of the day-ahead auction price, the intervention achieved a reduction of about 54% in both countries, with almost identical results. As we explore whether this reduction in the raw price per MWh translated into a reduction in the overall price level, the difference between the two countries becomes stark. On one hand, the decline in the wholesale electricity price prompted Spain's energy inflation to decrease by more than 20%. This in turn caused a reduction of 8% in the price level of industrial goods, which translated into a drop in goods-only inflation of about 5%. As a result of this process, Spain's overall inflation was reduced by more than 3% during the first six full months of the IbEx. When looking at Portugal, however, the effect of the intervention on CPI remains undetectable. While the estimates for the different CPI categories range between -5 and 2%, none of them is statistically significant.

To make sense of this difference, we must look into the mechanism that links wholesale electricity prices with the overall price level in each of these countries. In the case of Spain, there is a direct connection between wholesale markets and the price paid by consumers. As explained in section 2.4.1, the regulated PVPC tariff is directly indexed by MIBEL day-ahead auction prices. Therefore, any reduction in the wholesale price of electricity is immediately felt by consumers under the PVPC, which make up to

40% of households and firms using up to 10kW. While this has allowed a portion of Spanish consumers to directly benefit from the IbEx, the design of the PVPC has been criticized for exposing consumers to the volatility of wholesale markets. As a result, the EC enabled the approval of the IbEx under the condition that Spain amends the formulation of the PVPC to reflect long-term contracts.

When looking at Portugal, there is no direct link between wholesale prices and consumers' electricity bills. The price of the regulated tariff in Portugal is based on MIBEL prices from a year prior. As such, consumers under this tariff will have to wait until June 2023 to benefit from the IbEx. Additionally, only 5% of consumers receive their electricity through the regulated scheme, for which the effect of a reduction in the tariff on Portugal's CPI is expected to be rather small, if at all.

The IbEx outlines that, on top of consumers whose electricity bill is indexed by wholesale prices, the mechanism should also benefit other consumers in the retail market as their contracts expire and get renewed taking into account the price correction. In this sense, part of the estimated reduction in Spain's energy inflation in the previous section is likely due to a "second wave" of effects of the IbEx. This is made evident by looking at the impact of the intervention on the day-ahead auction price, which follows an erratic up-and-down pattern (see bottom left of figure 9). By contrast, the effect on Spain's NRG follows an obvious downward trend which increases over time (see bottom left of figure 15). This suggests that the reduction in DAA alone cannot fully explain the decline in NRG. By contrast, there is no evidence of a delayed effect of the IbEx on Portugal's inflation, which would be indicative of retail companies updating their contracts based on the correction mechanism. This relates to the lack of competition in Portugal's energy sector, as outlined in 2.4.2, and suggests that the few companies that dominate the retail market did not face incentives to revisit their prices after the IbEx came into force. At the time of writing, retail electricity prices for the second semester of 2022 were not yet published by *Eurostat*. Once these data become available, it would be interesting to explore the explanation for Portugal's results by estimating synthetic counterfactuals with the retail price of electricity as outcome variable.[§]

[§]The updated dataset is set to be released on April 26, 2023 (Eurostat, 2023).

We can extend the lessons from the IbEx beyond Spain and Portugal to better understand wholesale electricity markets in the EU. The energy crisis has shown that while gas-fired electricity may have the same uses as electricity produced from other sources, they are two different creatures when it comes to pricing. As the transition to a low-emissions economy moves forward and the EU shifts away from Russian gas, we can only expect this source of energy to get increasingly expensive. In this sense, the EU electricity market should incorporate a decoupling mechanism between gas and other technologies, just like the IbEx does. Another option is illustrated by the EU-wide emergency correction mechanism which automatically applies when international gas prices sit above 180€/MWh for three consecutive days. Throughout its first four weeks in place, the mechanism is yet to be activated, for which we will pay special attention to analyze its effectiveness in alleviating price volatility in the coming months.

On March 14, 2023, the EC unveiled a reform proposal for the EU electricity market. Instead of amending the wholesale of electricity, the draft focuses on reframing long-term contracts in the retail market to shield consumers from price surges. In particular, the EC wants to make three contract types uniform across Member States; one designed for firms which goes up to 15 years; another one for households which goes up to three years; and one for governments which establishes a price range such that, if electricity prices fall below the lower limit, the state must compensate energy providers, whereas if prices exceed the upper limit, the state is entitled the difference (Directorate-General for Energy, 2023). This constitutes the latest development in the energy crisis and foretells a long back-and-forth process between Member States and the Commission until legislation is approved. It also highlights the need for researchers to continue to contribute to the discussion through evidence-based policy analysis.

6 Conclusion

This paper has gathered unique insights into the link between wholesale electricity markets and the overall price level by estimating the effect of the Iberian exception on different price indicators using synthetic control methods. In particular, we analyzed the day-ahead auction price of electricity as well as a series of increasingly specific

CPI categories. This strategy allowed us to draw a causal mechanism between a 54% reduction in the wholesale price of electricity prompted by the Iberian exception with a 3% drop in Spain's overall inflation, summarized as follows: the decline in wholesale electricity prices reduced energy-items inflation by more than 20%, which prompted the industrial-goods inflation category to drop by 8%. This caused a 5% reduction in the goods-only price level, which explains the reduction in the overall CPI. While a comparable reduction in the day-ahead auction price of electricity was also estimated for Portugal, no significant effect was found for any of the inflation categories under consideration.

The divergence in the results is mainly explained by the different retail market structures in each country. On one hand, Spain's PVPC tariff –which serves roughly 40% of small consumers– is directly indexed by wholesale prices. The large reduction in energy inflation is also likely due to a "second wave" of effects of the intervention, as electricity retailers updated the contracts of the remaining 60% of consumers taking into account the price reduction. On the other, no electricity tariff in Portugal is directly indexed by wholesale prices. Additionally, the fact that no delayed effect of the policy was found for any of Portugal's CPI categories suggests that retail companies have not revised their prices 6 months into the intervention. This highlights the lack of competition in Portugal's electricity retail sector, with a few firms controlling a large share of the market.

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Appendix

A.1 Figures

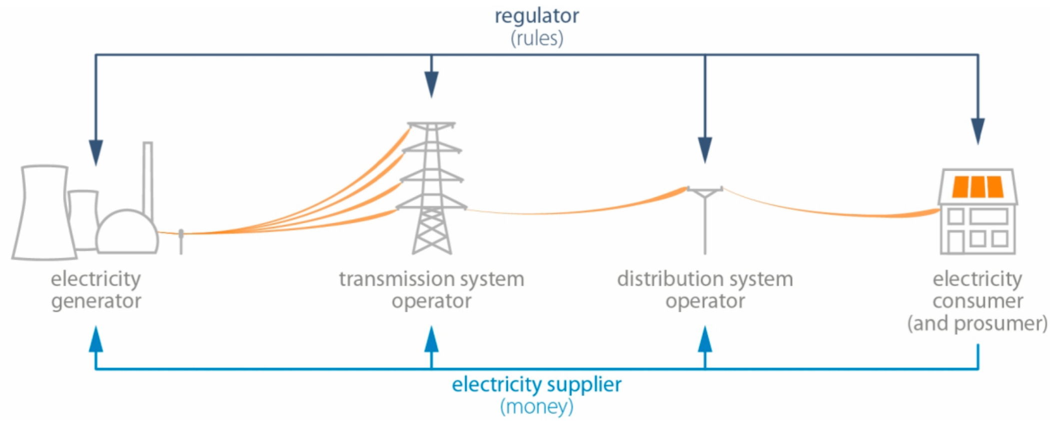

Figure 1. The electric grid. Source: ERBACH (2016).

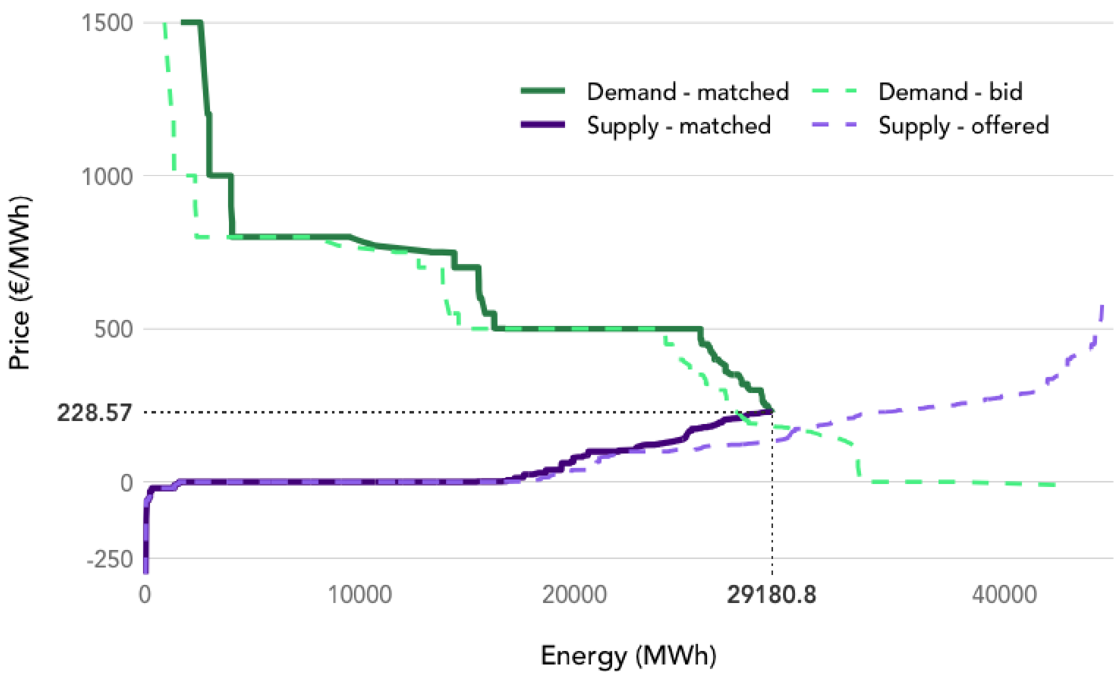

Figure 2. MIBEL supply and demand curves for hour 12 on 26/04/2022, which resulted in 29180.8 MWh sold at 228.57 €/MWh.

Source: OMIE (2022a).

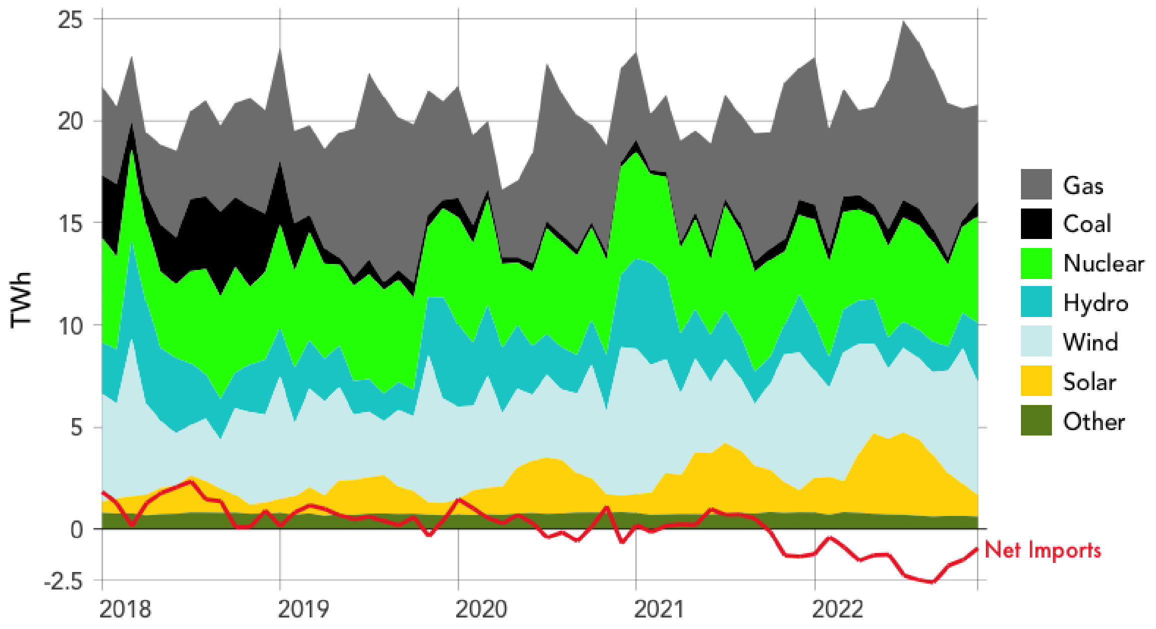

Figure 3. Monthly aggregated electricity generation in Spain by source between 2018 and 2022. Source: Energy-Charts (2022), own calculations.

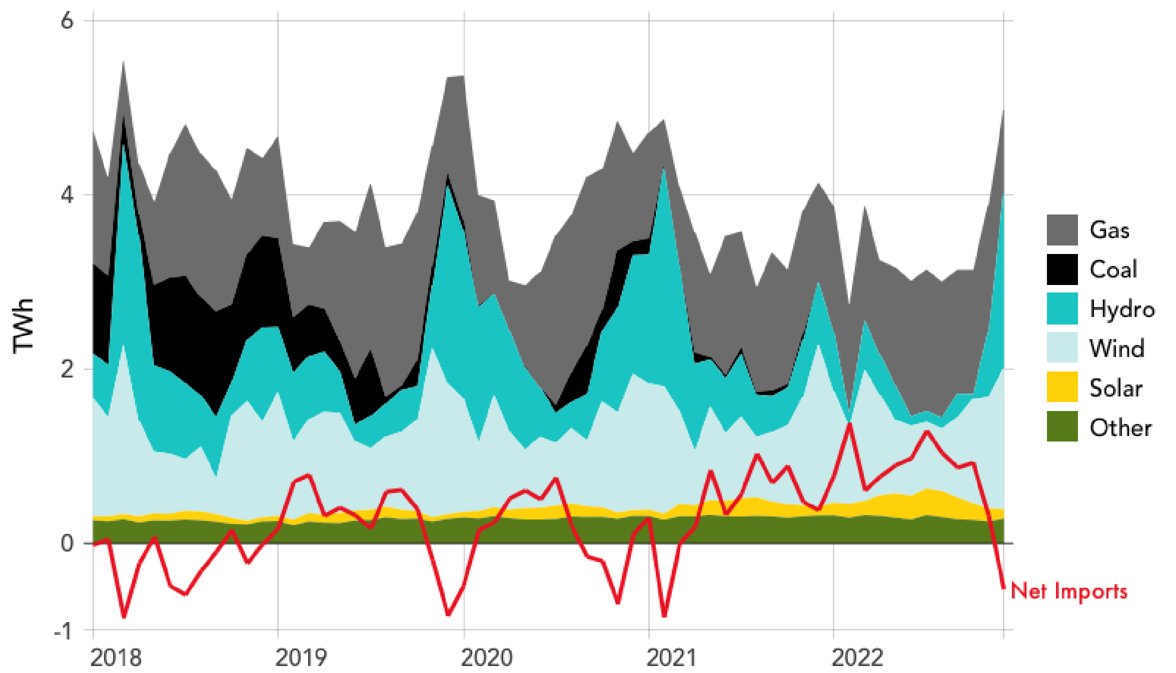

Figure 4. Monthly aggregated electricity generation in Portugal by source between 2018 and 2022. Source: Energy-Charts (2022), own calculations.

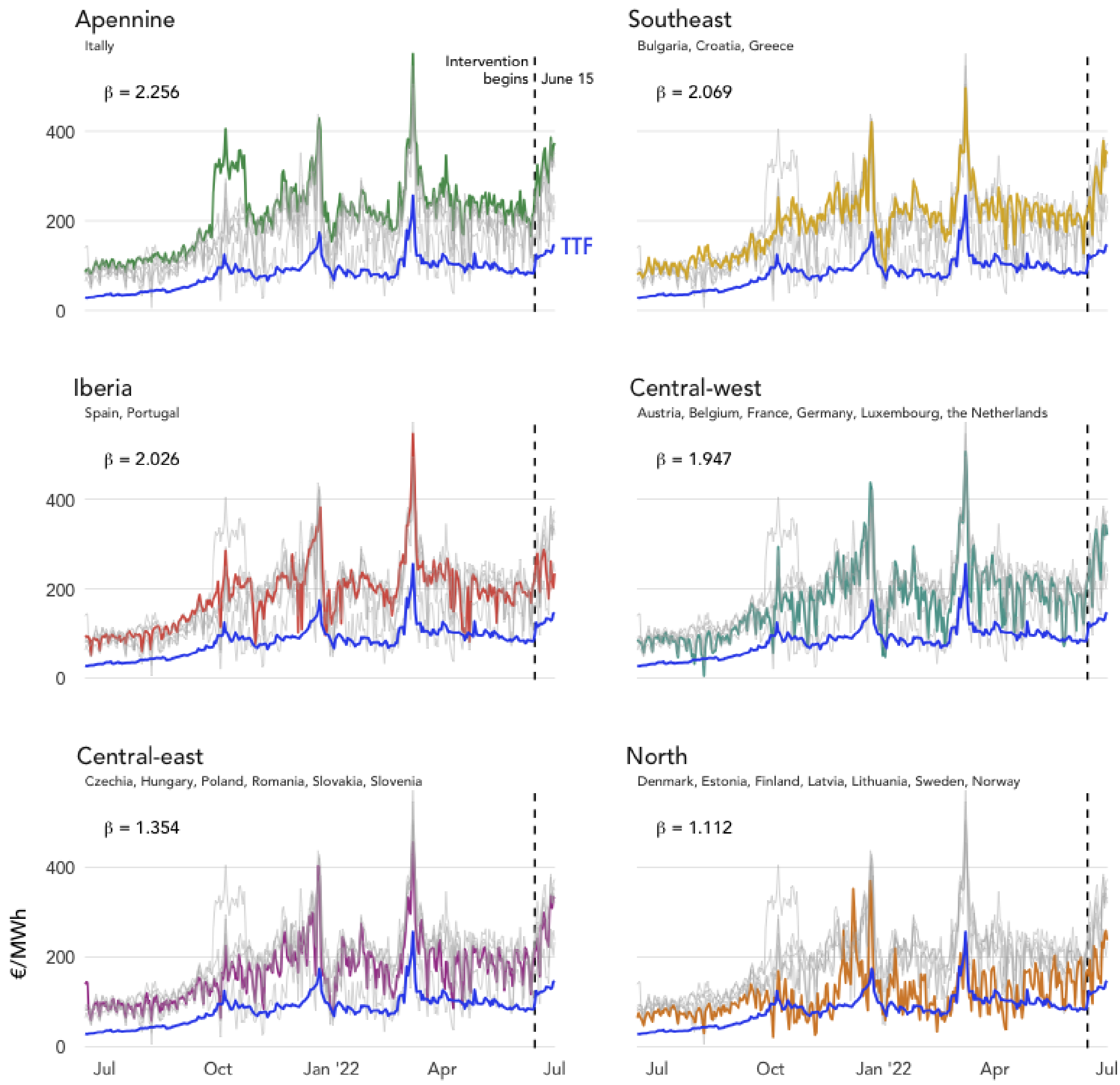

Figure 5. Evolution of TTF month-ahead gas contract and daily mean day-ahead electricity prices for six European regions. β are OLS coefficients from regressing wholesale electricity prices on TTF futures for each region.

Source: Energy-Charts (2022), Barchart (2022), own calculations.

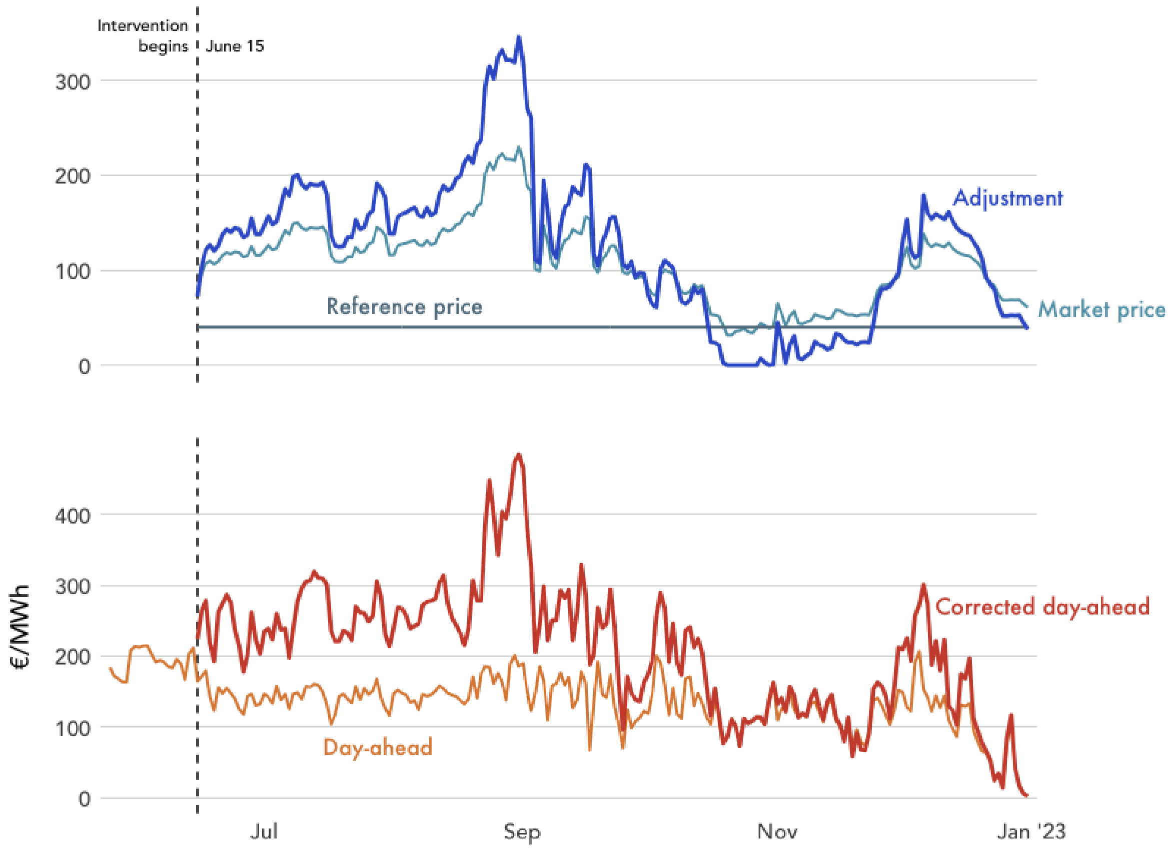

Figure 6. *Top*: Daily adjustment cost paid to gas generators as a function of the reference and market price.
Bottom: Daily average day-ahead MIBEL auction price and the corrected day-ahead auction price under the Iberian exception mechanism.

Source: Energy-Charts (2022), Omie (2022b), own calculations.

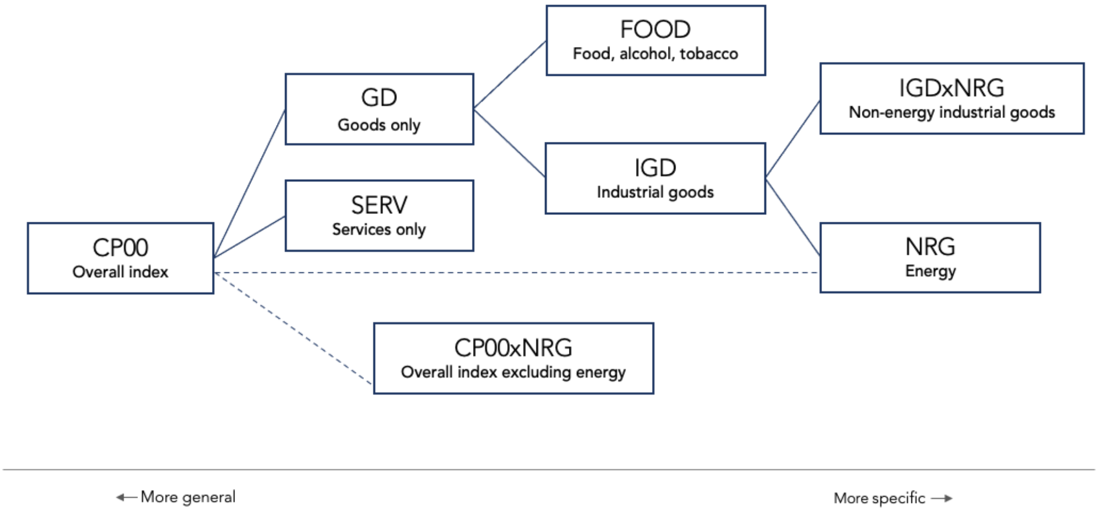

Figure 7. The eight CPI outcome variables considered in this study and the relation between them. Source: EUROSTAT (2018), own elaboration.

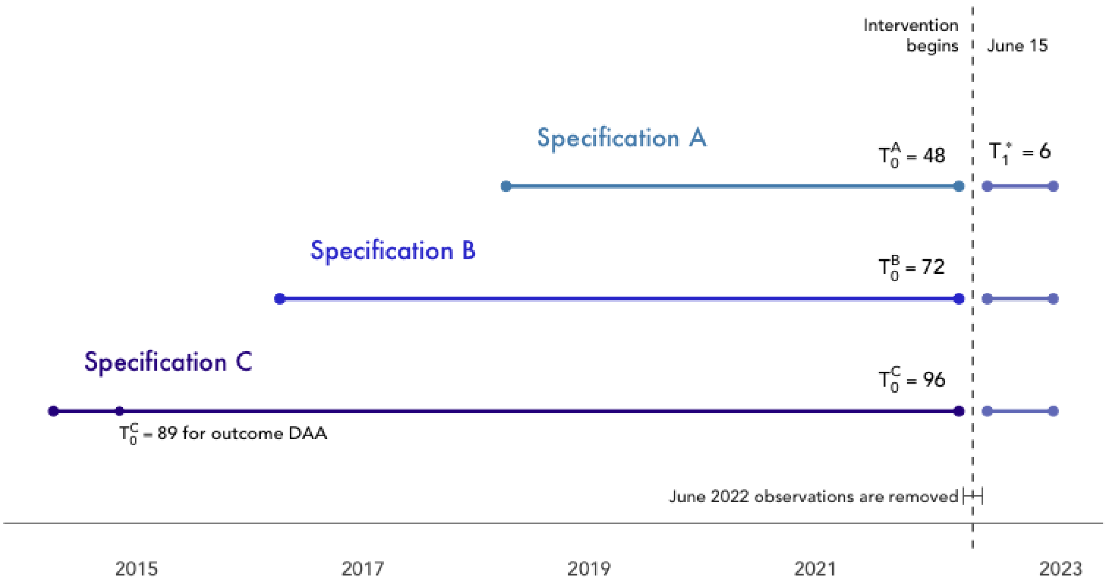

Figure 8. Specifications A, B and C, differing in the number of pre-treatment periods T_0. Source: own elaboration.

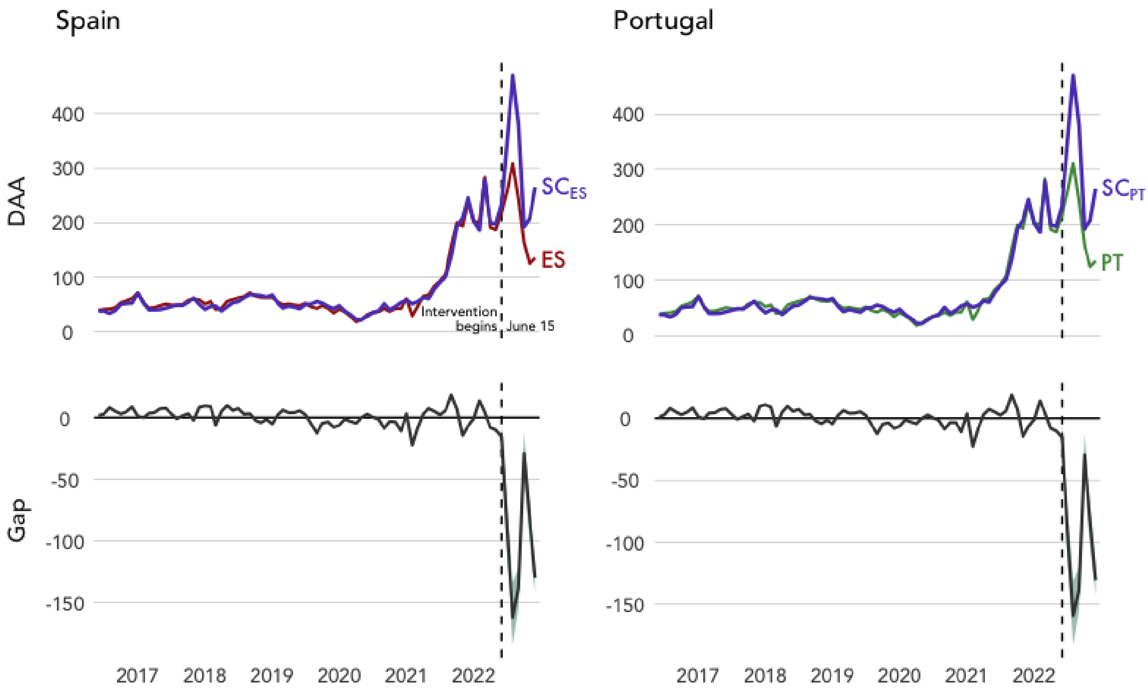

Figure 9. *Top*: Observed and synthetic DAA trends for Spain and Portugal. *Bottom*: Difference between observed and synthetic trends with 90% confidence intervals.

Source: ENERGY-CHARTS (2022), OMIE (2022b), own calculations.

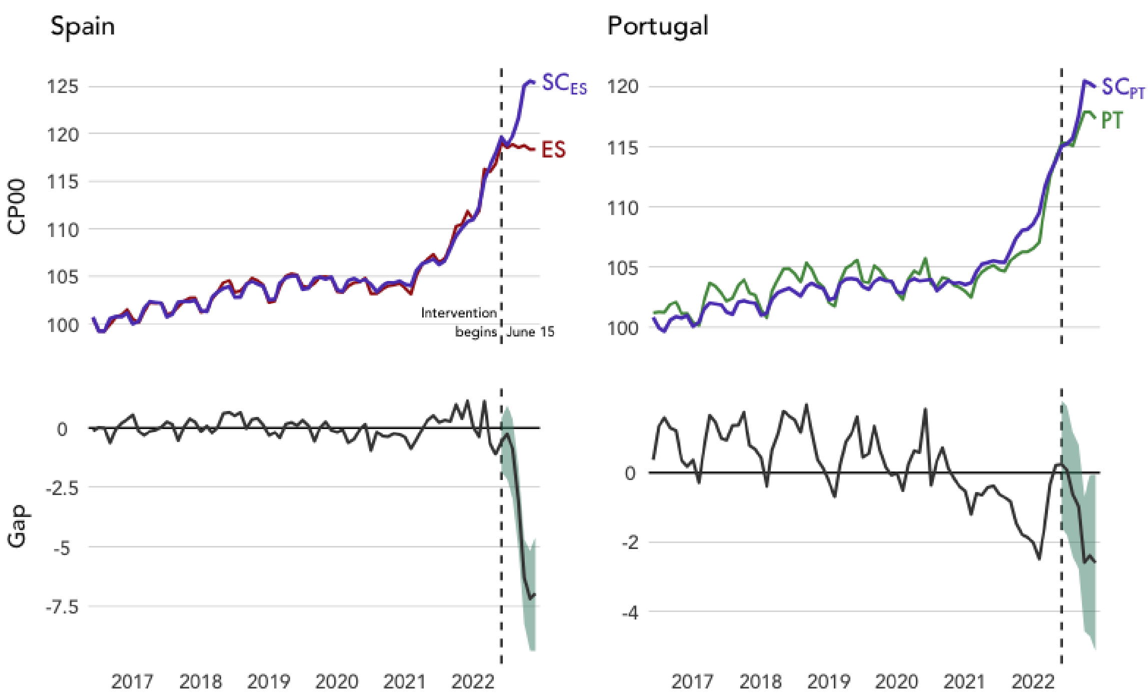

Figure 10. *Top*: Observed and synthetic CP00 trends for Spain and Portugal. *Bottom*: Difference between observed and synthetic trends with 90% confidence intervals.

Source: EUROSTAT (2018), own calculations.

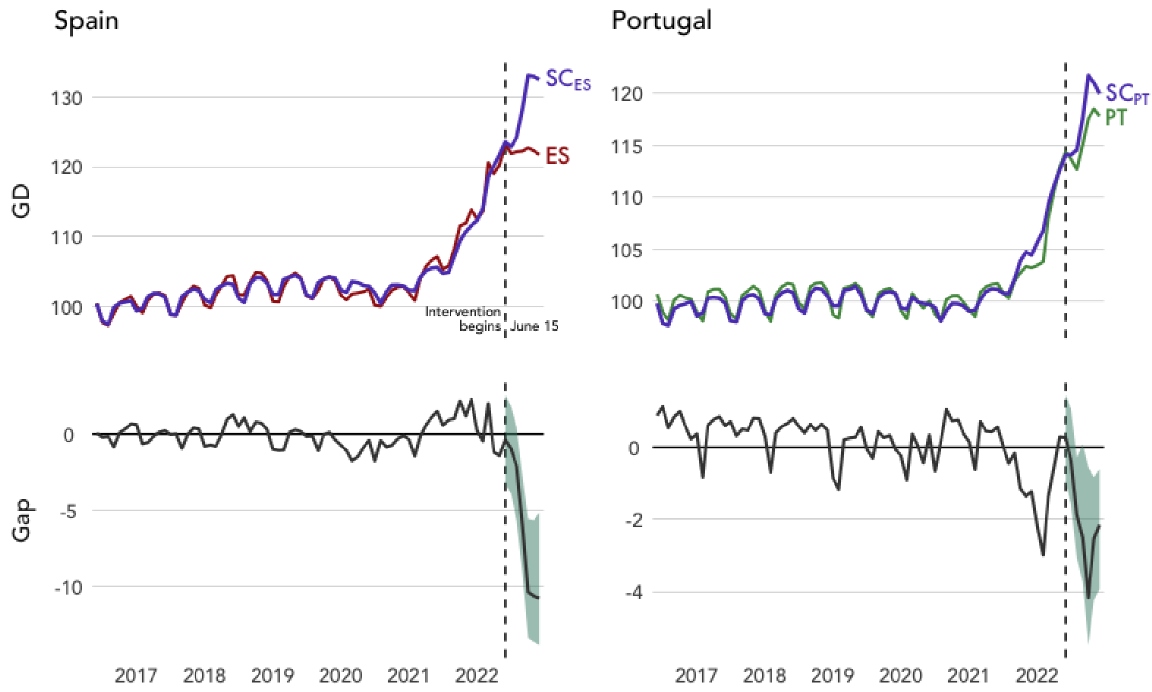

Figure 11. *Top*: Observed and synthetic GD trends for Spain and Portugal. *Bottom*: Difference between observed and synthetic trends with 90% confidence intervals.

Source: EUROSTAT (2018), own calculations.

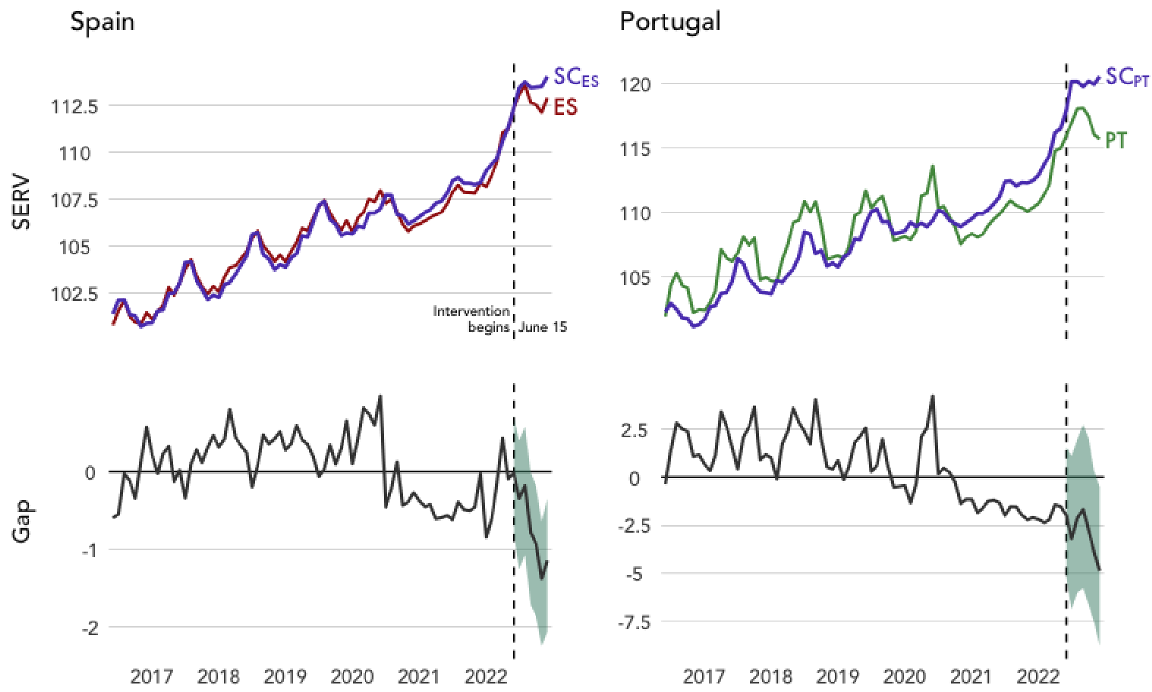

Figure 12. *Top*: Observed and synthetic SERV trends for Spain and Portugal. *Bottom*: Difference between observed and synthetic trends with 90% confidence intervals.

Source: EUROSTAT (2018), own calculations.

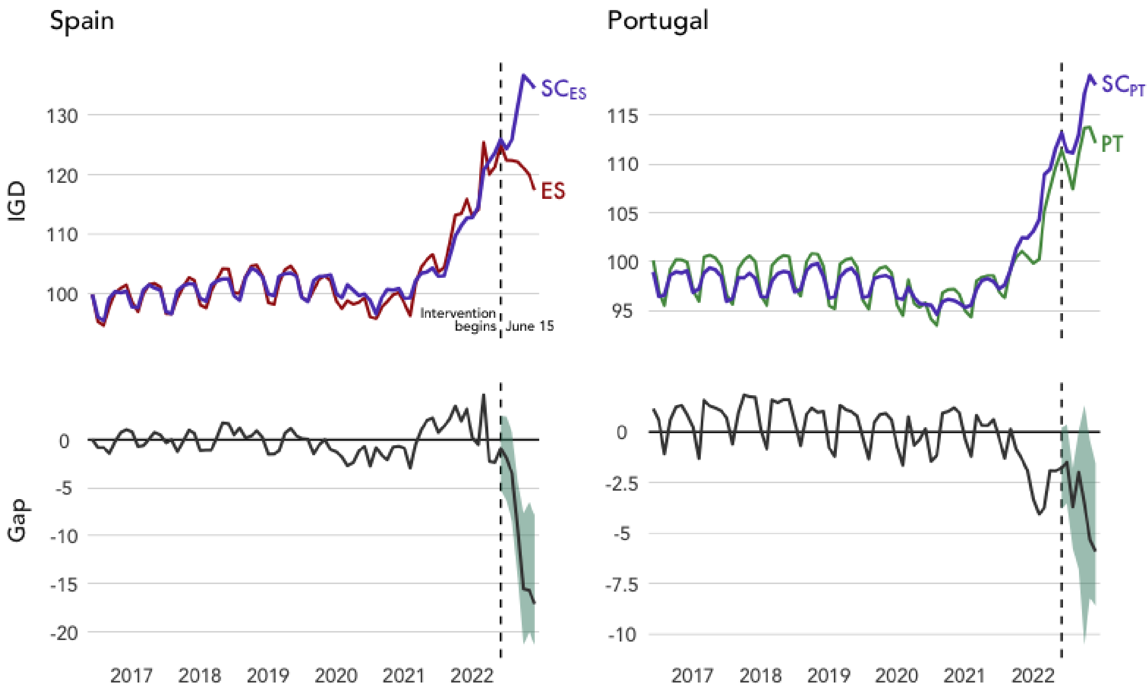

Figure 13. *Top*: Observed and synthetic IGD trends for Spain and Portugal. *Bottom*: Difference between observed and synthetic trends with 90% confidence intervals.

Source: EUROSTAT (2018), own calculations.

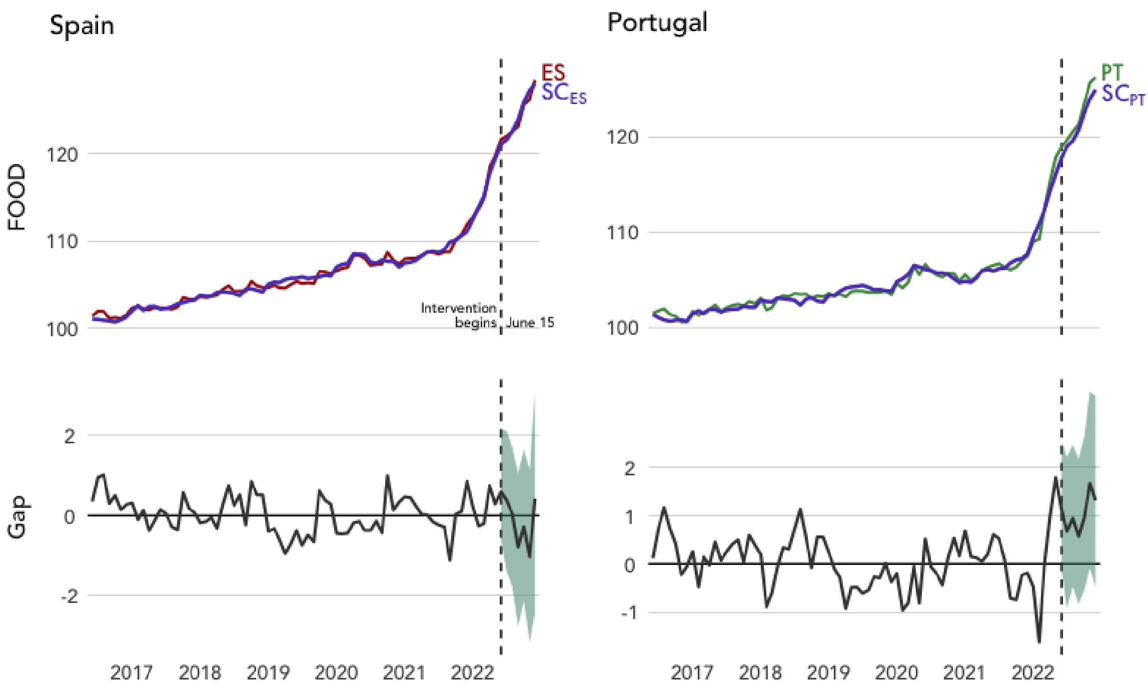

Figure 14. *Top*: Observed and synthetic FOOD trends for Spain and Portugal. *Bottom*: Difference between observed and synthetic trends with 90% confidence intervals.

Source: EUROSTAT (2018), own calculations.

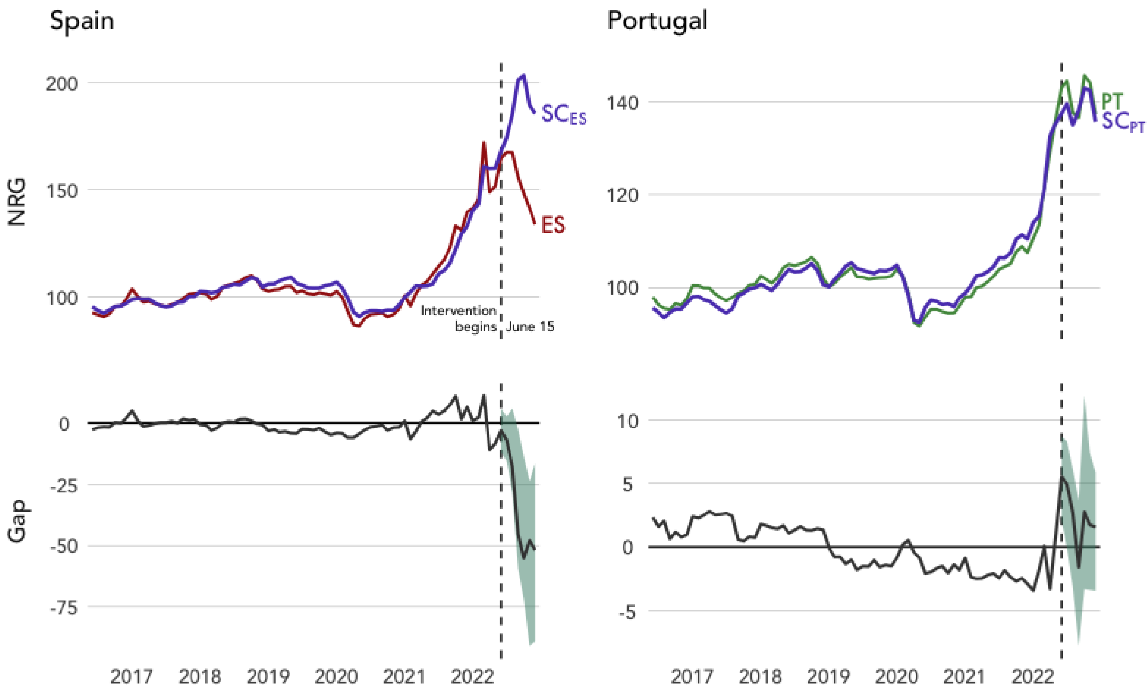

Figure 15. *Top*: Observed and synthetic NRG trends for Spain and Portugal. *Bottom*: Difference between observed and synthetic trends with 90% confidence intervals.

Source: EUROSTAT (2018), own calculations.

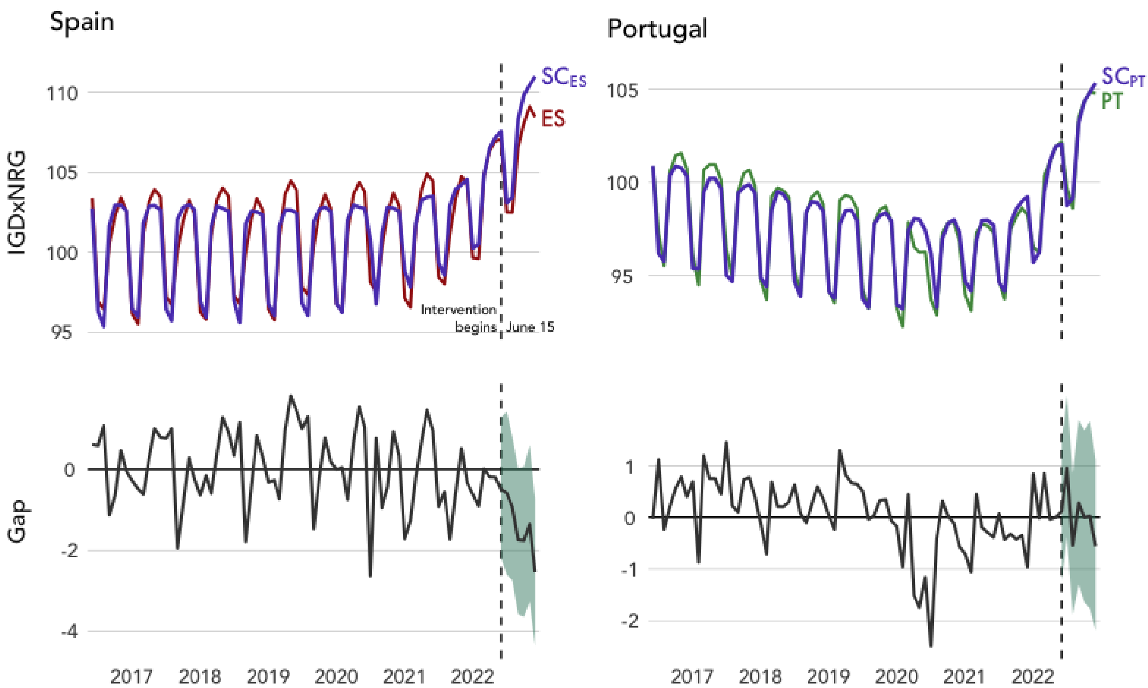

Figure 16. *Top*: Observed and synthetic IGDxNRG trends for Spain and Portugal. *Bottom*: Difference between observed and synthetic trends with 90% confidence intervals.

Source: EUROSTAT (2018), own calculations.

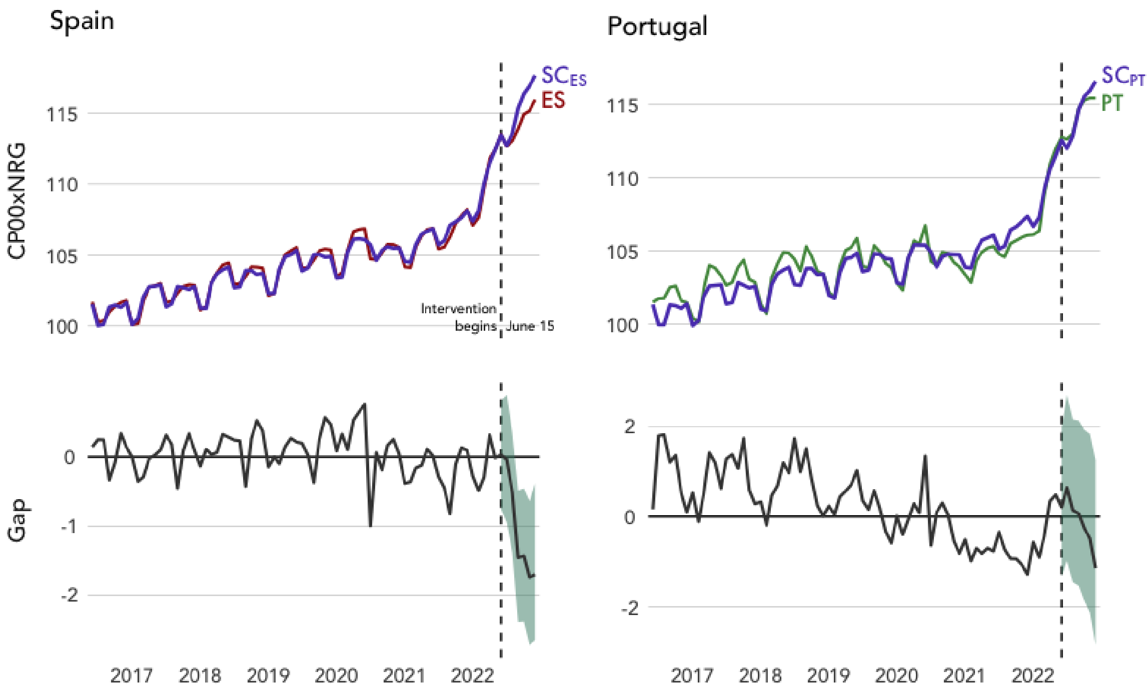

Figure 17. *Top*: Observed and synthetic CP00xNRG trends for Spain and Portugal. *Bottom*: Difference between observed and synthetic trends with 90% confidence intervals.

Source: EUROSTAT (2018), own calculations.

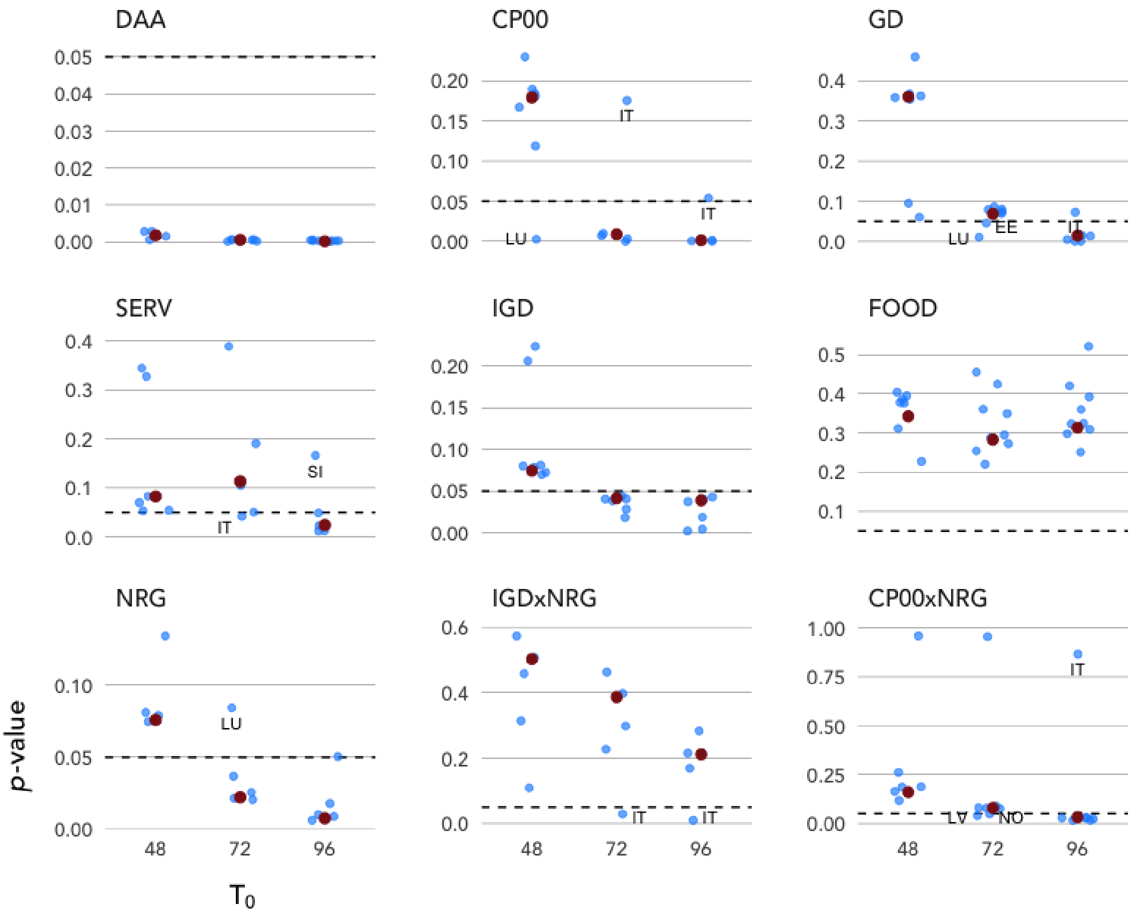

Figure 18. Distribution of p-values from testing the null hypothesis (8) on Spain's estimates leaving out one of the control units with non-zero weight. *Destabilizing units* at the .05 threshold –which is represented by a horizontal dashed line– are labeled. The red dots correspond to the p-values obtained with all the units in the donor pool. All p-values are computed via *iid* with 5,000 permutations.

Source: own calculations.

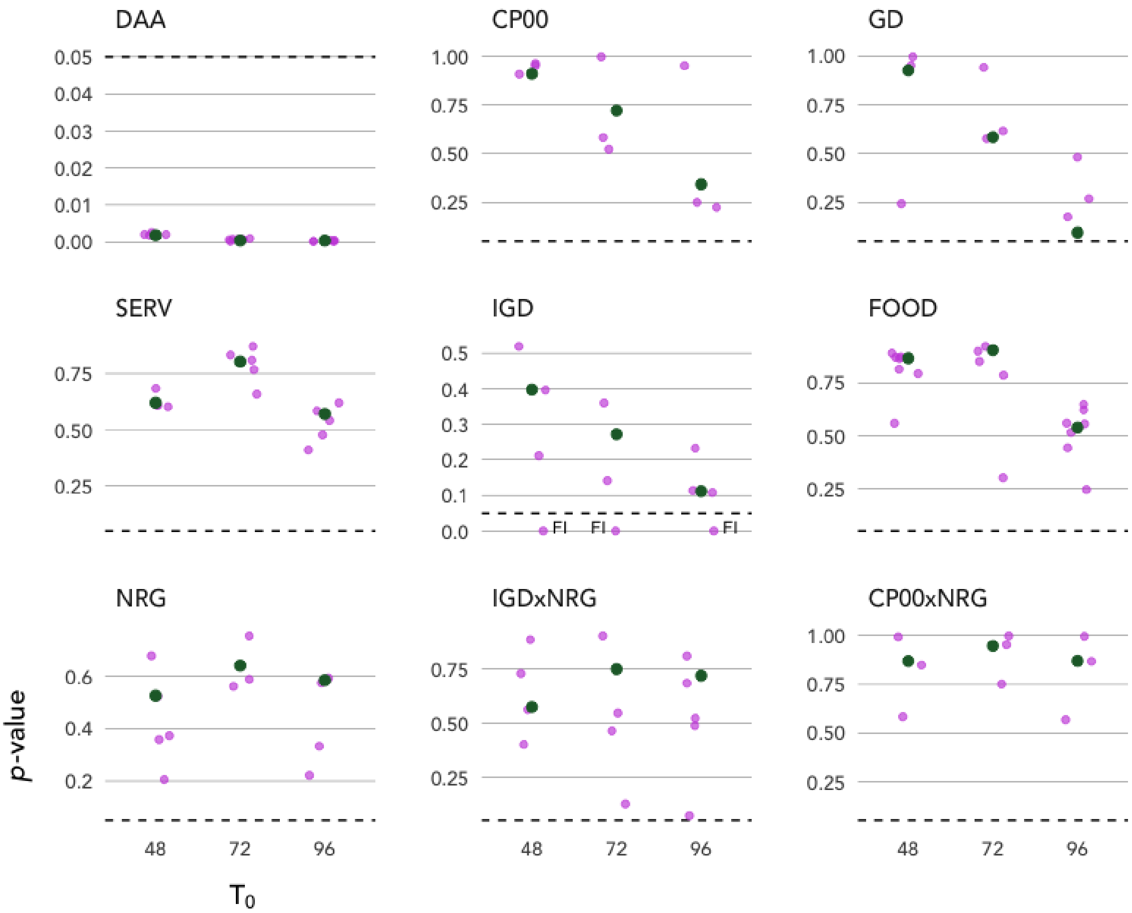

Figure 19. Distribution of p-values from testing the null hypothesis (8) on Portugal's estimates leaving out one of the control units with non-zero weight. *Destabilizing units* at the .05 threshold –which is represented by a horizontal dashed line– are labeled. The green dots correspond to the p-values obtained with all the units in the donor pool. All p-values are computed via *iid* with 5,000 permutations.

Source: own calculations.

A.2 Tables

	$T_0^A = 48$	$T_0^B = 72$	$T_0^C = 96^{\ddagger}$
DAA	-53.121	-54.266	-54.457
	[-65.556, -39.003]	[-64.025, -45.549]	[-63.935, -46.313]
CP00	-3.559	-3.476	-3.162
	[-5.693, -1.304]	[-5.247, -2.083]	[-5.089, -1.774]
GD	-5.602	-5.575	-4.734
	[-8.736, -0.282]	[-8.143, -2.303]	[-8.084, -2.220]
SERV	-1.037	-0.706	-0.771
	[-2.167, -0.173]	[-1.513, -0.032]	[-1.499, -0.184]
IGD	-8.561	-8.766	-7.603
	[-13.926, -0.713]	[-12.754, -3.230]	[-12.251, -3.281]
FOOD	-0.616	-0.168	0.274
	[-1.956, 1.413]	[-1.833, 1.437]	[-1.457, 1.724]
NRG	-26.621	-25.605	-20.940
	[-43.259, 1.800]	[-40.577, -5.817]	[-35.249, -6.743]
IGDxNRG	-1.209	-1.391	-1.462
	[-3.440, 0.892]	[-3.168, 0.359]	[-2.978, 0.115]
CP00xNRG	-0.932	-1.003	-1.069
	[-2.107, 0.317]	[-1.821, -0.102]	[-1.769, -0.280]

Table 1. Distribution of Spain's ATEs and 90% confidence intervals for different outcomes and T_0 values. All ATEs are expressed in percentage. $^{\ddagger}T_0^C = 89$ for outcome DAA.

	$T_0^A = 48$	$T_0^B = 72$	$T_0^C = 96^{\ddagger}$
DAA	-53.012	-54.141	-54.315
	[-65.549, -38.908]	[-64.039, -44.979]	[-64.195, -45.944]
CP00	-1.215	-1.296	-1.308
	[-4.017, 1.399]	[-3.051, 0.442]	[-2.957, 0.327]
GD	-0.652	-1.946	-2.040
	[-3.624, 1.047]	[-3.155, -0.157]	[-3.115, -0.903]
SERV	-2.862	-2.642	-2.867
	[-6.450, 1.378]	[-5.934, 1.086]	[-5.966, 0.457]
IGD	-3.220	-3.276	-4.376
	[-7.220, 0.077]	[-6.482, -0.305]	[-7.035, -2.024]
FOOD	0.893	0.825	1.414
	[-0.607, 2.555]	[-0.457, 2.234]	[0.064, 2.843]
NRG	0.584	1.416	1.240
	[-5.338, 5.163]	[-2.528, 5.093]	[-3.657, 5.119]
IGDxNRG	-0.564	0.027	0.149
	[-2.261, 1.222]	[-1.484, 1.581]	[-1.395, 1.750]
CP00xNRG	0.141	-0.150	-0.166
	[-1.476, 1.394]	[-1.575, 1.747]	[-1.507, 1.438]

Table 2. Distribution of Portugal's ATEs and 90% confidence intervals for different outcomes and T_0 values. All ATEs are expressed in percentage. $^{\ddagger}T_0^C = 89$ for outcome DAA.

	$T_0^A = 48$			$T_0^B = 72$			$T_0^C = 96^\ddagger$		
	iid_1	iid_5	iid_{10}	iid_1	iid_5	iid_{10}	iid_1	iid_5	iid_{10}
DAA	.005***	.002***	.002***	.002***	.001***	.001***	.002***	.001***	.001***
CP00	.167	.172	.180	.009***	.008***	.007***	.003***	.003***	.001***
GD	.353	.373	.358	.069*	.071*	.067*	.017**	.016**	.016**
SERV	.080*	.083*	.084*	.105	.119	.114	.021**	.025**	.021**
IGD	.093*	.088*	.078*	.048**	.040**	.040**	.031**	.039**	.041**
FOOD	.318	.339	.337	.284	.283	.293	.300	.321	.313
NRG	.093*	.083*	.086*	.022**	.023**	.020**	.007***	.008***	.008***
IGDxNRG	.505	.507	.512	.369	.384	.380	.201	.214	.210
CP00xNRG	.170	.173	.169	.080*	.078*	.076*	.028**	.026**	.025**

Table 3. Distribution of p-values from testing the null hypothesis (8) on Spain's estimates for different outcomes and T_0 values, obtained via *iid* permutations with 1,000 (iid_1), 5,000 (iid_5), and 10,000 (iid_{10}) permutations. $^\ddagger T_0^C = 89$ for outcome DAA.
Note: * $p < .1$; ** $p < .05$; *** $p < .01$.

	$T_0^A = 48$			$T_0^B = 72$			$T_0^C = 96^\ddagger$		
	iid_1	iid_5	iid_{10}	iid_1	iid_5	iid_{10}	iid_1	iid_5	iid_{10}
DAA	.001***	.002***	.002***	.003***	.001***	.001***	.001***	.001***	.001***
CP00	.914	.907	.907	.718	.718	.712	.341	.354	.344
GD	.921	.925	.921	.605	.585	.578	.090*	.090*	.097*
SERV	.622	.611	.613	.806	.811	.806	.570	.573	.571
IGD	.378	.398	.394	.288	.263	.269	.102	.102	.105
FOOD	.886	.866	.860	.900	.904	.906	.531	.534	.537
NRG	.520	.549	.541	.650	.635	.636	.583	.581	.574
IGDxNRG	.601	.581	.578	.736	.749	.748	.719	.721	.727
CP00xNRG	.865	.867	.864	.950	.942	.943	.873	.864	.867

Table 4. Distribution of p-values from testing the null hypothesis (8) on Portugal's estimates for different outcomes and T_0 values, obtained via *iid* permutations with 1,000 (iid_1), 5,000 (iid_5), and 10,000 (iid_{10}) permutations. $^\ddagger T_0^C = 89$ for outcome DAA.
Note: * $p < .1$; ** $p < .05$; *** $p < .01$.

	$T_0^A = 48$	$T_0^B = 72$	$T_0^C = 96^{\ddagger}$
DAA	.036**	.025**	.021**
CP00	.185	.026**	.020**
GD	.278	.090*	.059*
SERV	.185	.179	.108
IGD	.148	.115	.098*
FOOD	.500	.346	.422
NRG	.259	.179	.127
IGDxNRG	.556	.436	.265
CP00xNRG	.185	.103	.069*

Table 5. Distribution of p-values from testing the null hypothesis (8) on Spain's estimates for different outcomes and T_0 values, obtained via *mb* permutations. $^{\ddagger}T_0^C = 89$ for outcome DAA. Note: * $p < .1$; ** $p < .05$; *** $p < .01$.

	$T_0^A = 48$	$T_0^B = 72$	$T_0^C = 96^{\ddagger}$
DAA	.036**	.025**	.010**
CP00	.722	.628	.373
GD	.870	.590	.088*
SERV	.463	.731	.539
IGD	.389	.231	.088*
FOOD	.870	.910	.422
NRG	.537	.513	.539
IGDxNRG	.426	.667	.676
CP00xNRG	.778	.833	.686

Table 6. Distribution of p-values from testing the null hypothesis (8) on Portugal's estimates for different outcomes and T_0 values, obtained via *mb* permutations. $^{\ddagger}T_0^C = 89$ for outcome DAA. Note: * $p < .1$; ** $p < .05$; *** $p < .01$.

	$T_0^A = 48$	$T_0^B = 72$	$T_0^C = 96^\ddagger$
DAA	.739	.857	.857
CP00	.792	.833	.875
GD	.167	.167	.083*
SERV	.375	.417	.333
IGD	.208	.125	.167
FOOD	.542	.833	.875
NRG	.042**	.917	.042**
IGDxNRG	.583	.583	.542
CP00xNRG	.292	.250	.208

Table 7. Distribution of p-values from testing the null hypothesis of no effect on Spain's estimates for different outcomes and T_0 values, obtained via RMSPE ratios. $^\ddagger T_0^C = 89$ for outcome DAA.
Note: * $p < .1$; ** $p < .05$; *** $p < .01$.

	$T_0^A = 48$	$T_0^B = 72$	$T_0^C = 96^\ddagger$
DAA	.739	.857	.857
CP00	.792	.875	.792
GD	.917	.667	.625
SERV	.542	.542	.542
IGD	.625	.750	.625
FOOD	.583	.542	.292
NRG	.999	.999	.999
IGDxNRG	.750	.999	.917
CP00xNRG	.917	.958	.999

Table 8. Distribution of p-values from testing the null hypothesis of no effect on Portugal's estimates for different outcomes and T_0 values, obtained via RMSPE ratios. $^\ddagger T_0^C = 89$ for outcome DAA.
Note: * $p < .1$; ** $p < .05$; *** $p < .01$.