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Content

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Editor's note[1]

Pedro Duarte Neves

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1. This issue of the *Banco de Portugal Economic Studies* includes three studies. The first assesses the influence of households' financial knowledge on how inflation expectations are formed. The second provides an analysis of hospital efficiency in Portugal. The third quantifies the effect of Brexit on trade flows in goods and services between Portugal and the United Kingdom.

2. The study opening this issue of the *Banco de Portugal Economic Studies*, prepared by Quelhas, looks at how the process of forming economic agents' inflation expectations can be influenced by the degree of financial knowledge. The study uses individual data from April 2020 to March 2024 from the Consumer Expectations Survey, published each month by the European Central Bank. This survey, which has already been examined in previous issues of the Banco de Portugal Economic Studies, documents, among other economic dimensions, euro area households' inflation perceptions and expectations.

The study's most innovative contribution is defining a degree of financial knowledge for each participant in the survey, based on the ability to correctly answer four questions covering various aspects, such as risk diversification and the calculation of the real interest rate. A fifth of respondents answered all questions correctly; three fifths got two or three of the questions right. On the basis of this proxy, the author identified three degrees of financial knowledge: high, medium and low.

The study presents two conclusions:

(i) Individuals with a higher degree of financial knowledge tend to display medium-term expectations closer to the 2% target, past inflation perceptions closer to the current level and lower short-term inflation expectations;
(ii) Individuals with a lower degree of financial knowledge tend to have a higher rate of non-response, more imprecise answers and more frequent, less plausible answers.

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1. The analyses, opinions and conclusions expressed in this editorial are entirely those of the editor and do not necessarily coincide with those of Banco de Portugal or the Eurosystem.

The study by Quelhas warrants two additional observations, which are further elaborated in the sections below: the role of financial knowledge in intertemporal consumption and saving decisions; the contribution of financial literacy to macroeconomic and financial stability.

3. The seminal work of economist Robert Hall,[2] published in 1978 in the Journal of Political Economy, formalises the trade-off between current and future consumption, focusing on the stochastic implications of forward-looking behaviour.[3]

The relatively unique importance of this contribution was well documented by Nobel Prize laureate in Economics Angus Deaton, in his book Understanding Consumption. Angus Deaton presents the book as an update of a previous contribution on consumption, co-written with John Muellbauer. The preface to that book notably illustrates how seminal that research by Robert Hall was: "in particular since Hall's (1978) paper on the stochastic implications of forward-looking behaviour, there has been a great flurry of [research] activity (...) we had read Hall's paper and discussed it in the book, but could not anticipate the outpouring of research that it was to engender".[4]

The literature inspired by that work seeks to understand the elasticity of intertemporal substitution. This elasticity gives an insight into the answer to the following question: given that, in relative terms, current prices are lower, how will expectations of higher inflation in the future bring about a reduction in current savings and, consequently, an increase in current consumption relative to future consumption?

The study by Quelhas introduces an additional element for understanding intertemporal consumption and saving decisions: the degree of financial knowledge of economic agents.

2. Robert Ernest Hall has spent most of his professional career at Stanford University. To honour the importance of his exceptional contribution to Economic Sciences, we recall here, among his many seminal works, his Notes on the Current State of Empirical Macroeconomics, presented in July 1976 at a workshop in empirical macroeconomics at Stanford. In it, he made the famous distinction between "fresh water" and "salt water" economists according to the geographical location of their professional activity. "As a gross oversimplification, current thought can be divided into two schools. The fresh water view holds that fluctuations are largely attributable to supply shifts and that the government is essentially incapable of affecting the level of economic activity. The salt water view holds shifts in demand responsible for fluctuations and thinks government policies (at least monetary policy) is capable of affecting demand. (...) The old division between monetarist and Keynesians is no longer relevant (...)".

3. This link is exemplified through a Euler equation for private consumption, which makes it possible to characterise consumption and saving decisions over time. It is only fair to mention the previous work of Milton Friedman, Franco Modigliani and Richard Brumberg, which were the starting point for economic research in consumption and saving.

4. See *Understanding Consumption*, Clarendon Lectures in Economics, Angus Deaton (1992), Oxford University Press.

The results suggest that, all other things being equal, individuals with less financial knowledge will tend to make greater adjustments (increasing) to current consumption relative to future consumption, when inflation expectations change (increase). The insight behind this conclusion – the most important input from the study by Quelhas – was mentioned in the previous section of this editorial: inflation expectations for individuals with greater financial knowledge tend to coincide more closely with the monetary policy objective and to be less responsive to temporary changes in price developments. This is, of course, a very preliminary finding and should be reassessed in more comprehensive modelling of intertemporal consumption choices, in particular by explicitly considering the role of liquidity constraints in the ability to adjust consumption over the life cycle.

4. The study by Quelhas recaptures the importance of financial literacy. The OECD defines this concept as "a combination of financial awareness, knowledge, skill, attitude and behaviour necessary to make sound financial decisions and ultimately achieve individual financial well-being". Citing the April 2022 issue of this editorial:

> "Financial customers that are better informed and have greater financial literacy can make decisions that better match their risk profile, be it while managing the family budget, making saving options, or choosing between alternative financial products. Greater financial literacy will tend to make non-compliance with obligations, excessive indebtedness and financial exclusion less likely; overall, greater financial literacy will strengthen the resilience of the financial system against adverse shocks, contributing to macroeconomic and financial stability."

Initiatives to promote financial literacy are an essential pillar for strengthening social capital. In short, they can be classified into three broad groups: financial literacy surveys, national plans for financial education and development of core competencies for financial literacy.

Last April, the National Council of Financial Supervisors (Portuguese acronym: CNSF) released the results of the 4th survey on the financial literacy of the Portuguese population. This survey, developed under the National Plan for Financial Literacy, is part of the OECD's international comparison exercise of financial literacy levels. Portugal ranked 13th in the global financial literacy indicator among the 39 participating countries.

National plans for financial education set out the general principles and action to increase citizens' financial literacy. In Portugal, the CNSF's National Plan for Financial Education 2021-25 is in force. In May 2023, the Banco de Portugal presented the Digital Financial Literacy Strategy for Portugal. At European level, the Joint Committee of the European Supervisory Authorities has regularly released repositories of financial

education initiatives developed by national competent authorities[5] and has carried out financial training initiatives, publishing information and training materials.[6]

The European Commission and the OECD International Network on Financial Education (INFE) published a financial competence framework for adults[7] in January 2022 and a framework for children and youth in September 2023.[8] These frameworks identify the desirable financial knowledge, attitudes and behaviours to make informed decisions.

5. In the October 2023 issue of the *Banco de Portugal Economic Studies*, a study by Braz and Cabral examined the efficiency of the Portuguese health system within the euro area. This study concluded that (i) in Portugal, as in around half of the euro area countries, there were efficiency gains from 2014 to 2019, and that (ii) Portugal was in an intermediate position in the euro area in 2019 in terms of health efficiency indicators, both from the viewpoint of the use of resources and results obtained.

As such, the methodological approach consisted in the non-parametric estimation of a production frontier using the Data Envelopment Analysis for euro area countries. This frontier represents the efficiency relationship between the use of resources (measured by health expenditure per capita, in purchasing power parity) and the result obtained (as indicated by life expectancy) and makes it possible to assess how each country performs against this benchmark.

The study by Braz, Cabral and Cunha included in this issue of the *Banco de Portugal Economic Studies* presents a similar approach to the analysis of hospital efficiency in Portugal over the period 2012-22, now including a representative sample of public hospitals. For this purpose, the authors considered staff costs, intermediate consumption and the number of beds as resources, and appointments, emergency care, surgery and hospital discharges as results.

The main findings are:

(i) There are inefficiencies in hospital care which, based on the methodology used, can be quantified by the possibility of reducing resources by 20% to achieve the same results, or by the possibility of increasing results by 20% with the same resources;

5. See *Thematic Report on national financial education initiatives on digitalization, with a focus on cybersecurity, scams and fraud*, Joint Committee of the European Supervisory Authorities, published on 12 January 2023.

6. See *ESAs' interactive factsheet on inflation and the rise in interest rates*, published on 15 May 2023, and *ESAs' interactive factsheet that answers consumers' most frequently asked questions about sustainable finance*, published on 30 November 2023.

7. See European Union/OECD (2022), *Financial competence framework for adults in the European Union*.

8. See European Union/OECD (2023), *Financial competence framework for children and youth in the European Union*.

(ii) There is a large dispersion of efficiency among hospitals, but there is persistence in the hospitals that constitute the efficiency frontier;
(iii) The average quality of health services provided remained broadly stable over the decade under review;
(iv) There is a positive relationship between the most efficient hospitals and those providing better health services.

The study by Braz, Cabral and Cunha stresses the importance of continuing to assess the efficiency of resources used in health in Portugal, reflecting the constantly evolving National Health Service (*Serviço Nacional de Saúde* – SNS). Suggestions for a research agenda include the following: the role of the private sector in the provision of health services; analysis of public-private sector links in terms of complementarity and competition; analysis of distributional issues, assessing whether possible efficiency gains could undermine equity in access to health.

6. The final study in this issue of the *Banco de Portugal Economic Studies* seeks to quantify the effects of Brexit on trade flows in goods and services between Portugal and the United Kingdom. For this purpose, the author uses a statistical counterfactual. The estimates obtained – which of course should be considered with the utmost caution, bearing in mind the technical assumptions of the exercise – suggest that bilateral flows have declined, taking 2021 as a reference, by around €2 billion, (i) split roughly equally between imports and exports, and (ii) focusing more on the flow of goods than on the flow of services (with ¾ and ¼ shares respectively). Finally, the author uses empirical proxies to estimate that Brexit could have an impact of -0.1% on Portuguese GDP. This is close to the estimates provided by other studies for Portugal and also, on average, for the European Union.

Brexit was an unparalleled event in the European integration process, which has been marked by successive enlargements. Perhaps for that reason, studies of the effects of exiting an economic union are very scarce. Existing studies suggest that the greatest effects on economic activity will hit (in addition to the United Kingdom) more dependent trade partners (e.g. Ireland and Malta). Finally, Brexit has also had an impact on other aspects – such as capital flows – which are even less explored in the literature.

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Non-technical summary

July 2024

Inflation expectations and household choices: the role of financial knowledge

João Quelhas

Inflation expectations are of paramount importance in macroeconomics as they affect prices and wages set by firms and the consumption and saving decisions of households. It is also widely accepted that monitoring the evolution of inflation expectations is highly relevant for central banks, which aim to set a credible monetary policy focused on price stability. This article examines how the process of forming inflation expectations and the subsequent economic decisions are influenced by financial knowledge.

The empirical analysis, both for the euro area and for Portugal, uses household-level data on consumers' expectations regarding the economy and their demographic characteristics provided by the Consumer Expectations Survey (CES) of the European Central Bank, a novel mixed-frequency online survey. It begins with a description of the methodology used, presenting a detailed assessment of the sample's representativeness. Next, a financial knowledge index is developed based on the background questions in CES, leading to conclusions similar to those of other indices. About a quarter of those surveyed in the euro area correctly answered all the questions, while Portugal shows the fourth lowest percentage of individuals with higher financial knowledge.

The study proceeds by exploring household expectations, with a particular focus on the role of financial knowledge. The analysis reveals that individuals with lower financial knowledge tend to exhibit a higher proportion of zero responses, use fewer decimal places in their expectations, but more frequently opt for multiples of five and values between -10% and 10%. When considering individual-level heterogeneities, it is concluded that those with higher financial knowledge generally have a perception of past inflation that is closer to the current level and exhibit lower short-term inflation expectations. Regarding medium-term expectations, it is found that more knowledge corresponds to smaller deviations, in absolute terms, from the ECB's target of 2%, which enhances the effectiveness of monetary policy.

Turning to consumers' spending plans, a central mechanism prevalent in macroeconomic models is explored: the Euler consumption equation. Using variations in inflation expectations, intertemporal substitution elasticities between 0.6 and 0.7 are found, consistent with estimates in the literature, considering all countries. The values for Portugal slightly exceed these, potentially due to the shorter sample period. When

the sample is segmented based on the level of financial knowledge, it is observed that the elasticity of consumption growth expectations relative to changes in inflation expectations decreases for those who are more financially literate (Figure 1).

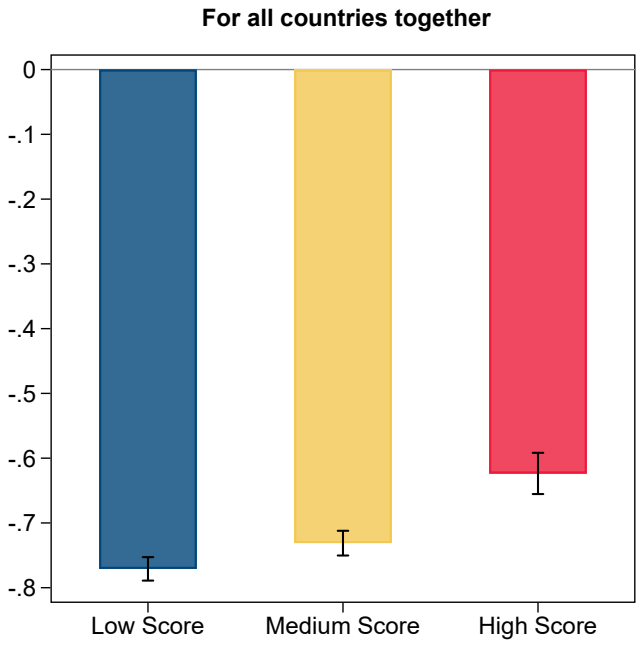

FIGURE 1: Intertemporal substitution elasticity by level of financial knowledge

The recent increase in inflation in the euro area has raised broader macroeconomic concerns, particularly regarding the development of inflation expectations. This study provides additional evidence explaining why promoting financial knowledge can be relevant for the conduct of monetary policy, contributing to the fulfillment of its mandates. Firstly, it enables consumers to have a better perception of the current level of inflation. This improved understanding allows individuals to make more informed economic decisions, aligning their expectations with the actual economic conditions.

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Inflation expectations and household choices: the role of financial knowledge

João Quelhas
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July 2024

Abstract
Using the Consumer Expectations Survey from the European Central Bank, this study explores the role of financial knowledge in consumers' inflation expectations formation process and in the mechanism linking such expectations with choices. It is found that short-term expectations are generally lower and medium-term expectations are closer to the inflation target for individuals with a higher level of financial knowledge both in the euro area and Portugal. It also estimates an elasticity of intertemporal substitution − response of expected consumption growth to changes in expected inflation between 0.6 and 0.7. The link weakens as financial knowledge increases.
Keywords: Expectations, Financial Knowledge, Consumer Expectations Survey (JEL: D84, E21)

"Inflation expectations are terribly important.
We spend a lot of time watching them."

Jerome Powell − September 22, 2021

1. Introduction

Over the past decade, researchers and central banks have started to collect survey data on the expectations from consumers, firms, and professional forecasters. These surveys convey insights into how the economic agents form and update their expectations, the heterogeneity and biases in these expectations, and how they feed into economic decisions that can have wide implications for the economy and for the monetary policy. This article studies how the formation process of inflation expectations by households and subsequent economic choices are influenced by financial knowledge. It focus on the euro area and Portugal, shedding light on why higher levels of financial knowledge may help central banks maintain expectations closer to the inflation target.

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Consumers' inflation expectations are of paramount importance in macroeconomics as they may affect the prices and the wages set by firms and the consumption-savings decisions of households. In most theoretical dynamic models, inflation expectations shape economic agents' decisions, thus affecting consumption, investment, and inflation through three main channels, as stated in Crump *et al.* (2022) and D'Acunto *et al.* (2024). First, all else equal, higher inflation expectations should lower real interest rates and therefore encourage consumption and investment today ("*real interest rate channel*"). Higher inflation expectations may also lead households to demand higher wages to avoid a loss in real income, and firms tend to offer higher wages to retain staff ("*wage-setting channel*"). Third, in the presence of price rigidities, it may be optimal for the fraction of firms capable of adjusting prices to do so in response to expected inflation over the period during which their prices will remain fixed ("*price-setting channel*"). Given their relevance for individual and aggregate outcomes, studying the patterns of inflation expectations in the cross-section and time series is crucial.

It is widely accepted as well that monitoring the evolution of inflation expectations is of great importance for central banks, who are committed to a credible and price stability-oriented monetary policy. Anchored expectations enhance policy effectiveness by ensuring that shifts in monetary policy influence inflation outcomes as expected, while also reducing uncertainty and volatility in the economy. The driving forces behind heterogeneity in expectations across individuals can also help understand why economic agents react differently to the same shocks and policy interventions. One important driver of these differences is financial literacy, as it has been documented in the literature that it influences the way households act on their subjective beliefs about inflation. In fact, research by Lusardi (2008), Armantier *et al.* (2010) and Bruine *et al.* (2011) demonstrated that consumers with lower financial literacy and a reduced ability to process financial statistics and information tend to overestimate inflation.

The aim of the present study is twofold. First, it explores the expectations formation process by households, studying how financial knowledge helps them to build more accurate expectations for the evolution of prices. Several dimensions are analysed: first, survey responses are investigated to measure answering effort; then, it looks at the disagreement of short-term expectations across financial knowledge levels; finally, it also delves into the relationship between deviations of medium-term expectations from the inflation target and financial knowledge. To assess the effects of inflation expectations on consumers' intertemporal choices, it examines the *real interest rate channel* mentioned above. Using the methodology from Crump *et al.* (2022), the Euler equation is estimated with measures of households' expectations of both consumption growth and inflation. The elasticity of intertemporal substitution (EIS) is estimated for households in each group of financial knowledge to understand whether it varies significantly among them.

This article uses household-level information on expectations of euro area consumers about the economy, as well as socioeconomic and demographic characteristics from the European Central Bank's (ECB) Consumer Expectations Survey (CES), a novel online, mixed-frequency panel survey. This monthly survey asks a rotating panel of euro area household heads a series of qualitative and quantitative questions on perceptions and expectations for several macroeconomic and financial developments. Importantly,

from the survey responses, it is also derived a *proxy* for financial knowledge as it contains specific questions made during the background interview to each household, covering important dimensions such as compounding, real interest rates and investment decisions. It is important to note that our focus will be on financial knowledge and not on the other dimensions of financial literacy, namely financial attitudes and financial behaviour. The CES also contains individual-level data since April 2020 on inflation and spending expectations that are used to estimate the consumption Euler equation.

This study begins with an overview of the survey methodology, presenting a detailed evaluation of its sample representativeness for both the euro area and Portugal. An index of financial knowledge is built and it yields qualitatively similar results to other indices, such as the one from the European Commission (EC). Around one fourth of the surveyed euro area consumers answered correctly to all questions, while Portugal presents the fourth smallest percentage of respondents obtaining a high score. The index is used to examine the role of financial knowledge on inflation expectations and economic choices.

It proceeds by investigating the heterogeneous inflation expectations of consumers. The analysis unveils that those with high scores employ more effort to answer survey questions on inflation expectations: the proportion of respondents answering zero or multiples of 5 is lower while the use of decimals and answers between -10 and 10 is more prevalent. It concludes that enhanced financial knowledge generally means inflation perceptions closer to actual inflation rate and lower short-term expectations. Regarding medium-term expectations, those with high financial knowledge tend to expect changes in prices around the inflation target of 2% defined by the ECB.[1]

Turning to consumers' spending plans, this article studies a mechanism prevalent in macroeconomic models, the consumption Euler equation. Using variations in expected inflation, it is estimated an elasticity of intertemporal substitution between 0.6 and 0.7, consistent with other findings in the literature. Estimates for Portugal slightly exceed these figures. Upon segmenting based on levels of financial knowledge, it is concluded that the responsiveness of expected real consumption growth to changes in inflation expectations is attenuated among consumers with greater financial knowledge. This result is less pronounced in Portugal, as no statistically significant differences are found.

Related Literature. Recently, a growing number of studies has been using surveys data to explore inflation expectations and their impact on economic choices. In fact, Weber *et al.* (2022) provide a comprehensive review of this literature, emphasising the importance of households' and firms' inflation expectations in both macroeconomic and microeconomic models. The authors discuss how they are measured, the patterns they display, their determinants, and how they shape decisions. This study relates to two main streams of research that emerged from the literature on consumer inflation expectations: exploring their patterns by demographic characteristics and how they affect economic decisions, estimating the elasticity of intertemporal substitution.

1. For the sake of simplicity, throughout the article, it is referred to a 2% inflation target, even though the author is aware of the previous quantitative definitions of price stability. These include the one in place after 2003: "Price stability shall be defined as a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below, but close to 2% over the medium term."

Knowing the central role of households in driving economic activity, policymakers have increasingly focused on monitoring their expectations, placing them in the centre of modern monetary policy (Woodford (2004), Bernanke (2007), Gali (2008), and Sims (2009)). To address this, several measures and surveys have been developed to track household expectations. Armantier *et al.* (2017) discuss the role of the New York Fed Survey of Consumer Expectations in providing a comprehensive view of household economic outcomes. It complemented the existing data sources (such as, the University of Michigan Survey of Consumers, the Federal Reserve Board's Survey of Consumer Finances, and the Bureau of Labour Statistics' Consumer Expenditure Survey) by providing a more integrated data approach while covering a broad range of topics related to households expectations and decisions. In the euro area, the CES was created to assume a similar role, complementing the information from the Business and Consumer Surveys (BCS), conducted by the EC on a quarterly basis. Gomes *et al.* (2024) examine inflation expectations among euro area consumers, focusing on these surveys. They find that the CES is a valuable addition to the set of inflation expectation measures, aligning more closely with two established indicators of inflation expectations (those of professional analysts and market expectations) when compared with the EC's BCS.

Several patterns regarding households' inflation expectations consistently emerged across surveys, regions, and time periods. These include an upward bias in numerical inflation expectations against actual inflation, significant disagreement and uncertainty surrounding future inflation, strong correlations in short- and medium-term inflation expectations, and their predictability using perceived inflation. As an example, one can mention the work by Weber *et al.* (2022) that finds average and median numerical inflation expectations of households systematically higher than the actual inflation rates that occur subsequently with survey data from the University of Michigan Survey of Consumers. Moreover, examining demographic groups provides insight into the sources of the observed upward bias in inflation expectations. Several studies indicate that this bias varies a lot across demographics: women tend to exhibit a higher positive bias compared to men (Armantier *et al.* (2010) and D'Acunto *et al.* (2021)), while those with more cognitive abilities display a lower bias (D'Acunto *et al.* (2019)). Furthermore, cross-sectional variations in macroeconomic expectations, including inflation expectations, can be partially explained by a combination of formal education and income levels (see, for example, Armantier *et al.* (2010) and Das *et al.* (2020)). Notably, households from lower socioeconomic backgrounds often exhibit systematically higher inflation expectations compared to their counterparts. This paper departs from the upward bias in euro area consumers' inflation expectations relative to actual inflation found in Gomes *et al.* (2024) to check whether their level varies across different levels of financial knowledge. At the same time, it highlights novel empirical findings for Portugal, given that it is the first to explore the CES data for this country.

Recent research has also departed from the standard theoretical models to examine the causal link between inflation expectations and economic decisions, recognising that observed variations in decision-making may stem from similar underlying determinants affecting inflation expectations. Initial studies, such as Bachmann *et al.* (2015), showed limited evidence of high inflation expectations leading to increased spending plans,

but subsequent research has provided more affirmative results. For example, Crump *et al.* (2022) used inflation expectations from the New York Fed's Survey of Consumer Expectations, estimating an intertemporal elasticity of substitution value of between 0.5 and 0.7. This work inspires the empirical setting in Section 4. Similarly, Drager and Nghiem (2021) found similar results for German households using a survey developed by the University of Hamburg and Ichiue and Nishiguchi (2015) presented evidence consistent with the Euler equation using household survey data in Japan during the zero-lower bound period between 2006 and 2013. Duca-Radu *et al.* (2021) pooled data from seventeen European countries and found that households exhibit more positive attitudes towards spending on consumer durables when expecting inflation to rise.

In this line, a study by D'Acunto *et al.* (2022) exploiting a natural experiment setting uses the pre-announced increase in the VAT in Germany in 2005 as a source of exogenous variation in inflation expectations among German households relative to those of other European countries. Their findings indicate that the rise in expectations of German households relative to comparable households in neighbouring countries was associated with higher reported willingness to spend in the future, despite no differences in their expectations of future income and other factors. Together, these results suggest a causal chain running from higher inflation expectations to higher consumption levels, especially in the absence of offsetting interest rate responses, e.g the zero-lower bound.

Nevertheless, much of this research relies on cross-sectional datasets. Vellekoop and Wiederholt (2019) look at changes in expectations within individuals over time, finding a positive link between inflation expectations and future consumption choices. Finally, D'Acunto *et al.* (2023) highlight that controlling for multiple characteristics and cognitive abilities is crucial in establishing a positive association between inflation expectations and the willingness to purchase durable goods.

Outline. The paper is organised as follows. Section 2 describes the data used in the empirical applications. Section 3 explores the formation process of inflation expectations, investigating how financial knowledge shapes these expectations. Section 4 presents the estimation of the elasticity of intertemporal substitution and documents the differences by level of financial knowledge. Section 5 concludes with final remarks.

2. Data

2.1. ECB's Consumer Expectations Survey

This study uses survey data from the ECB's CES between April 2020 and March 2024.[2] The CES is an internet-based survey of a rotating panel of household heads conducted at a monthly frequency since January 2020 and data is available since April 2020. The survey initially covered participants from six euro area countries: Belgium, Germany, Spain, France, Italy and the Netherlands. In 2022, work began on the collection of data for five more euro area countries: Ireland, Greece, Austria, Portugal and Finland.

2. For a comprehensive overview of the CES, see ECB (2021) and Georgarakos and Kenny (2022).

The survey was first piloted in January 2020. This phase enabled an evaluation of the quality and usefulness of the survey responses. The targeted sample size during the pilot phase was approximately 10,000 respondents and has now increased to 19,000, as shown in the Online Appendix (Figure A.1). The number of respondents increased steadily throughout the development phase, allowing better analysis of the behaviour of certain population subgroups and enhancing the overall quality and country coverage.

The CES is a mixed-frequency modular survey with timely data comparable across countries. The underlying approach is to use mixed frequencies, with some questions asked monthly and others at a quarterly or annual frequency. This approach is designed not to overburden respondents, while collecting information at meaningful intervals. After being recruited into the panel, survey respondents are first asked to complete a background module that collects information on relatively time-insensitive variables as gender, employment status, educational background, and annual income. After that, the CES is composed by three parts. An annual interview aims to collect information on incomes, financial and real asset holdings, debts and household demographics. A quarterly module collects information on topics such as consumption, credit access and employment at a lower frequency. A monthly core module includes perceptions and expectations as regards inflation, labour market, spending, housing and credit decisions, as well as other time-sensitive information that can be introduced for some months.[3]

The CES has an unbalanced panel as consumers respond to the survey over multiple rounds but not always uninterruptedly, meaning that there is a different number of observations for each unit of analysis. The vast majority of panel members, irrespective of the sampling method used, normally complete their first monthly module in the same round as the background survey. Only a few panel members remain inactive for one or more rounds before their first complete participation. To help limit the impact of conditioning and sample selectivity effects on the quality of CES data over time, the survey is set up as a rotating panel so that panel members who exit the survey normally are replaced by new members. A panel rotation has been implemented in a gradual manner. The target maximum length of participation in the CES is set to 24 completed survey rounds. The panel retention has proven effective as most panel members always complete their monthly survey tasks, as shown in the Online Appendix (Figure A.2). Excluding the initial sample building phases, the share of new entrants in each wave was around 10%. The survey gathers both qualitative and quantitative data. Qualitative variables involve questions where respondents choose from predefined categories or non-numeric options. In contrast, quantitative variables involve questions where respondents provide numeric estimates. To address outliers, data points for all quantitative indicators are adjusted at the 2^{nd} and 98^{th} percentiles of the weighted distribution of responses for each survey round and country. Median values are calculated using the symmetric linear interpolation, proposed by Cox (2009),

3. As stated by ECB (2021), the development of the CES involved cognitive interviewing sessions with panel participants to ensure that respondents' understanding aligns with the intended meaning of the questions. Additionally, it drew upon international best practices and insights gained from similar surveys.

to accommodate response patterns (clustering around integer values) and questionnaire constraints (allowing only one decimal place).

Sample Evaluation. The survey targets the population aged 18 and above residing in each country. The number of unique individuals surveyed by country is shown in the Online Appendix (Figure A.3). The sample aims for representativeness across age, gender, and region. While individuals aged 70 or above are included, initially, the focus is on the $18 - 70$ age range due to challenges in recruiting older people for online questionnaires. The age group of 70 or above is not included in the our applications. The CES comprises a probability sample, where all individuals have a known chance of selection, and a non-probability sample drawn from existing online panels, where only a specific subset of individuals belonging to the target population has a non-zero probability of being selected. This combination helps control for sampling effects.

ECB (2021) reveals that the main discrepancy observed in the sample in comparison to population benchmarks is the under-representation of elderly individuals, those aged 70 and above, in both samples. This under-representation is likely influenced by the online mode of data collection. In non-probability samples, there is a notable over-representation of females, even in monthly modules with gender quotas. Probability samples exhibit a relatively better representation, accounting for sampling error that can be calculated for probabilistic samples. Although the unweighted sample proportions fulfil the minimum requirement of representing at least 50% of the population in the main sub-regions, they also reasonably align with population shares. To address these limitations, survey results are re-weighted using age, gender, and region benchmarks from Eurostat for this calibration. In this investigation, cross-sectional weights, available for each household and survey round and blended combining probability and non-probability samples, are used to obtain more accurate results.[4]

A comprehensive sample evaluation was conducted for Portugal, given that this is the first study highlighting the results for this country from the CES. This assessment used data collected during the initial waves spanning from April to December 2022, the pilot phase of the survey.[5] The participation of individuals in the panel exhibits a notably short duration, with a median span of only 2 months within a 9-month period. Despite this brevity, there is a striking stability in the characteristics of individuals across different waves of participation. The sample size has remained stable around 1,100 individuals, as shown in the Online Appendix (Figure A.4). Regarding the demographic representation, evident issues emerge, particularly in terms of age and education levels.

Regarding the calibration variables and the unweighted structure of the sample, there is a significant under-representation of individuals aged 71 and above, echoing trends observed in other countries as referred above, while the $35 - 54$ age group consists of 52% of the sample instead of 35% found in the population. Regarding gender, the balance replicates well the share of men and women. Female participation slightly declines,

4. The blended weights indicate the number of adults in the population represented by each respondent, ensuring that the sample aligns with population sizes within each country and across all countries.

5. Administrative (Census 2021) and survey data (EU-SILC 2021) is used as benchmarks for Portugal.

however, along the survey rounds. There is an over-representation of *Lisboa* and under-representation of *Alentejo*, in what concerns the regional coverage.

Using sample weights, there is an under-representation of low education levels, with only 9.5% of participants having education below secondary level, starkly contrasting with the expected 55%. There is also an over-representation of tertiary education levels (51% vs. 21%). Other minor discrepancies include an over-representation of employed, constituting 62% of the panel compared to the expected 52%. Within the employed, employees are over-represented, comprising 86% compared to the anticipated 78% and of certain sectors like manufacturing, trade, transportation, and storage. No big differences against EU-SILC data in terms of the household disposable income structure.

Nevertheless, the weighted aggregate statistics, such as expectations for economic growth or unemployment rate and perception about the households' own financial situation, show a comparable alignment with those obtained from similar questions in the EC BCS. Furthermore, the median of CES responses emerges as a more suitable metric for robust comparisons with actual data from the Statistical Office.

2.2. *Financial Knowledge*

As a first step, it is built a *proxy* for financial knowledge using four questions from the background module of the CES. The questions cover important topics such as simple and compound interests, real interest rates and risk diversification. These are detailed in the Online Appendix (Table B.1) along with the percentage of correct answers for each one.

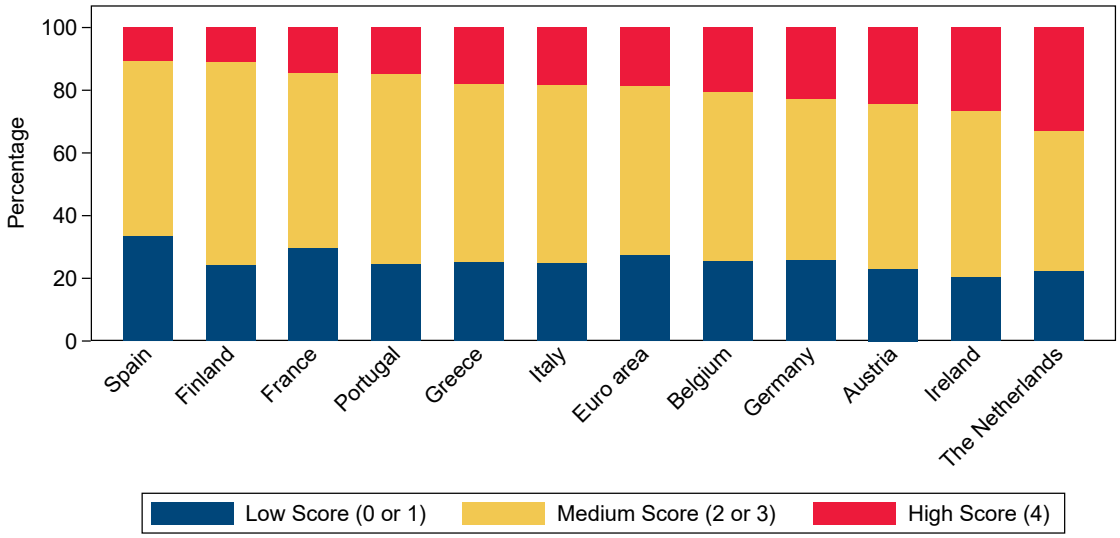
The correct responses provided by each household are aggregated, assigning a score in line with equivalent indices, e.g., the one from the EC.[6] The low-score group includes households with 0 or 1 correct answers. The group with a medium score is the one with those that got 2 or 3 correct answers. The ones with correct answers in all questions are classified with a high score.[7] The results for each country are shown in Figure 1.

Only 19% of the surveyed consumers in the euro area answered correctly all the four questions, with over half managing only two or three correct answers, and more than a quarter struggling with the questions (unable to answer any or just one out of four). The Netherlands and Ireland stand out as the best performers, with approximately three in ten respondents demonstrating a high level of financial knowledge (33% and 27%, respectively). On the contrary, Portugal ranks among the ones with a small percentage of households achieving a high score (15%), alongside Spain, Finland and France, which have even lower proportions. Overall, the majority of respondents (74%) grasp the impact of inflation and its potential repercussions on purchasing power. However, only 32% understand the workings of compound interest, despite its significance for personal finance management and long-term saving objectives. Concerning investment risks, 61%

6. Check the results of the study "*Monitoring the level of financial literacy in the EU*" from the EC here.

7. The results are robust to other specifications of the financial knowledge index: (1) a combination of questions 1 and 2 which are the questions related to real rates (cf. Online Appendix B); (2) a self-assessment question, in which households report how knowledgeable do they see themselves on financial matters.

correctly state that investing across a diverse range of companies is generally less risky than putting all investments into a single company.



Notes: All observations available until March 2024 are included. Weights are used in the computation.

FIGURE 1: Level of financial knowledge by country

2.3. *Inflation Expectations*

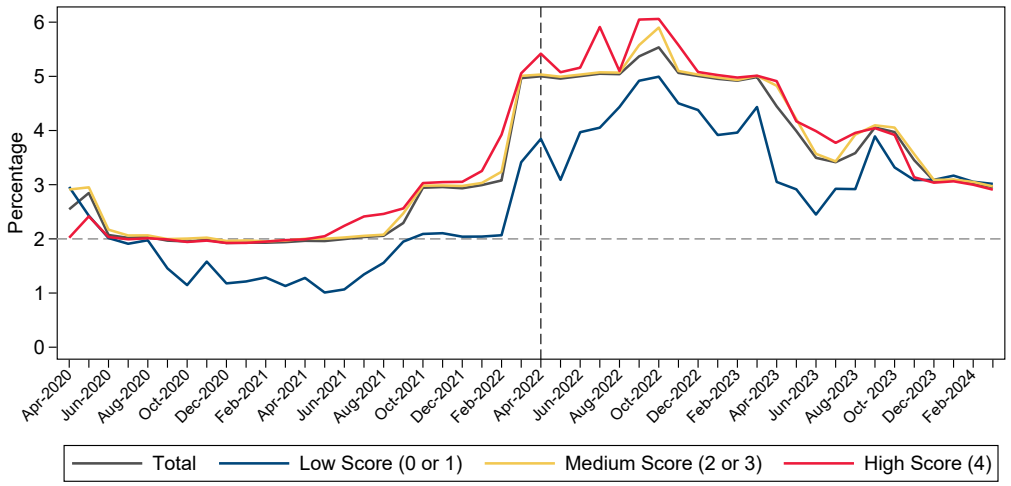
The CES asks several questions measuring consumer expectations about the evolution of prices in the next 12 months and between two and three years ahead, aligning well with the ECB's projection horizon in Macroeconomic Projection Exercises. Combining these with detailed information on household characteristics allows to shed light on both the inflation expectations formation process and the mechanism linking such expectations with choices. A common feature underlying these questions is that they are asked with reference to "changes in prices in general" instead of "inflation" (or "deflation"). Using the latter would require some familiarity of respondents with the concepts of inflation or deflation and may prompt (at least some of them) to respond based on their knowledge (or lack thereof) of the underlying statistical measure.

The question considered regarding short-term expectations comes from the following open-ended question on the expectation for prices in general during the next 12 months:

> *How much higher (lower) do you think prices in general will be 12 months from now in the country you currently live in? Please give your best guess of the change in percentage terms. You can provide a number up to one decimal place. ___._%*

The valid range is from -100.0 to 100.0. The value is 0 if the respondent chose "*Prices will be exactly the same (0% change)*" in the respective qualitative question (Online Appendix C).

Figure 2 illustrates the dynamics of inflation expectations over the next 12 months in the euro area by level of financial knowledge. Historically, medium-term expectations



Notes: All observations available until March 2024 are included. Weights are used in the computation. Median values are calculated using the symmetric linear interpolation, proposed by Cox (2009). The euro area sample includes from April 2022 onwards data from the five new countries included in the survey. The break in the series is represented by the vertical dashed gray line.

FIGURE 2: Inflation expectations for the next 12 months by financial knowledge

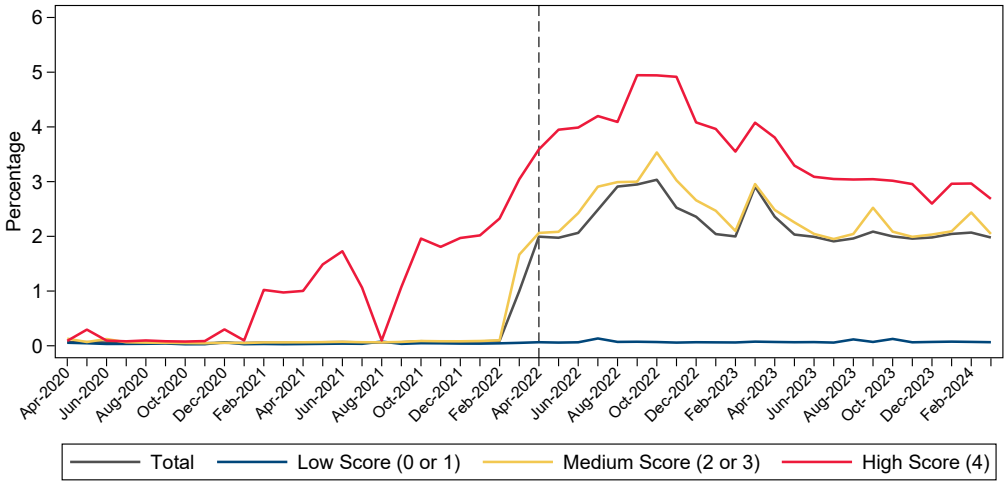
remained relatively stable until December 2021, aligning closely with the ECB's inflation target of 2%, mainly among households with heightened financial knowledge. The sudden up-tick in March 2022 suggests that households perceived the actual inflation rise in the first quarter of 2022 as potentially more persistent in nature. Furthermore, there's a discernible upward trend in inflation expectations from the end of 2021 through the end of 2022. In 2023, this trend reversed, with expectations decreasing towards 3% but not returning to the 2% target level. These movements have been similar across levels of financial knowledge, however the median consumer in the low score group had always lower inflation expectations. This reflects a higher disagreement between individuals in this group as many have negative expectations for the evolution of prices, as shown by the descriptive statistics for each group, available in the Online Appendix (Table A.1). Between the medium and high score groups, there are no visible differences at the aggregate level. A similar figure for Portugal is available in the Online Appendix (Figure A.6).

2.4. *Spending Expectations*

To estimate the elasticity of intertemporal substitution, it is also examined households' plans for the level of consumption. This is an open-ended question on the expectation for household spending on all goods and services during the next 12 months:

> *By what percent do you expect your household spending on all goods and services to change during the next 12 months compared with your spending in the past 12 months? Even very small changes in the amount your household will spend are of interest. Please give your best guess of the change in percentage terms.* ___._%

The valid range is from -100.0 to 100.0, but in this question there is also the option to report "Don't know". The value is 0 if the respondent chose "*My household spending will remain exactly the same (0% change)*" in the respective qualitative question (Online Appendix C).



Notes: All observations available until March 2024 are included. Weights are used in the computation. Median values are calculated using the symmetric linear interpolation, proposed by Cox (2009). The euro area sample includes from April 2022 onwards data from the five new countries included in the survey. The break in the series is represented by the vertical dashed gray line.

FIGURE 3: Spending expectations for the next 12 months by financial knowledge

Spending expectations were relatively stable until the end of 2021 for the low and medium score groups, while for the ones with a higher score it increased up to 2%, as shown in Figure 3. In 2022, the group with a medium score also shifted expectations upwards, coinciding with the increase in inflation expectations reported and the shock in energy and food prices at the start of the Ukraine war. Thereafter, the expectations for the growth rate of consumption remained relatively stable, despite a slight trend downwards. This did not happen for the median household with a low score. A similar figure for Portugal is available in the Online Appendix (Figure A.7).

Other variables are used hereafter, e.g. inflation perceptions, 3-years ahead inflation expectations and for total net income in next 12 months. The wording of these questions can be seen in the Online Appendix C. One should note that the country dimension indicates the country of residence of the respondent. Moreover, the euro area sample includes from April 2022 onwards data from the five new countries included in the survey. The results are qualitatively unchanged if we keep only the six initial countries in the sample.

3. Heterogeneous Inflation Expectations

The wealth of information gathered by CES presents an opportunity to delve into the heterogeneity of inflation expectations among distinct demographic and socioeconomic cohorts. In this section, the aim is to investigate how financial knowledge influences the shaping of these expectations. First, it is important to better understand how

accurate perceptions of inflation are, since consumers depart from these when forming their expectations. Then, relevant properties that characterise the survey responses about short-term inflation expectations are presented. It is also investigated whether financial knowledge is relevant in driving disagreement in inflation expectations at the individual level. Finally, it is assessed how medium-term expectations deviate from the inflation target for each level of financial knowledge. While the rationality assumption in consumers' inflation expectations has already been scrutinised through aggregate analysis (cf. Dias *et al.* (2008)), this study contributes with a micro-level approach.

3.1. Accuracy in Inflation Perceptions

Consumers' beliefs regarding recent inflation dynamics strongly influence expectations about future inflation.[8]. Thus, the starting point of this analysis must be to inspect whether inflation perceptions, i.e., the perception about the evolution of the prices over the last 12 months, would be more accurate with higher levels of financial knowledge.

To do so, the error made by an individual i of country j at time t is computed as the absolute difference between the respective point estimate and the actual inflation of country j at time t, $\pi^p_{ijt} - \pi_{jt}$. Formally, we test the association between the perception error and the level of financial knowledge, denoted by lit^{medium}_{ijt} for the medium score and lit^{high}_{ijt} for the high score, in Equation 1, which goes as follows

$$\pi^p_{ijt} - \pi_{jt} = \alpha + \omega_1 lit^{medium}_{ijt} + \omega_2 lit^{high}_{ijt} + \beta X_{ijt} + \varepsilon_{ijt}, \quad (1)$$

where it is also included a set of demographic controls, represented by X_{it}.[9]

Table 1 shows the results for the eleven countries together and for Portugal. Notably, the constant term underscores a significant positive bias in inflation perceptions, which is exacerbated by the exceptional period of analysis considered. This bias is reduced as the level of financial knowledge increases in both cases. The magnitude of the reductions is surprisingly large and statistically significant at the 1% level of significance for the medium and high score groups in comparison with the low score group.

3.2. Disagreement in Short-term Inflation Expectations

Recent research has been collecting evidence on multiple drivers behind disagreement in inflation expectations. In fact, these range from shopping experiences to demographic characteristics as they influence how each individual receives information about prices. For instance, Gomes *et al.* (2024) find that older and low-income households have higher inflation expectations, on average, when using the CES data. Weber *et al.* (2022) also show that heterogeneous cognitive abilities contribute to shape inflation expectations. In this subsection, we explore the role of financial knowledge in driving this disagreement.

Table 2 shows descriptive statistics on survey responses about short-term inflation expectations. The share of zeros represents the fraction of those reporting that "*prices*

8. This was initially identified among Swedish households by Jonung (1981) and consistently confirmed for households, firms and professional forecasters thereafter by other studies, such as Weber *et al.* (2022).

9. The demographic controls include: age, gender, income, education, housing type, size and partner.

	For all countries together			For Portugal		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	7.12***	7.26***	7.69***	13.88***	13.91***	16.52***
	(0.33)	(0.04)	(0.38)	(0.55)	(0.21)	(0.68)
Financial Knowledge (omitted = Low Score)						
Medium Score	-0.88***	-1.12***	-0.45***	-2.91***	-2.93***	-1.62***
	(0.07)	(0.05)	(0.07)	(0.28)	(0.27)	(0.27)
High Score	-2.48***	-2.58***	-1.46***	-5.38***	-5.47***	-2.96***
	(0.13)	(0.11)	(0.10)	(0.32)	(0.29)	(0.28)
Observations	714,802	714,802	714,802	26,185	26,185	26,185
Adjusted R^2	0.10	0.16	0.13	0.10	0.13	0.14
Within R^2	0.10	0.11	0.13	0.10	0.11	0.14
Country- and time-fixed effects		✓			✓	
Demographic controls			✓			✓

Notes: The euro area sample includes from April 2022 onwards data from the five new countries. Weights are used in the estimations. Robust standard errors, clustered at the household and month level, are reported in parentheses. Data on actual inflation rates at the country-level was collected from Eurostat. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

TABLE 1. Effect of financial knowledge on individual inflation perceptions

will remain exactly the same (that is 0% change)" in the qualitative question. The remaining statistics are calculated from the open-ended expectation question mentioned above.

Financial Knowledge	Low Score	Medium Score	High Score
Share of 0s			
For all countries together	22.7%	14.0%	9.2%
For Portugal	8.5%	7.3%	5.9%
Decimals use			
For all countries together	24.7%	25.3%	29.1%
For Portugal	17.1%	16.3%	18.0%
Multiples of 5			
For all countries together	50.8%	44.2%	35.0%
For Portugal	59.9%	56.0%	46.9%
Between -10 and 10			
For all countries together	80.4%	84.1%	89.9%
For Portugal	70.4%	75.2%	85.2%
Observations			
For all countries together	192,247	391,400	136,109
For Portugal	6,370	15,880	3,935

Notes: The euro area sample includes from April 2022 onwards data from the five new countries. Weights are not used in the computation.

TABLE 2. Descriptive statistics about survey responses for short-term inflation expectations

One finds that significant divergences emerge between the responses across levels of financial knowledge. Notably, across all countries, the proportion of respondents reporting a zero change in prices decreases as financial knowledge rises, with the lowest share observed among individuals with high score (9.2%). In contrast, those with low score exhibit the highest proportion of zero responses (22.7%). This trend persists when focusing on Portugal alone, where the disparities remain present, but in a much smaller magnitude (8.5% for low, 5.9% for high). Moreover, the use of decimals in inflation expectations slightly increases with higher financial knowledge across all countries, reaching 29.1% among individuals with high financial knowledge, compared to 24.7% among those with low financial knowledge. Similar trends are observed for Portugal.

Regarding the propensity to report the short-term expectations in multiples of five, individuals with low scores exhibit a higher inclination towards this pattern (50.8%) compared to those with medium (44.2%) or high financial knowledge (35.0%) across all countries. In Portugal, this trend persists, with the percentage of responses adhering to multiples of five decreasing as financial knowledge increases (59.9% for low, 46.9% for high). Furthermore, the majority of respondents across all countries expect inflation within the range of -10 to 10, with the highest percentage observed among individuals with high financial knowledge (89.9%). Similarly, in Portugal, a higher percentage of respondents with high financial knowledge (85.2%) report inflation expectations within this range compared to those with low financial knowledge (70.4%).

Next, it is presented a test on how financial knowledge impacts the level of inflation expectations. It is used a panel regression in which expectations for prices are modelled as a function of the score obtained in the questions highlighted above.

Formally, this relationship is expressed in Equation 2 as follows:

$$\pi^{e}_{ijt} = \alpha + \gamma\pi^{e}_{ijt-1} + \varphi\pi^{p}_{ijt} + \omega_1 lit^{medium}_{ijt} + \omega_2 lit^{high}_{ijt} + \beta X_{ijt} + \varepsilon_{ijt}, \quad (2)$$

where π^{e}_{ijt} corresponds to inflation expectations 12-months ahead for individual i from country j at time t, π^{p}_{ijt} corresponds to perceived inflation in the past 12 months, lit^{medium}_{ijt} and lit^{medium}_{ijt} are dummies for the level of financial knowledge. As robustness of the results, several demographic controls are added as dummies, denoted by X_{ijt}.[10]

Table 3 presents the results for these specifications with all countries included in the CES together and for Portugal alone. For all countries collectively, the coefficients associated with financial knowledge reveal significant effects. Specifically, individuals with a medium level of financial knowledge exhibit, on average, a lower level of inflation expectations than the ones with a lower level, with coefficients of -0.19 without controls and -0.17 with demographic controls, both statistically significant at the 1% level. Similarly, a high level of financial knowledge also leads to a significant negative impact on inflation expectations, with even stronger coefficients of -0.28 without controls and -0.21 with demographic controls, again significant at the 1% level. With country- and time-fixed effects, results remain very similar to these.

10. The demographic controls include: age, gender, income, education housing type, size and partner.

For Portugal, similar patterns emerge but, compared to individuals with lower scores, there is no clear difference for those with medium level. Those with high financial knowledge levels display on average lower inflation expectations, with the coefficients of -0.59 and -0.50 for each specification, both statistically significant at the 5% level.

These findings suggest that individuals with greater financial knowledge tend to have lower inflation expectations.[11] The coefficients for the demographic controls are broadly aligned with the patterns estimated by a number of recent studies that use household survey data from various sources. Namely, inflation expectations are higher for the older individuals, the low-income ones, numerous households and females.

	For all countries together			**For Portugal**		
	(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Constant	0.66***	0.53***	0.28***	0.48***	0.45***	0.12
	(0.03)	(0.10)	(0.06)	(0.22)	(0.30)	(0.54)
Lagged Inf. Expectations	0.39***	0.39***	0.39***	0.47***	0.45***	0.47***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
Inflation Perceptions	0.34***	0.36***	0.34***	0.24***	0.25***	0.24***
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Financial Knowledge (omitted: Low Score)						
Medium Score	-0.19***	-0.17***	-0.17***	-0.17	-0.15	-0.10
	(0.05)	(0.03)	(0.03)	(0.22)	(0.23)	(0.22)
High Score	-0.28***	-0.24***	-0.21***	-0.59***	-0.54***	-0.50**
	(0.05)	(0.05)	(0.04)	(0.21)	(0.22)	(0.21)
Observations	593,147	593,147	593,147	19,928	19,928	19,928
Adjusted R^2	0.55	0.56	0.55	0.53	0.54	0.53
Within R^2	0.55	0.51	0.54	0.53	0.53	0.53
Country- and time-fixed effects		✓			✓	
Demographic controls			✓			✓

Notes: The euro area sample includes from April 2022 onwards data from the five new countries. Weights are used in the estimations. Robust standard errors, clustered at the household and month level, are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, resp.

TABLE 3. Effect of financial knowledge on individual inflation expectations

The findings underscore the role of financial knowledge in shaping individual inflation expectations. Previous studies, such as Lusardi (2008), Armantier *et al.* (2010) and Bruine *et al.* (2011), show that consumers with a lower ability to process financial statistics and information tend to overestimate inflation, as they are less informed about short and medium-term price trends. Their consumption baskets may also be different, which is more vulnerable to increases in prices. This study extends these conclusions to expectations about prices as it concludes that consumers with a lower level of financial knowledge tend to have higher point-estimates about the future evolution of prices.

11. This result does not contradict the information presented in Figure 2 as controls for inflation perceptions and other characteristics are included and the average effects are considered, *ceteris paribus*.

3.3. Deviations from the Inflation Target

It is also relevant to inspect whether financial knowledge affects consumers' ability to foresee inflation in the medium-term. The article proceeds to test whether any systematic heterogeneity exists in the precision and accuracy with which economic agents form their medium-term inflation expectations based on the level of financial knowledge.

First, the difference between the expectation for the annual growth of prices 3-years-ahead and the inflation target of 2% set by the ECB is computed and it is considered the absolute value of the result. Then, a formal test similar to the one presented in Equation 2 is carried out, in which π_{it}^{e} is replaced by the absolute value of that difference. Again, it is also used a set of demographic controls to isolate the effect of financial knowledge.

	For all countries together			For Portugal		
	(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Constant	1.10***	1.06***	1.14***	1.20***	1.17***	1.07***
	(0.05)	(0.06)	(0.08)	(0.11)	(0.17)	(0.42)
Lagged Inf. Expectations	0.48***	0.47***	0.47***	0.48***	0.47***	0.47***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
Inflation Perceptions	0.19***	0.20***	0.20***	0.18***	0.19***	0.18***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.12)	(0.01)
Financial Knowledge (omitted: Low Score)						
Medium Score	-0.54***	-0.53***	-0.44***	-0.82***	-0.80***	-0.65***
	(0.04)	(0.05)	(0.04)	(0.10)	(0.10)	(0.10)
High Score	-1.04***	-1.00***	-0.84***	-1.43***	-1.41***	-1.16***
	(0.05)	(0.06)	(0.45)	(0.14)	(0.14)	(0.13)
Observations	588,677	588,677	588,677	19,928	19,928	19,928
Adjusted R^2	0.49	0.50	0.49	0.49	0.49	0.49
Within R^2	0.49	0.45	0.49	0.49	0.48	0.49
Country- and time-fixed effects		✓			✓	
Demographic controls			✓			✓

Notes: The euro area sample includes from April 2022 onwards data from the five new countries. Weights are used in the estimations. Robust standard errors, clustered at the household and month level, are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, resp.

TABLE 4. Effect of financial knowledge on deviations of medium-term expectations from target

Table 4 shows that, as financial knowledge rises, the divergence of the medium-term expectations from the inflation target of 2% diminishes noticeably. Individuals with medium scores exhibit smaller differences compared to their counterparts, as evidenced by negative coefficients with statistical significance, even when controlling for systematic biases in inflation perceptions and other demographic controls. Moreover, those with a high score tend to have smaller deviations from target, highlighting the profound impact of financial education and its relevance for central banks. The results remain consistent when considering Portugal independently, reaffirming the robustness of the relationship. In this context, individuals with higher score have a even more negative coefficient than compared with the ones for all countries together.

Given the role of financial knowledge in shaping the inflation expectations formation process, it is also crucial for central banks to grasp its impact on the nexus between these expectations and economic decisions. Actually, expectations on future price changes are crucial for households' consumption allocation over time and they may lead to different reactions at the individual level in response to monetary policy. This study proceeds to explore the mechanism linking such expectations with choices.

4. Household Choices and Financial Knowledge

When households anticipate higher future prices, they are incentivised to buy more goods now while prices are now lower, lowering the expected spending growth rate.

This is described by the standard consumption Euler equation, a fundamental concept in macroeconomic models. Inflation expectations play a significant role in this equation, influencing consumption and saving decisions. Essentially, higher inflation expectations can stimulate the aggregate demand, thus potentially increasing inflation by reducing economic slack. This section follows Crump *et al.* (2022) to estimate the elasticity of intertemporal substitution of consumers in the euro area and in Portugal. It also assesses whether estimates change with the level of financial knowledge.

4.1. Theoretical Motivation

The theoretical motivation of this estimation approach lies in the intertemporal Euler equation, as explained in Crump *et al.* (2022). The equation characterises the optimal consumption and saving decisions of households that have the ability to borrow and lend at a known nominal rate of return, R_t. In its basic form, assuming separable isoelastic preferences, which can be interpreted as utility functions that exhibit a constant elasticity, this equilibrium condition can be expressed as:

$$1 = E_t^i \left[\beta_i \left(\frac{C_{t+1}^i}{C_t^i} \right)^{-\frac{1}{\sigma}} \left(\frac{R_t}{\prod_{t+1}} \right) \right], \tag{3}$$

where the discount factor β_i represents the household's time preference, and C_t^i denotes its consumption of a bundle of goods and services. It is important to note that the overall level of consumption can differ across households indexed by i, implying the absence of a representative consumer. However, the composition of the consumption bundle and its price index, $\prod_t$, is the same for all individuals in each country. The assumption of a "representative" price index, which is widely adopted in macroeconomics, aligns well with CES questions, designed to capture expectations of aggregate inflation rather than individual price changes, which might be more directly relevant to respondents.

Inflation expectations are allowed to vary across households, as observed in the data. This diversity in inflation expectations contributes to differences in the *"ex-ante"* real interest rates perceived by households over time, given a particular nominal interest rate. According to the Euler equation, these variations should correlate with disparities in planned consumption. The estimates of the intertemporal substitution elasticity, denoted by the σ, quantify the strength of this relationship. Taking a log-linear approximation of Equation 3 yields the following relationship:

$$E_t^i[\Delta c_{t+1}^i] = \sigma \log \beta_i + \sigma R_t - \sigma E_t^i[\pi_{t+1}] + o_{it}, \tag{4}$$

where lower case letters represent logs and $o_{i,t}$ is a remainder collecting second and higher order terms in the approximation. This simple linear equation is the starting point for the following regressions. Equation 4 is ubiquitous in macroeconomics, starting from the pioneering work of Hall (1978). Intuitively, an increase in expected inflation, $E_t^i[\pi_{t+1}]$, lowers the perceived real interest rate (for a fixed nominal interest rate, R_t), thereby reducing the incentive to save and raising current consumption relative to future consumption. This generates the negative relation in Equation 4.

4.2. Empirical Strategy

The strategy follows the methodology in Crump *et al.* (2022), relying on direct measures of euro area households' expectations of both inflation and their consumption growth from survey data. With these, Equation 4 can be estimated directly with a standard OLS regression model. The dependent variable is the expected real consumption growth computed as the difference between the expectation for the growth of spending on all goods and services during the next 12 months and the expectation for inflation over the same next 12 months. This approach allows for differences across households in their expectations of aggregate inflation, but not in the households' own price index.

4.3. Elasticity of Intertemporal Substitution

Table 5 presents the estimation results. Column (1) reports the regression coefficient on expected inflation, $-\hat{\sigma}$, in a specification without control variables. The absolute value of the coefficient can be interpreted as the elasticity of intertemporal substitution or, in other words, the response of expected consumption growth to changes in expected inflation. It also tested the inclusion of real expectations for income growth as one well-documented failure of the permanent income hypothesis (PIH) is the "excess sensitivity" of consumption growth to expected income changes. The PIH suggests that predictable changes in income shouldn't affect how consumption grows over time because people plan their consumption based on their expected lifetime income. However, studies often find that anticipated income growth does impact consumption growth, which contradicts the PIH.[12] Column (2) presents the estimation with this addition, confirming that this is a relevant variable. Column (3) shows results adding several demographic variables as controls.[13] Column (4) reports the results using other macroeconomic variables as controls, being one of them the expectation for the nominal interest rate to address the concern that if the interest rate the household faces is correlated with their inflation expectations this could be a source of bias. [14]

It is consistently found an elasticity of intertemporal substitution between 0.58 and 0.73 across various model specifications, for euro area consumers. These estimates, falling at the higher end of similar studies using data on consumption choices (Attanasio and Weber (2010)), are precisely determined with small robust standard errors.

Moreover, even in the simplest specification, it is accounted for approximately 35% of the variation in expected real spending growth over the sample period. All reported estimates are statistically significant, indicating a departure from a null hypothesis. As suggested by Crump *et al.* (2022), the rejection of an EIS of 0 strongly suggests that households' expectations align with a pronounced intertemporal substitution motive. In Portugal, statistically significant results are also observed across all specifications, with

12. See Jappelli and Pistaferri (2010) for a survey of this literature.

13. The demographic controls include: age, gender, income, education, housing type, size and partner.

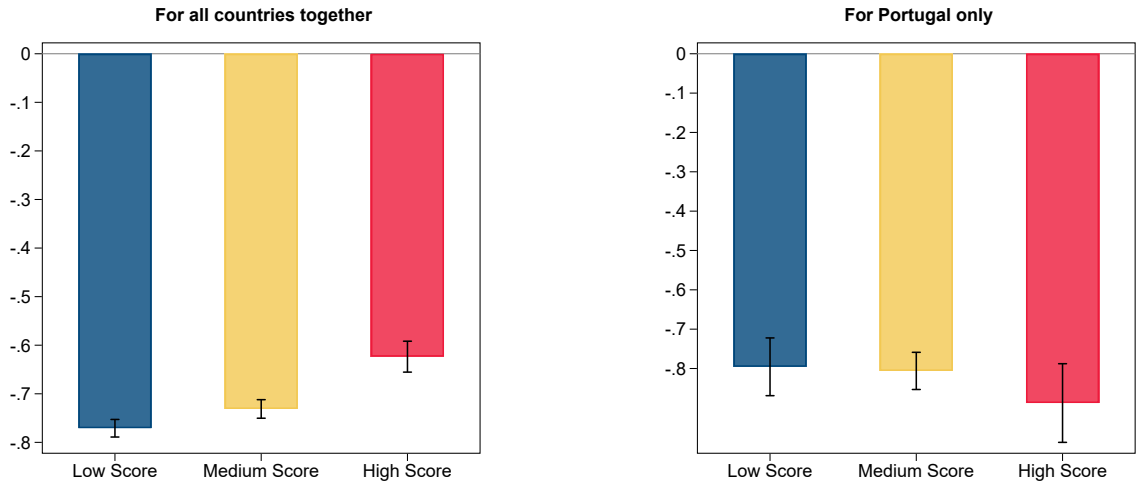
14. The macroeconomic controls include: past credit access, expectation for credit access, expectation about unemployment rate and expectation for interest rate on savings accounts.

a stronger elasticity ranging from 0.72 to 0.81. Notably, around 40% of the variation in expected real spending growth is explained in this context.[15]

	For all countries together				For Portugal			
	(1)	**(2)**	**(3)**	**(4)**	**(1)**	**(2)**	**(3)**	**(4)**
Expected Inflation	-0.81***	-0.73***	-0.58***	-0.60***	-0.76***	-0.81***	-0.72***	-0.75***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.03)
Real Exp. Inc. Growth		0.08***	0.05***	0.05***		-0.04***	-0.11***	-0.09***
		(0.01)	(0.01)	(0.01)		(0.01)	(0.01)	(0.01)
Observations	590,807	590,807	613,844	573,494	20,947	20,947	22,532	22,532
Adjusted R^2	0.56	0.56	0.34	0.34	0.57	0.57	0.38	0.40
Within R^2	0.37	0.37	0.34	0.34	0.38	0.38	0.38	0.40
Household-fixed effects		✓				✓		
Demographic controls			✓				✓	
Macroeconomic controls				✓				✓

Notes: The euro area sample includes from April 2022 onwards data from the five new countries. Weights are used in the estimations. Robust standard errors, clustered at the household and month level, are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, resp.

TABLE 5. Elasticity of intertemporal substitution



Notes: The euro area sample includes from April 2022 onwards data from the five new countries. Weights are used in the estimations. The black lines represent the 95% confidence intervals.

FIGURE 4: Elasticity of intertemporal substitution by level of financial knowledge

Figure 4 presents the estimated coefficient, $-\sigma$, splitting the sample for each level of financial knowledge. It is used the specification from Column (3) of Table 5. Using all countries, it is shown remarkable differences for the elasticities of intertemporal

15. The negative coefficient for the real expected income growth emerges as a result of the sample window available for Portugal. The estimated coefficients for the expected income growth concerning the euro area are similar to the ones shown in Crump *et al.* (2022). When using the data for the euro area after April 2022 (as for Portugal), the estimated coefficients also decrease to close to 0 or even negative values.

substitution. The consumers with a lower score are the ones with stronger reactions in expected spending when inflation expectations change. In contrast, consumers with higher financial knowledge exhibit lower estimates for the elasticity. When considering only households from Portugal, these differences are muted as it cannot be rejected the hypothesis that the coefficients are different across levels of financial knowledge.

5. Final Remarks

Understanding inflation expectations and household choices is important for economic research as well as for the design and evaluation of policies, being central to monetary policy. In this regard, survey data plays a pivotal role as it provides reliable information at a relatively high and timely frequency. It may help to assess the dynamic evolution of ongoing household sector developments, as well as the related policy responses, that often have heterogeneous effects on different population segments.

The CES fills this purpose by collecting individual-level data on consumers economic and financial behaviour in the euro area. This study starts by presenting the survey and its design, while evaluating the representativeness of the sample for the euro area and for Portugal. Then, it leverages the richness of the survey to explore heterogeneities of inflation expectations, focusing on the role of financial knowledge. Those with high scores employ more effort to answer survey on inflation expectations. They also have a perception of the past evolution closer to actual inflation and lower short-term expectations. This result aligns well with other heterogeneities already identified in the literature. Regarding medium-term expectations, those with more financial knowledge tend to report smaller deviation from the inflation target of 2% defined by the ECB.

When turning to household choices, a fundamental mechanism commonly found in macroeconomic models, the consumption Euler equation, is explored. Using variations in expected inflation, estimates for the elasticity of intertemporal substitution between 0.6 and 0.7 are obtained, consistent with results found in previous literature. The estimates for Portugal are slightly higher. When splitting the sample by level of financial knowledge, it is found that the response of expected real consumption growth to inflation expectations is weaker for the households with a higher financial knowledge. This result, however, is muted for Portugal as there is no measurable difference across groups, which may be also due to a smaller sample available.

Inflation expectations attract significant attention from researchers and central banks, in particular in times of turmoil such as the COVID-19 pandemic (Gomes *et al.* (2021)) and exceptionally rising prices. The recent surge in inflation in the euro area economy has raised concerns about the broader macroeconomic environment, including inflation expectations developments. This study provides further evidence on why promoting financial knowledge may be relevant for the conduct of monetary policy, helping them accomplish their mandates. First, it helps households to improve their perception about inflation. Then, it brings medium-term inflation expectations closer to the inflation target, one of the main objectives of central banks. Finally, it lowers the responsiveness of consumption plans in times of high inflation.

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Banco de Portugal
Banco de Portugal Economic Studies, Vol. X, No. 3

Non-technical summary

July 2024

An analysis of hospital efficiency in Portugal

Cláudia Braz, Sónia Cabral and Leonor Cunha

Hospitals play a crucial role in delivering medical care worldwide. In Portugal, hospital expenditure has consistently increased over the last two decades. This trend can be traced largely to the growing role of private hospitals, whose spending is currently half funded by the government. Except for the period most impacted by the pandemic, there has been a major shift in the composition of hospital activities, as well as a significant rise in the number of medical services supplied. Nonetheless, possible inefficiencies are evidenced by long waiting lists for medical procedures or a shortage of doctors in the public sector, as well as perceived budgeting and centralised control shortcomings. In this context, the relevance of performing hospitals' efficiency evaluations becomes even more evident.

This study investigates the technical efficiency of a representative sample of 22 Portuguese public-corporate (EPE) hospitals from 2012 to 2022, employing Data Envelopment Analysis (DEA) as the analytical tool. DEA estimates a non-parametric production frontier based on the most efficient hospitals, allowing the assessment of each hospital's performance relative to this frontier. In the baseline specifications, both input-oriented and output-oriented models are estimated considering 3 input variables (personnel expenses, intermediate consumption, and number of beds) and 4 output variables (appointments, emergencies, surgeries, and inpatient discharges). Given the small size of the sample, principal component analysis (PCA) was used as a technique to reduce the dimensionality of the original variables and DEA models with 1 input-1 output were estimated using PCA-derived variables.

The results obtained in this study are in line with previous empirical research, pointing to sizeable inefficiencies and a great dispersion in efficiency scores across hospitals. The simple average of the individual metrics of efficiency is around 0.8 in 2022, down from approximately 0.85 in 2012 (Figure 1). This means that, on average, it could be possible to either lower inputs by 20% while producing the same outputs or to raise outputs by 20% with the same inputs. The decline in average hospital efficiency is stronger since 2017. The results by hospital point to a broad-based reduction in efficiency scores, with only two or three hospitals (depending on the models) being able to improve

their relative efficiency throughout the period. The small subset of efficient hospitals that constitute the frontier is rather stable over time.

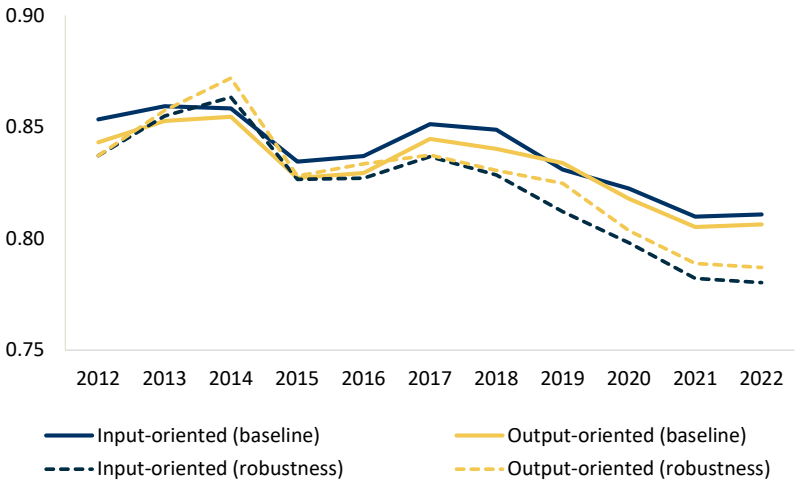

FIGURE 1: Hospital technical efficiency from 2012 to 2022 | Average of DEA individual scores

Notes: Balanced sample of 22 EPE hospitals in each year. DEA models with 1 input-1 output, where the inputs and outputs are calculated with PCA (first principal component scores). The PCA of the baseline models uses three input variables (personnel expenses, intermediate consumption, and occupancy) and four output variables (appointments, emergencies, surgeries, and inpatient discharges). The robustness models use the number of doctors and nurses, measured in full-time equivalents (FTE), instead of wages and salaries in the calculation of the first principal component of inputs.

DEA is a method to evaluate only technical efficiency, without controlling for the quality or access to healthcare services. In healthcare, as in other public services, the quality of service is critical since it has a direct impact on the population. To address this issue, this study constructs a simple composite indicator to assess the quality of health services provided by these hospitals, using variables pertaining to the timeliness and appropriateness of care. The findings indicate a general stabilisation in average quality over the period. Furthermore, there is a positive correlation between this quality indicator and DEA scores, indicating that hospitals with higher technical efficiency also tend to provide better healthcare services.

This study underscores the need for a thorough investigation about healthcare provision in Portugal, encompassing dimensions beyond those explored herein. The intricacy of the sector and its evolving architecture, particularly with the expansion of *Unidades Locais de Saúde*, amplifies the challenge. While the analysis conducted in this study may not yield definitive conclusions or concrete policy recommendations, the observed decline in the technical efficiency of public hospitals is inherently concerning and demands attention.

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An analysis of hospital efficiency in Portugal

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July 2024

Abstract
This study uses Data Envelopment Analysis (DEA) to assess the technical efficiency of a representative panel of 22 Portuguese public hospitals in the period from 2012 to 2022. Based on the different estimated models, there was a decline in average hospital efficiency, particularly since 2017. The results by hospital reveal a high persistence of those that form the efficiency frontier in each year and a widespread decrease in efficiency scores. DEA is a technique that evaluates the performance of hospitals relative to their peers, not taking into account the impact of exogenous factors or quality effects. To address the latter, a simple composite indicator was constructed to evaluate the quality of health services provided by these hospitals. The results show a general stabilisation in average quality over the period and suggest that hospitals with higher technical efficiency also tend to provide better healthcare services. (JEL: I1, I11)

1. Introduction

Hospitals are essential for providing medical care worldwide. Evaluating their efficiency is paramount, as it directly impacts the quality and accessibility of healthcare services, especially amid resource constraints experienced by systems globally. Moreover, hospitals that operate efficiently are better positioned to adapt to the evolving global healthcare landscape characterised by technological advancements, demographic changes, and shifting disease patterns.

Efficiency analysis in the healthcare sector, and particularly in hospitals, often resorts to Data Envelopment Analysis (DEA), a linear programming method that evaluates the relative performance of different units based only on their combination of inputs and outputs (see Hollingsworth (2008) for a review). O'Neill *et al.* (2008) provide a systematic review of hospital efficiency studies published between 1984 and 2004, using DEA and related techniques. More recently, Kohl *et al.* (2019) complement the previous surveys

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covering 262 papers, published from 2005 to 2016, on DEA applications in healthcare with special focus on hospitals.

Focusing on DEA applications to Portuguese hospitals, Moreira (2008) evaluates the impact of the 2002's Portuguese health system reform on hospitals' technical efficiency and concludes that hospitals converted to public enterprises achieved relatively higher efficiency gains. The results of Rego *et al.* (2010) also suggest that the introduction of market processes and changes in organisational structure had a positive impact on Portuguese public hospitals. Simões and Marques (2011) report significant levels of inefficiency in a sample of 68 Portuguese hospitals, with more than half of them being congested in 2005. Marques and Carvalho (2013) also find considerable inefficiency levels in the Portuguese hospitals, but with some improvements over the period 2005–2008. The Portuguese Court of Audit also conducted an efficiency analysis using DEA (Tribunal de Contas 2011). The study focuses on 49 hospital units for inpatient care and 47 units for outpatient activity and the findings reveal an overall cost inefficiency in 2008 of 27% in the former case and 41% in the latter.

More recently, Ferreira *et al.* (2018) investigate the optimal scale size of a sample of 27 Portuguese public hospitals from 2013 to 2016 and find that around half of the hospitals are oversized, when aiming for scale efficiency, and that there is an uneven distribution of health workforce across the country, with excess of staff located in urban areas. Pereira *et al.* (2020) propose a methodology that combines DEA with multiple criteria decision-making, considering criteria interactivity and incorporating decision-makers' preferences. The authors apply this approach to evaluate the performance of 25 Portuguese public hospitals and conclude that 40% of them were inefficient. Pereira *et al.* (2021) use a network DEA with Monte Carlo simulation to measure the efficiency of a sample of 27 Portuguese public hospitals in 2017 and show that two-thirds of those providers were inefficient.

The present study contributes to this literature by applying DEA to analyse the relative efficiency of a balanced panel of 22 Portuguese public hospitals from 2012 to 2022, thus including pre and post pandemic periods. The results obtained in this study are in line with previous empirical research, pointing to sizeable inefficiencies and a great dispersion in efficiency scores across hospitals. In this sample of hospitals, it could be possible in 2022, on average, to either lower inputs by around 20% while producing the same outputs or to raise outputs by 20% with the same inputs. There is a broad-based decrease in efficiency from 2012 to 2022, with only two or three hospitals (depending on the models) being able to improve their relative efficiency throughout that period. The subset of efficient hospitals that constitute the frontier is rather stable over time.

The application of conventional DEA allows only to assess hospitals' technical efficiency, not taking into account the quality or access to healthcare services. In fact, measuring simultaneously technical efficiency and quality is not straightforward in the literature. On this, Ferreira and Marques (2019) investigate the relationship between quality, access, and technical efficiency of a sample of 27 Portuguese public hospitals from 2013 to 2016 and find evidence of some trade-offs between efficiency and quality. This study constructs a simple composite indicator, using variables pertaining to timeliness of the provision and appropriateness of the care, and find little change in

the indicator in the period under analysis and a positive correlation with DEA scores, meaning that more efficient hospitals tend to provide higher quality services.

The study is organised as follows. Section 2 provides a brief overview of the hospital system in Portugal, emphasising key features and reforms implemented over the past two decades. Section 3 consists of several subsections aimed at describing the methodology (subsection 3.1) and the data (subsection 3.2), and presenting the results (subsection 3.3). Section 4 offers concluding remarks.

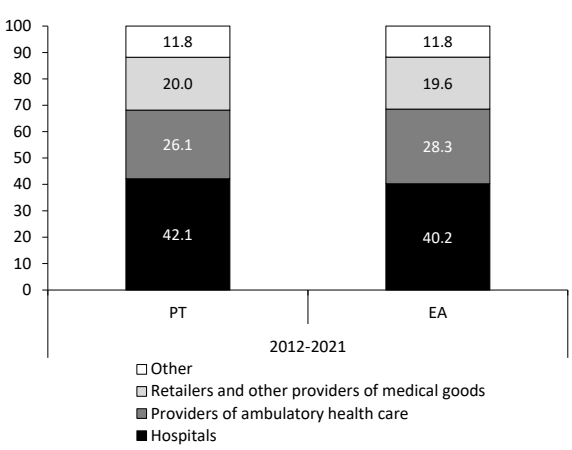
2. The hospital system in Portugal

The Portuguese hospital system encompasses both private institutions, including public-private partnerships (PPP), and hospitals belonging to the National Health Service (*Serviço Nacional de Saúde, SNS*). Regarding the latter, a crucial change occurred in 2002 with the enactment of a new legal framework for hospital management (Law No. 27/2002). This legislation defined a new business-type hospital management model, which provided the units with autonomy in financial, administrative, and human resource matters. The establishment of corporate hospitals, initially designated as *Hospitais SA* and later reconfigured as *Hospitais EPE* in 2005 (under Decree-Law No. 95/2005), was built upon this transformation. Currently, health public-corporate entities (EPE) and non-corporate (non-EPE or SPA) are regulated by Decree-Law No. 18/2017. For a description of the main aspects of the SNS reform over the past decades, see Nunes and Ferreira (2019) and Braz and Cabral (2023).

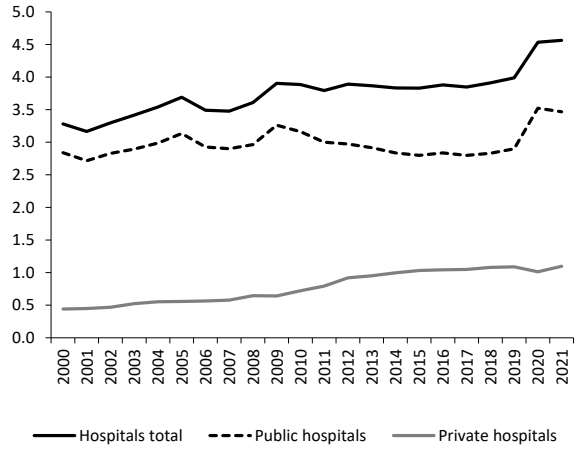
According to data provided by the SNS, the number of public hospitals in Portugal was 45 in 2021. They consisted in 22 hospital centres (1 psychiatric, non-EPE), 12 hospitals (2 non-EPE), 3 oncology institutes and 8 local health units (*Unidades Locais de Saúde, ULS*). Hospital centres horizontally integrate several hospitals located in the same city or region and are considered as a single unit in SNS data. The same occurs with ULS that provide comprehensive health care services across different levels of care, such as primary, hospital, and long-term care. Excluding non-EPE entities, ULS and specialised hospitals outside hospital centres, there are 31 units remaining. For the purpose of this study, the focus will be on 22 of these entities (18 hospital centres and 4 EPE hospitals) for which data are available, covering the period from 2012 to 2022. In 2021, the 22 hospitals included in the sample represented around 80% of personnel expenses and intermediate consumption of the total in EPE general units (excluding ULS). Comparing with data on the universe of public hospitals in mainland Portugal, from the 2021 satellite health account (SHA) compiled by Statistics Portugal, the balanced sample of 22 hospitals accounted for around 60% of total beds and almost 65% of total medical appointments, emergency cases and inpatient discharges.[1]

1. According to the 2021 SHA, Portugal mainland has a total of 221 hospitals. Among these, 104 are public, 115 are private, including those associated with non-profitable institutions, and 2 are in PPP arrangements (only 1 at the end of that year). Although the proportion of general hospitals is similar across both the public and private sectors, it is noteworthy that specific specialized hospitals, such as maternity, oncology, and paediatrics, are exclusively found within the public sector.

On average, over the last decade, hospitals in Portugal account for around 42% of total current health expenditure excluding residential long-term care facilities (Figure 1, panel A). This value is slightly above that observed in the euro area as a whole. Hospital current expenditure as a ratio to GDP has shown a slow upward trend from 2000 to 2019, corresponding to an average annual growth of around 3% in real terms. This increase was mostly driven by the rise of private hospitals spending (Figure 1, panel B). Notably, Portugal witnessed in this period an expansion of health services offered by private hospitals, as well documented by Gouveia (2023), who analyses comprehensively the Portuguese SNS, with a special focus on private providers. In 2021, private hospital provision was 24% of total hospital expenditure. It is noteworthy that the years affected by the pandemic (2020 and 2021) experienced a substantial increase in hospital expenditure, attributable solely to the public component.



(A) Average breakdown by provider in Portugal and the euro area | Percentage



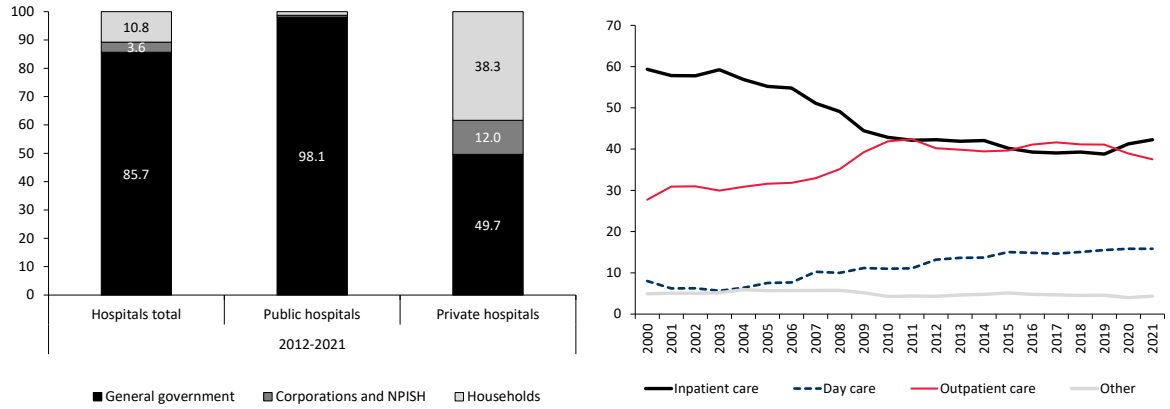
(B) Total, public and private current hospital expenditure in Portugal | As a percentage of GDP

FIGURE 1: Current health expenditure by provider

Sources: Eurostat and Statistics Portugal.
Notes: The euro area average excludes Croatia, Latvia, Malta and Slovenia. Total current health expenditure excludes spending on residential long-term care facilities.

One characteristic of the provision of private hospitals in Portugal is that it is financed to a large extent by general government: 50% on average over 2012-2021 (Figure 2, panel A).[2] This collaborative financing model can be exemplified by several initiatives: i) public sector employees covered by *ADSE* healthcare insurance have access to medical services provided through private sector facilities; ii) surgery vouchers (*vale-cirurgia*) allow patients registered in *Sistema Integrado de Gestão de Inscritos para Cirurgia (SIGIC)* to be redirected to a private institution if the maximum waiting time for surgery has elapsed. These type of contracts and agreements not only integrate private hospitals into the broader healthcare system but also ensure their active participation in delivering a comprehensive range of health services.

2. Around 28% in 2012-2021 when considering exclusively the financing of private hospitals by the SNS.



(A) By financing agent | Percentage of total (B) By function | Percentage of total

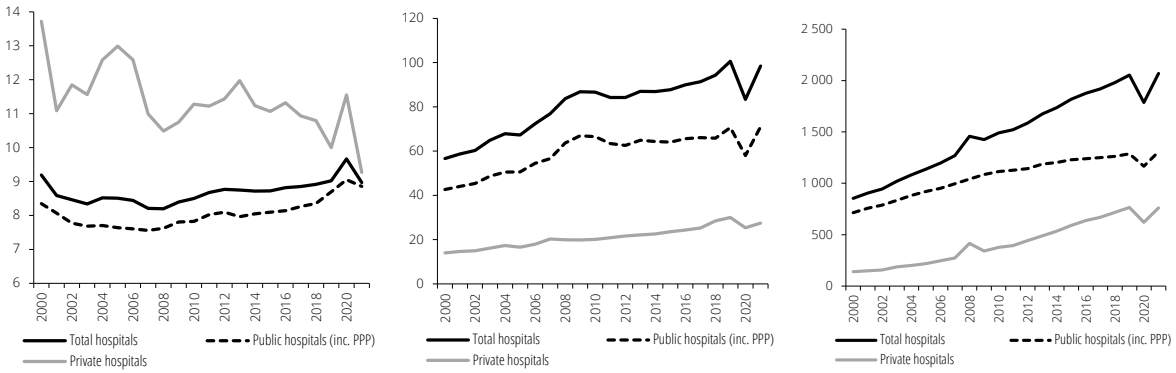
FIGURE 2: Hospital current expenditure in Portugal

Source: Statistics Portugal.
Notes: In panel A, the financing by general government includes SNS, compulsory and voluntary public health subsystems and other public institutions and social security funds. The financing by corporations and NPISH (non-profit institutions serving households) includes insurance corporations, private health subsystems managed by corporations and by NPISH and other NPISH. In panel B, the category 'other' includes all remaining items: home-based care and long-term care, ancillary services (non-specified by function), medical goods (non-specified by function), preventive care, governance and health system and financing administration, and other health care services not elsewhere classified. The most important item in the case of Portugal is ancillary services.

It is also important to analyse the evolution of hospital expenditure by function. The treatment of inpatients is the function that mostly differentiates the activity of a hospital vis-à-vis the other units providing health care. The data reveal a marked decrease in spending on inpatient care, with its weight diminishing from approximately 60% to 40% between 2000 and 2019 (Figure 2, panel B). This decline is counterbalanced by a corresponding rise in day care and outpatient care expenditures. According to the literature, this shift in functions can be attributed to advancements in medical technology and treatment methods, resulting in reduced hospitalisations, shorter average inpatient stays, and cost savings. In the case of Portugal, cost reduction seems to be the predominant explanation, as both output indicators indicate a generally stable trend when comparing 2000 and 2019 (refer to Figure 3, panel A, for the average length of stay). The number of surgeries increased since 2000 (Figure 3, panel B), but it is plausible that a part is now classified under day care spending. As for outpatient care, the rise in expenditure is linked to the growing number of medical consultations, as depicted in Figure 3, panel C. Finally, it is important to acknowledge that a simplistic analysis, which relies solely on a basic aggregate count of medical acts, fails in capturing their specific characteristics. A more comprehensive exploration will be conducted in the subsequent sections for the subset of hospitals under analysis.

While in Portugal there has been a consistent increase in the allocation of general government financial resources towards hospitals and medical services, a tangible improvement in efficiency remains uncertain and some discontent among the population is noticeable. Various issues have been identified as contributing to this situation. The budgeting process of the SNS lacks a centralised control and has persistently

faced underfunding, despite the introduction of programme contracts in 2003. These contracts aimed to enhance the separation of the State as a funder from hospitals as service providers, with the goal of improving prospective planning. According to the Portuguese Public Finance Council (Conselho das Finanças Públicas 2023), the cumulative SNS deficits from 2014 to 2022 reached 2.5% of GDP, significantly surpassing the budgeted cumulative deficits of 1% of GDP. This discrepancy was primarily attributed to expenditure overruns. Notably, during the same period, capital injections equivalent to 2.3% of GDP were provided to hospitals. Linked to the underfunding situation is the accumulation of arrears to hospitals' suppliers. Despite monitoring since the Economic and Financial Assistance Programme, the issue persists, and while the amounts have shown a declining trend, a lasting solution is yet to be achieved, as emphasised by Barros (2023). Several other concerning aspects related to the operation of hospitals in Portugal, all closely linked, are often underscored. These include issues such as lengthy waiting lists for surgeries and other medical procedures, a shortage of personnel, and limited access to specialised emergency assistance.



(A) Inpatient average length of stay | Days

(B) Surgeries (except minor surgeries) performed in hospitals | Number by 1000 inhabitants

(C) Medical consultations in outpatient care at hospitals | Number by 1000 inhabitants

FIGURE 3: Hospitals production in Portugal

Source: Statistics Portugal.
Note: Data for 2021 is provisional.

3. Empirical application

3.1. Methodology: data envelopment analysis (DEA)

Data envelopment analysis (DEA) is a non-parametric linear programming technique for optimising and ranking decision-making units (DMUs) with several outputs and inputs. DEA enables the comparison of homogenous DMUs (i.e., they use the same resources to create the same type of outputs), in order to identify relatively efficient units (which form the frontier) and quantify the level of inefficiency of the remaining units in comparison to the best ones (as the distance to the frontier). DEA assigns an efficiency

value between 0 and 1, with 1 identifying relatively efficient units. In this study, the units of analysis are Portuguese public hospitals.

DEA can characterise the performance of hospitals in two ways: input-orientation (minimisation of inputs for a given level of outputs) and output-orientation (maximisation of outputs for a given level of inputs). The choice of the model depends upon the production process under analysis. In general, hospitals tend to have more control over inputs than outputs, which are mostly demand-driven. This holds true in the case of Portugal, where public hospitals, in particular, operate under contracts established with the government that define the quantity and pricing of healthcare services. This study estimates both input-oriented and output-oriented DEA models, which allow us to also assess if noteworthy discrepancies exist in the efficiency measures derived from these two model types.

Efficiency measurement also depends on returns to scale, which can be constant or variable. The classical method by Charnes *et al.* (1978) assumes that units operate with a technology with constant returns-to-scale (CRS), which means that any change in the input level should produce a proportional change in output (no scale effect). A later version by Banker *et al.* (1984) analyses efficiency from the perspective of variable returns-to-scale (VRS), in the sense that the size at which a unit operates can affect its productivity. DEA models used in this study assume VRS. Appendix A presents the mathematical formulation of the input- and output-oriented DEA models used in this study: radial Debreu–Farrell measures of technical efficiency assuming VRS.

DEA can be a useful technique with several advantages. It can handle models with multiple inputs and outputs, measured in very distinct scales, without requiring the specification of a functional form. It also works with a limited number of observations. However, the same characteristics that make DEA a helpful tool also lead to its several limitations, which should be kept in mind when interpreting results. The method does not take into account the existence of exogenous factors in the analysis and, thus, each unit's distance to the frontier is totally accounted as technical inefficiency. DEA is an extreme point technique, meaning that all extreme points are considered efficient. Hence, the estimates are critically influenced by the presence of outliers, measurement errors and statistical noise. The composition and size of the sample, as well as the selection of input and output variables, have a significant impact on the results. In cross-year comparisons of DEA scores it is crucial to bear in mind that the metrics have a relative nature and are conditional on the frontiers estimated for each year. The difference in the efficiency scores of a unit between two periods only reflects the extent to which a unit has improved its efficiency or fallen behind in comparison to its peers, holding the technology and scale constants in each respective period. In the literature, the Malmquist productivity index with VRS (Ray and Desli 1997) is employed to augment the calculated technical efficiency (referred to as "pure efficiency change") with the impact of technological progress and changes in production scale. However, it is important to highlight that conducting the Malmquist decomposition typically requires direct measurements of inputs and outputs, rather than derived measures like, for instance, those obtained from principal component analysis (PCA).

3.2. Data

This study focuses on Portuguese public-corporate (EPE) hospitals. The option to centre the analysis only on EPE hospitals was mostly determined by the availability of information. All the data used is publicly available in the benchmarking and monthly monitoring of SNS hospitals of the Central Administration of the Health System (*Administração Central do Sistema de Saúde, ACSS*) website.[3] The provision of these data is mandatory for hospitals and the public availability has the goal to enable a better understanding of the SNS's performance. These characteristics point to a high reliability of the data provided, which is particularly important in this context given the high sensitivity of DEA estimates to measurement errors.

The sample covers the period from 2012 to 2022. All variables were calculated as annual averages of the monthly data available in the website.[4] The choice of input and output variables was heavily determined by data availability and only EPE hospitals with complete information on all variables in all years are included in the sample. One assumption of the DEA model is that the units under analysis are homogeneous. Therefore, hospitals and hospital centres were considered in the sample, but vertically integrated ULS and specialised hospitals (such as oncology centres) were disregarded from the analysis. Ultimately, a balanced panel of 22 EPE hospitals belonging to the Portuguese SNS was obtained (the list of public hospitals that comprise the sample is presented in the tables of Appendix B). Nevertheless, it is important to acknowledge that complete homogeneity among the analysed units may not be guaranteed, potentially influencing the accuracy of the efficiency estimates.

Following the literature, this study considers three input variables (personnel expenses, intermediate consumption, and number of beds) and four output variables (appointments, emergencies, surgeries, and inpatient discharges), which are discussed in the next subsections. Given the number of hospitals in the sample and of the relevant input and outputs variables, it was essential to find a solution to reduce the so-called curse of dimensionality of DEA models: employing DEA with too few DMUs for a given set of inputs/outputs generates estimates that overstate efficiency. To address this issue, the statistical technique of PCA was implemented. PCA identifies a series of uncorrelated linear combinations of the original variables that contain most of the variance. If most of the variance in the data can be attributed to the first few principal components, then principal component scores can be used instead of the observations of the original input and output variables in DEA (Adler and Golany (2002) and Adler and Golany (2016)). In this sample, the first principal component captures always more than 90% of the variance of the inputs and over 80% for the outputs in every year.[5] Hence,

3. `https://benchmarking-acss.min-saude.pt/`

4. For 2022, only data from January to November was available at the time.

5. As an alternative to the cross-section PCAs in each year, pooled PCAs over the entire period were also tested separately for inputs and outputs. The results do not differ significantly.

the rescaled first principal component scores will be used as inputs and outputs in the DEA models.[6]

3.2.1. Input variables

DEA models of hospital efficiency typically consider labour, other operational expenses, and capital as the main inputs. The analysis in this study includes three main input variables and two additional ones for robustness purposes:

- Wages and salaries, current prices
  - Number of doctors, FTE (robustness)
  - Number of nurses, FTE (robustness)
- Intermediate consumption, current prices
- Number of beds available and equipped to receive inpatients

Labour is the most important input of Portuguese hospitals, accounting for around 53% of total operational costs. The baseline specifications use the value of total costs with wages and salaries, comprising regular wages, holiday bonuses, payments to overtime works and other supplements. As a robustness exercise, the number of doctors and nurses, measured in full-time equivalents (FTE), was used.

The second input variable is total intermediate consumption, computed as the sum of the cost of goods sold and materials consumed and of external supplies and services. Intermediate consumption includes the costs with pharmaceutical products and other medical material and also general and administrative expenses such as water, electricity or communications supplies. It represents around 44% of operational costs in the sample.

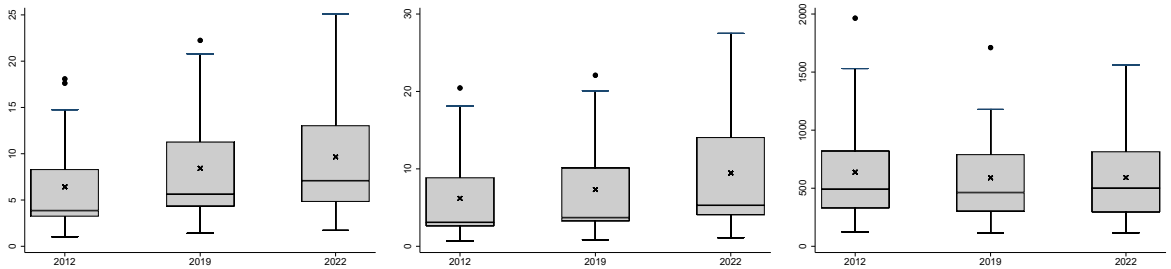
These two cost variables will be considered at current prices. Indeed, individual hospital-specific deflators are not available and utilising an aggregate deflator, similar across all hospitals, would not affect the construction of the production frontier.

Due to a lack of accurate financial data, many DEA studies specify capital in terms of the number of hospital beds. This is also the approach followed herein: capital is proxied by the number of beds that are available and equipped to receive inpatients.

The box plots in Figure 4 depict the distributions of the input variables in three distinct moments in time (2012, 2019 and 2022) for the 22 hospitals in the sample. Between 2012 and 2022, a significant growth in the mean costs related to personnel and intermediate consumption, exceeding 50% at current prices in both variables, was observed. This is fully compatible with the growth shown in Section 2 for current health expenditure in public hospitals (50% between 2012 and 2021). The growth in volume terms can be approximated by using the deflator of gross value added of sector Q - "health and social work activities" from national accounts, which increased by more than 20% in cumulative terms from 2012 to 2022. This would yield an average increase in these inputs of over 20% at constant prices. During this period, the mean count of FTE doctors rose by about 20%, while the number of FTE nurses increased by

6. Computed principal components scores have zero mean, and therefore some of the scores are negative. Since DEA inputs and outputs have to be strictly positive, each PCA score was rescaled by adding the absolute value of its minimum plus one.

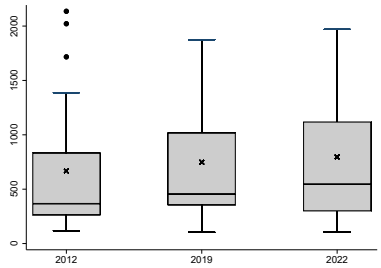
around 15%. Conversely, the average number of hospital beds experienced a decrease of approximately 7%. It is important to note that this outcome could be influenced by the effect of technological progress, leading to a reduction in the demand for inpatient care. For instance, over the past decade, there has been a significant rise in the proportion of day-surgeries, with a corresponding mechanical decline of inpatient cases. The median evolution of these variables is similar, with the number of beds stabilising over the period and the other inputs growing substantially. With the exception of the number of beds, there was an increase in the dispersion of the distribution of all input variables over this period, as evidenced by the larger dimensions of their central boxes in 2022.



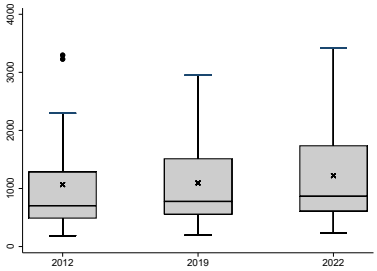
(A) Wages and salaries

(B) Intermediate consumption

(C) Number of hospital beds



(D) Doctors FTE



(E) Nurses FTE

FIGURE 4: Distribution of the input variables

Notes: Wages and salaries and intermediate consumption are measured in million euros. Number of hospital beds is the number of beds available and equipped to receive inpatients. The number of doctors and nurses is measured in terms of full-time equivalents (FTE). In each box plot, the central box shows the values from the 25th percentile to the 75th percentile (interquartile range); the horizontal line corresponds to the median of the distribution (50th percentile); the x marker identifies the arithmetic mean. The outliers are observations with a value higher than the sum of the 75th percentile and 1.5 times the interquartile range.

3.2.2. Output variables

In most studies, inpatient and outpatient (including day care) data are used as the main output categories. Taking into account data availability, this study considers four distinct output variables:

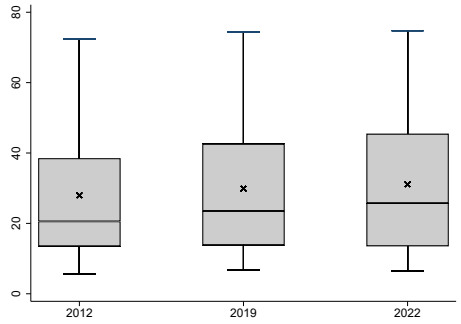
- Number of medical appointments
- Number of emergency service cases
- Number of inpatient discharges, adjusted by the inpatient case-mix index

- Number of programmed (not urgent) surgeries, adjusted by the (in- and outpatient) surgery case-mix index

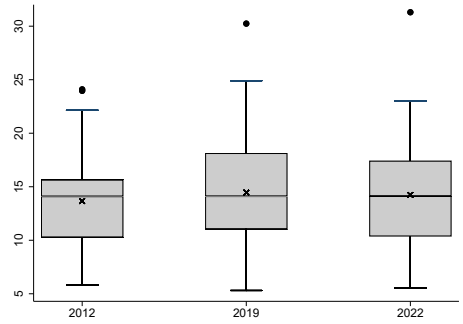
The last two variables, inpatient discharges and programmed surgeries, are adjusted by the respective case-mix index (CMI), an index that signals the average complexity and resource intensity of patients treated in each hospital. The adjustment of surgical and inpatient outputs by their respective CMIs aims to address the potential lack of homogeneity in the sample by taking into account some differences in complexity among hospitals. The CMIs of each hospital are included in the annual programme-contracts signed by the hospitals and the Ministry of Health (*contratos-programa*) and available in the ACSS website. Each hospital has four CMIs, corresponding to four distinct "production lines": inpatient and outpatient care, broken down into medical or surgical episodes. Regarding inpatient care, as CMIs are equal from 2014 onwards and the output data does not have a splitting between medical and surgical episodes, the 2014 values were used to adjust 2012 and 2013. The number of CMI-adjusted surgeries in each year is obtained as the sum of inpatient and outpatient programmed procedures, each CMI-adjusted using the corresponding index. From 2017 to 2022, none of the CMIs (based on the activities of 2015) were updated, which can hamper somewhat the adjustment that is made.[7]

Figure 5 shows box plots of the distributions of the four output variables at three different points in time: 2012, 2019, and 2022. These output variables have distinct behaviours from 2012 to 2022. In terms of both mean and median values, the number of urgency episodes broadly stabilised, whereas both medical appointments and surgeries augmented considerably, particularly the latter. Conversely, the average number of inpatients experienced a notable decline, of around 24% between 2012 and 2022 (14% in median terms). The results for this subsample of hospitals are aligned with the findings for total public hospitals, as described in Section 2. Regarding the dispersion of the distributions, there was a reduction for inpatients, while an increase was observed for the other variables, stronger in the case of surgeries.

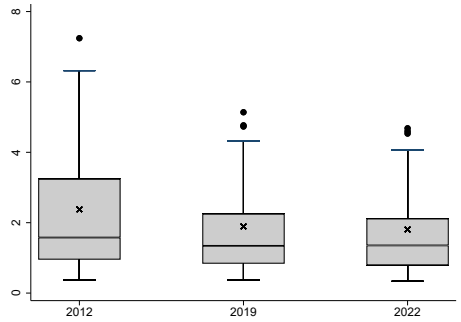
7. The CMIs were recently updated (based on the activities of 2019) but those values are only applicable from 2024 onwards.



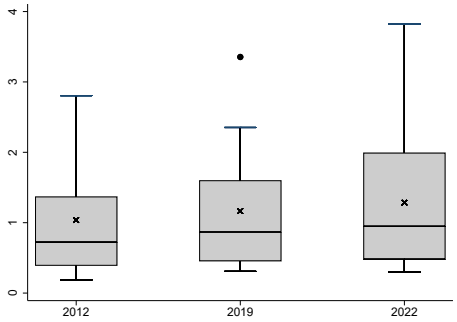
(A) Medical appointments



(B) Emergency cases



(C) Inpatient discharges



(D) Surgeries

FIGURE 5: Distribution of the output variables

Notes: All variables are measured in thousands. The number of inpatient discharges is adjusted by the inpatient case-mix index and the number of programmed (not urgent) surgeries is adjusted by the (in- and outpatient) surgery case-mix index. In each box plot, the central box shows the values from the 25th percentile to the 75th percentile (interquartile range); the horizontal line corresponds to the median of the distribution (50th percentile); the x marker identifies the arithmetic mean. The outliers are observations with a value higher than the sum of the 75th percentile and 1.5 times the interquartile range.

3.3. Results

A proper interpretation of the results requires a few clarifications about the meaning of the efficiency measures used in this study. Firstly, the estimation solely addresses technical inefficiency – how much could inputs (outputs) be reduced (increased) while keeping outputs (inputs) constant – without controlling for the quality of service or potential biases in access to healthcare services. Secondly, the measures presented are relative (in opposition to absolute measures), since they refer to the individual performance of a unit relative to the efficiency frontier constructed with the observations of all units in the sample. This point is especially relevant when comparing the same unit across different years. For instance, a decline in the efficiency score of a hospital does not necessarily indicate an absolute increase in inefficiency; rather, it just indicates that its performance relative to the other hospitals has deteriorated. Because of this relative nature of DEA efficiency scores, the 2020-2021 pandemic period can be included in the analysis. Given that the severe shock was shared by all hospitals, it had no significant influence on the relative metrics computed, despite the abnormal developments observed in the underlying outputs during that period.

Figure 6 plots the simple arithmetic mean of hospital's efficiency measures estimated by DEA from 2012 to 2022, using input-oriented and output-oriented models. The detailed efficiency scores of each hospital are included in Appendix B. In the baseline models, the underlying PCAs use the three input variables (personnel expenses, intermediate consumption, and number of beds) and the four output variables (appointments, emergencies, surgeries, and inpatient discharges) presented above. The robustness models use doctor FTE and nurses FTE instead of wages and salaries in the calculation of the first principal component of inputs.

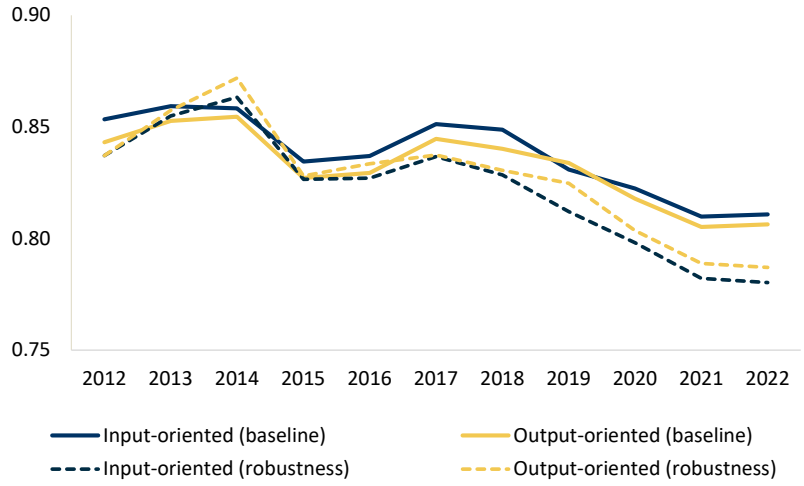


FIGURE 6: Hospital efficiency from 2012 to 2022 | Average of DEA individual scores

Notes: Balanced sample of 22 EPE hospitals in each year. DEA models with 1 input-1 output, where the inputs and outputs are calculated with PCA (first principal component scores). The PCA of the baseline models uses three input variables (personnel expenses, intermediate consumption, and number of beds) and four output variables (appointments, emergencies, surgeries, and inpatient discharges). The robustness models use doctor FTE and nurses FTE instead of wages and salaries in the calculation of the first principal component of inputs.

The average of the technical efficiency metrics in input- and output-oriented models is very similar in each year. The baseline models estimate an average value of technical efficiency of around 0.8 in 2022, implying that, on average, the 22 Portuguese hospitals included in the sample could either reduce their inputs by 20% while producing the same outputs or increase their outputs by 20% while using the same inputs. The average efficiency obtained from the alternative models is fairly close, but somewhat lower.

All models point to a decline in average hospital efficiency over time, particularly since 2017. The magnitude of the change is also consistent across models: from 2012 to 2022, the estimated reduction in average efficiency ranges from 4.4% in the baseline output-oriented model (5% in the baseline input-oriented model) to 6.8% in the alternative input-oriented model (6% in the alternative output-oriented model).

A comparison of individual hospital efficiency measures in the extreme years of the sample, 2012 and 2022, is included in Figure 7. Both baseline DEA models show that there was a decline in technical efficiency for most hospitals. From 2012 to 2022, only two hospitals improved their efficiency score in both input- and output-oriented models

(Centro Hospitalar Baixo Vouga EPE and Hospital Espírito Santo Évora EPE), and a third one increased its technical efficiency in the input-oriented model (Centro Hospitalar Trás os Montes Alto Douro EPE). The subset of hospitals identified as efficient, constituting the frontier, remains both limited and consistent throughout the period, varying from three to five hospitals depending on the years. For instance, three out of the initial four hospitals that formed the frontier in 2012 have maintained their score and constitute the frontier in 2022: Centro Hospitalar de Entre Douro e Vouga EPE, Centro Hospitalar Universitário São João EPE and Hospital Santa Maria Maior EPE (Barcelos). Only the last two are estimated as efficient across all years and models.

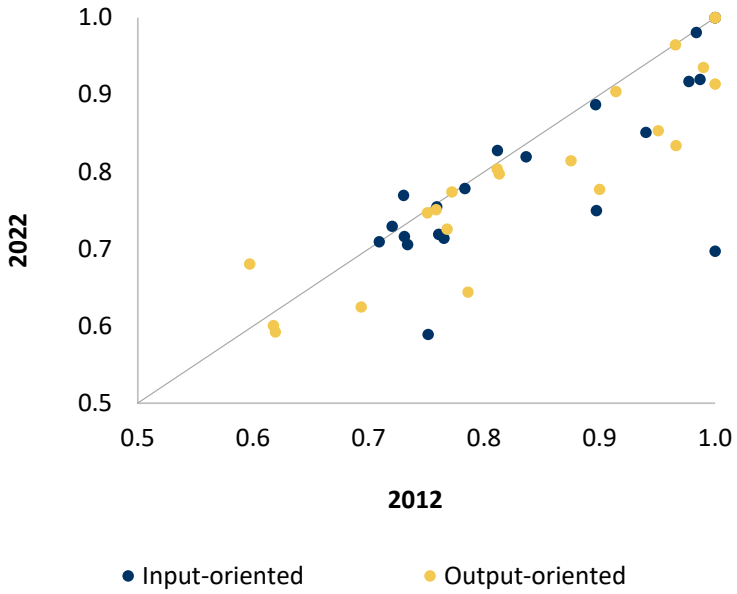


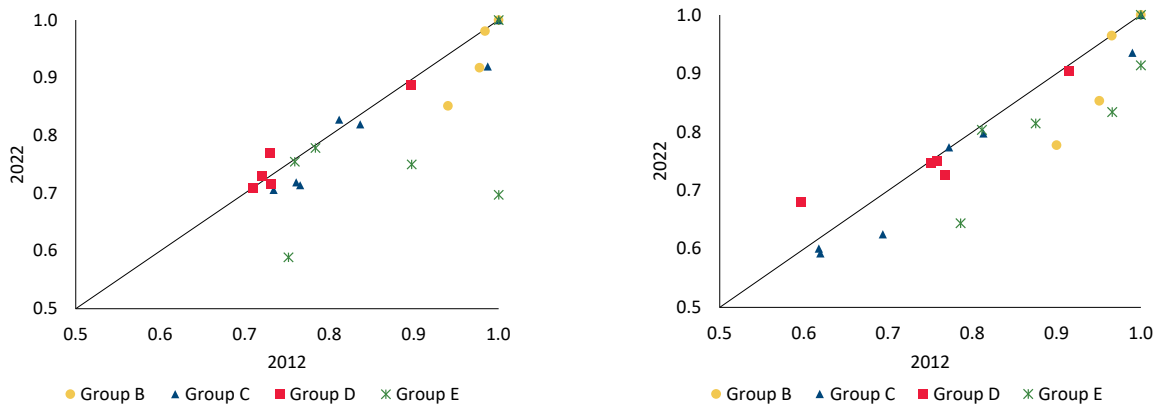
FIGURE 7: Hospital efficiency in 2012 and 2022 | DEA individual scores

Notes: Balanced sample of 22 EPE hospitals in each year. DEA models with 1 input-1 output, where the inputs and outputs are calculated with PCA (first principal component scores). The PCA of these models uses three input variables (personnel expenses, intermediate consumption, and number of beds) and four output variables (appointments, emergencies, surgeries, and inpatient discharges).

Within the framework of the Economic and Financial Assistance Programme to Portugal, a benchmarking initiative was established for public hospitals, aimed at monitoring, determining prices included in the programme contracts, and encouraging hospitals to adopt the most efficient practices. To achieve this, hospitals were organised into six homogeneous groups based on the identification of structural factors influencing costs. This involved analysing several variables such as size, scale, presence of teaching components, and contextual factors related to building characteristics or the area of influence. The monthly benchmarking process conducted by ACSS focuses on EPE hospitals (excluding psychiatric hospitals) and public-private partnerships (PPPs), encompassing six distinct dimensions and over 30 variables. Consequently, there are two types of incentives for hospital performance and efficiency: one based on individual performance against predefined targets, and the other based on benchmarking against

institutions within the same hospital funding group, reflecting each institution's position relative to the most efficient hospital in the group.

Figure 8 illustrates the DEA efficiency scores in 2012 and 2022, obtained from the full sample of 22 hospitals, categorised based on the ACSS groups. Hospitals in group D, and to a lesser extent, those in group B, exhibit similarity in efficiency scores in 2012, particularly in the input-oriented model. In group D, characterised by high structural costs, there was either maintenance or improvement in efficiency over time, while the reverse is observed in two out of four hospitals in group B. Regarding groups C and E, initial within-group efficiency scores varied widely in 2012, and the desired convergence to the best performer of each group, measured by the estimated DEA scores, does not appear to have materialised.



(A) Input-oriented (B) Output-oriented

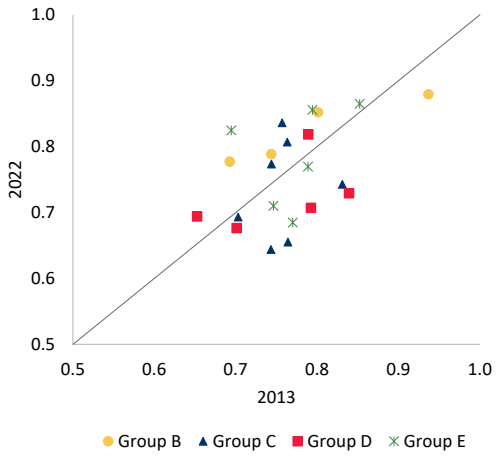
FIGURE 8: Efficiency scores by groups of hospitals

Notes: Balanced sample of 22 EPE hospitals in each year. DEA models with 1 input-1 output, where the inputs and outputs are calculated with PCA (first principal component scores). The PCA of these models uses three input variables (personnel expenses, intermediate consumption, and number of beds) and four output variables (appointments, emergencies, surgeries, and inpatient discharges). Hospital groups are defined according to the ACSS benchmarking exercise of Portuguese EPE hospitals. See `https://benchmarking-acss.min-saude.pt/`.

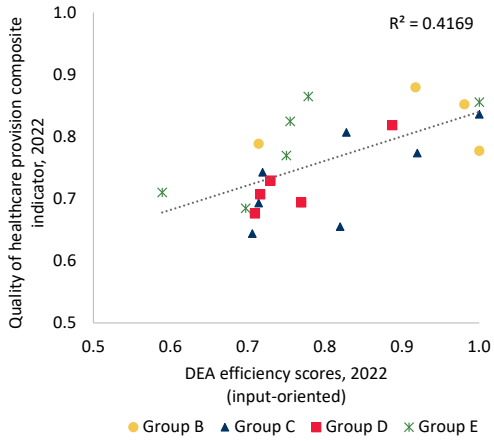
As mentioned previously, DEA is a technique to evaluate only technical efficiency. Regarding healthcare, as in the provision of many other public services, the quality of service holds significant importance as it influences directly the health status of the population. There are a few quality indicators available to assess hospital provision. This study uses four variables, which are also employed in the ACSS benchmarking exercises, all pertaining to the timeliness and appropriateness of care, in order to create a simple composite quality indicator: i) Percentage of initial consultations provided within the guaranteed maximum response time; ii) Percentage of non-readmissions within 30 days; iii) Percentage of hospitalisations with a delay of less than or equal to 30 days; and iv) Percentage of hip fractures with surgery performed within the first 48 hours. To construct the composite indicator, all individual variables were aggregated assuming equal weighting. Hence, the values of the composite indicator lack an economic interpretation *per se*.

The quality of healthcare provision by hospitals in Portugal, as assessed by the composite indicator, has remained stable from 2013 (the first year of available data) to 2022. Upon closer examination of the 22 hospitals included in the sample, approximately half demonstrated improvements in the quality of services provided, while the remaining half experienced deterioration. Furthermore, no discernible patterns were observed by benchmarking groups (Figure 9, panel A).

The quality composite indicator for each hospital can be compared with the DEA scores. A comparison for 2022 reveals a positive linear correlation of around 65% between the efficiency scores derived from the input-oriented DEA model and the quality of services provided.[8] This indicates that hospitals with relatively lower inputs for the same outputs also tend to offer better services to the population, particularly in terms of access times and the speed and quality of treatment. Within the upper segment of the variables, there are elements from all four benchmarking groups: hospitals that are technically more efficient and provide higher-quality services (Figure 9, panel B).



(A) Composite indicator in 2013 and 2022



(B) Relation between the quality composite indicator and DEA scores in 2022

FIGURE 9: Quality of hospitals' healthcare provision

Notes: Balanced sample of 22 EPE hospitals in each year. The composite indicator is the simple average of four variables: i) Percentage of initial consultations provided within the guaranteed maximum response time; ii) Percentage of non-readmissions within 30 days; iii) Percentage of hospitalisations with a delay of less than or equal to 30 days; and iv) Percentage of hip fractures with surgery performed within the first 48 hours. Input-oriented DEA model with 1 input-1 output, where the inputs and outputs are calculated with PCA (first principal component scores). The PCA of this model uses three input variables (personnel expenses, intermediate consumption, and number of beds) and four output variables (appointments, emergencies, surgeries, and inpatient discharges). Hospital groups are defined according to the ACSS benchmarking exercise of Portuguese EPE hospitals. See `https://benchmarking-acss.min-saude.pt/`.

8. The same holds for output-oriented DEA efficiency scores, but the linear correlation is slightly lower: 57%.

4. Concluding remarks

Hospital expenditure in Portugal has shown a consistent upward trend over the past two decades. This trend can be largely attributed to the increasing contribution of private hospitals, whose spending is currently half funded by the government. During this period, there has been a significant shift in the composition of hospital activities and a notable increase in the number of medical services provided, except for the period most affected by the pandemic. Still, there is dissatisfaction amongst the population, often highlighted through the long waiting lists for medical procedures or the shortage of doctors working for the public sector, as well as perceived failures in budgeting and centralised control. In this context, the importance of conducting efficiency analyses becomes even more prominent.

This study uses DEA to assess the relative technical efficiency of a representative panel of 22 Portuguese public hospitals in the period from 2012 to 2022. On the basis of the different models estimated, there was a decline in average hospital efficiency, particularly since 2017. The results by hospital point to a high persistence of those that form the efficiency frontier in each year and a widespread decrease in efficiency scores. It is important to interpret DEA estimates not as absolute measures, but rather as relative metrics that gauge the performance of hospitals relative to its peers. In addition, this technique does not account for exogenous factors or quality effects. To address the latter limitation, a simple composite indicator was calculated to assess the quality of health services provided by these hospitals. The findings indicate a general stabilisation in average quality over the analysed period. Furthermore, a positive correlation between this quality indicator and DEA scores is observed, indicating that hospitals with higher technical efficiency also tend to provide superior healthcare services.

The current analysis underscores the need for a thorough investigation aimed at establishing an absolute benchmark for hospital activity in Portugal and determining the most effective strategies to attain it. Furthermore, it is important to acknowledge the ongoing evolution of the SNS architecture, notably with the introduction of ULS, which implies a gradual transformation in the healthcare landscape regarding hospitals. Lastly, drawing robust conclusions and formulating policy recommendations in an intricate sector such as healthcare requires a granular analysis, encompassing various dimensions beyond those explored in this study. Nonetheless, the observed decline in the technical efficiency of public hospitals is inherently concerning and warrants attention.

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Appendix A: Analytical framework

In this study, hospital efficiency is evaluated by the radial Debreu–Farrell measures of technical efficiency, output-oriented and input-oriented. The mathematical description of the linear programming problems to be solved assuming a variable returns to scale (VRS) DEA model (Banker *et al.* 1984) are presented below. All DEA calculations in this study are performed using the Stata commands developed by Badunenko and Mozharovskyi (2016).

For the output-oriented radial DEA model, the objective function for a given DMU h is:

$$\max_{\lambda,\theta} \theta^{out}, \tag{A.1}$$

subject to:

$$\theta^{out} y_{hj} \leq \sum_{k=1}^{K} \lambda_k y_{kj}, \quad j = 1, 2, \ldots, N$$

$$x_{hi} \geq \sum_{k=1}^{K} \lambda_k x_{ki}, \quad i = 1, 2, \ldots, M$$

$$\lambda_k \geq 0, \quad k = 1, 2, \ldots, K$$

$$\sum_{k=1}^{K} \lambda_k = 1 \qquad ,$$

where M is the number of inputs, N is the number of outputs, K is the number of DMUs. y is a KxN matrix of available data on outputs, so y_{kj} is the amount of output j produced by DMU k; x is a K×M matrix of available data on inputs, so x_{ki} is the amount of input i used by DMU k. λ_k are the weights associated to each DMU k. The last constraint that these weights add up to 1 ensures a VRS model.

The objective here is to find, for each DMU k $(k = 1, 2, h, \ldots, K)$, a linear combination of the other units that increases in proportional or radial terms the production of the N outputs to the highest possible value given the consumption of the M inputs. The inverse of the maximised factor, i.e., $1/\theta^{out}$, is the technical output-efficiency score that ranges from 0 (fully inefficient) to 1 (fully efficient). The linear programming in Equation (A.1) has to be solved for each of the K DMUs, hospitals in this study, in order to obtain K efficiency scores.

In input-oriented DEA models, the objective is to find, for each DMU k $(k = 1, 2, h, \ldots, K)$, a linear combination of the other units that reduces in proportional or radial terms the consumption of the M inputs for the least possible value given the production of the N outputs. The input-oriented efficiency score of DMU h can be represented mathematically as:

$$\min_{\lambda,\theta} \theta^{in}, \tag{A.2}$$

subject to:

$$\theta^{in} x_{hi} \geq \sum_{k=1}^{K} \lambda_k x_{ki}, \quad i = 1, 2, \ldots, M$$

$$y_{hj} \leq \sum_{k=1}^{K} \lambda_k y_{kj}, \quad j = 1, 2, \ldots, N$$

$$\lambda_k \geq 0, \quad k = 1, 2, \ldots, K$$

$$\sum_{k=1}^{K} \lambda_k = 1 \qquad ,$$

with all variables defined as above and solved with an analogous linear programming process. The minimised objective function θ^{in} is the input-efficiency score of DMU h that ranges from 0 (fully inefficient) to 1 (fully efficient).

The inefficiency of each DMU is measured as its distance to the frontier. This distance can be measured in terms of inputs (% decrease in inputs for the same level of outputs) or of outputs (% increase in outputs for the given inputs). That is, the level of inefficiency of each DMU is $1 - \theta^{in}$ in the input-oriented model and $1 - 1/\theta^{out}$ in the output-oriented case.

Appendix B: DEA detailed results of the balanced sample of 22 SNS hospitals

Name	Code	Group	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Centro Hospitalar Baixo Vouga EPE	CHBV	C	0.8115	0.8387	0.8433	0.8271	0.8294	0.8221	0.8401	0.8477	0.8505	0.8207	0.8278
Centro Hospitalar Entre Douro Vouga EPE	CHEDV	C	1	1	1	0.9638	0.9572	0.9887	1	0.9960	1	1	1
Centro Hospitalar Leiria EPE	CHL	C	0.8364	0.8430	0.8398	0.8061	0.8182	0.8365	0.8520	0.8332	0.8792	0.8350	0.8196
Centro Hospitalar Lisboa Ocidental EPE	CHLO	E	0.7514	0.7307	0.7170	0.6314	0.6277	0.6854	0.6808	0.6444	0.6025	0.5944	0.5891
Centro Hospitalar Médio Ave EPE	CHMA	B	0.9401	0.9639	0.9332	0.9057	0.9089	0.9458	0.9283	0.9230	0.9232	0.8716	0.8512
Centro Hospitalar Médio Tejo EPE	CHMT	C	0.7652	0.7923	0.8190	0.7722	0.7786	0.7718	0.7472	0.7529	0.7203	0.6820	0.7140
Centro Hospitalar Póvoa Varzim Vila Conde EPE	CHPVVC	B	0.9774	0.9883	0.9782	0.9914	0.9746	0.9743	0.9459	0.9505	0.9510	0.9295	0.9174
Centro Hospitalar Tondela Viseu EPE	CHTV	D	0.7309	0.7537	0.7708	0.7540	0.7473	0.7408	0.7156	0.7049	0.7038	0.7150	0.7161
Centro Hospitalar Trás os Montes Alto Douro EPE	CHTMAD	D	0.7203	0.7816	0.7339	0.7126	0.7130	0.7348	0.7241	0.7384	0.7325	0.7215	0.7294
Centro Hospitalar Tâmega Sousa EPE	CHTS	C	0.9870	0.9852	1	1	1	1	1	1	1	0.9588	0.9197
Centro Hospitalar Universitário Algarve EPE	CHUA	D	0.7091	0.6949	0.7166	0.7092	0.7018	0.7026	0.6999	0.7017	0.6971	0.6884	0.7093
Centro Hospitalar Universitário Coimbra EPE	CHUC	E	1	1	1	1	1	1	1	0.7407	0.6737	0.6742	0.6973
Centro Hospitalar Universitário Cova Beira EPE	CHUCB	C	0.7607	0.7699	0.7727	0.7606	0.7789	0.7725	0.7576	0.7445	0.7284	0.7233	0.7191
Centro Hospitalar Universitário Lisboa Central EPE	CHULC	E	0.8972	0.8863	0.8146	0.7653	0.7567	0.8039	0.8158	0.7620	0.7514	0.7289	0.7500
Centro Hospitalar Universitário Lisboa Norte EPE	CHULN	E	0.7590	0.7049	0.7521	0.7361	0.7629	0.8403	0.8297	0.7758	0.7374	0.7134	0.7549
Centro Hospitalar Universitário Porto EPE	CHUP	E	0.7833	0.7777	0.7676	0.7854	0.7731	0.7923	0.8184	0.8248	0.8168	0.8004	0.7784
Centro Hospitalar Universitário São João EPE	CHUSJ	E	1	1	1	1	1	1	1	1	1	1	1
Centro Hospitalar Vila Nova Gaia Espinho EPE	CHVNGE	D	0.8964	0.9158	0.8965	0.7858	0.8096	0.8737	0.9005	0.8542	0.8655	0.9159	0.8872
Hospital Distrital Figueira Foz EPE	HDFF	B	0.9838	0.9774	0.9991	0.9957	1	0.9900	0.9632	0.9832	0.9894	0.9838	0.9807
Hospital Distrital Santarém EPE	HDS	C	0.7338	0.7702	0.7914	0.7178	0.7296	0.6947	0.6794	0.6968	0.7039	0.7035	0.7058
Hospital Espírito Santo Évora EPE	HESE	D	0.7302	0.7298	0.7359	0.7381	0.7455	0.7559	0.7735	0.8027	0.7644	0.7550	0.7694
Hospital Santa Maria Maior EPE	HSMM	B	1	1	1	1	1	1	1	1	1	1	1
Average			0.8534	0.8593	0.8583	0.8345	0.8370	0.8512	0.8487	0.8308	0.8223	0.8098	0.8107
Median			0.8239	0.8408	0.8294	0.7856	0.7943	0.8293	0.8349	0.8137	0.7906	0.7777	0.7739
Minimum			0.7091	0.6949	0.7166	0.6314	0.6277	0.6854	0.6794	0.6444	0.6025	0.5944	0.5891
Number of efficient hospitals			4	4	5	4	5	4	5	3	4	3	3

TABLE B.1. DEA efficiency measures, input-oriented, baseline model (1x1 PCA)

Notes: Balanced sample of 22 EPE hospitals in each year. DEA models with 1 input-1 output, where the inputs and outputs are calculated with PCA (first principal component scores). The PCA of these models uses three input variables (personnel expenses, intermediate consumption, and number of beds) and four output variables (appointments, emergencies, surgeries, and inpatient discharges). Hospital groups are defined according to the ACSS benchmarking exercise of Portuguese hospitals. See `https://benchmarking-acss.min-saude.pt/`.

Name	Code	Group	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Centro Hospitalar Baixo Vouga EPE	CHBV	C	0.7721	0.7864	0.7860	0.7522	0.7582	0.7541	0.7878	0.7953	0.8038	0.7680	0.7739
Centro Hospitalar Entre Douro Vouga EPE	CHEDV	C	1	1	1	0.9478	0.9393	0.9844	1	0.9946	1	1	1
Centro Hospitalar Leiria EPE	CHL	C	0.8129	0.8420	0.8559	0.7958	0.8074	0.8244	0.8409	0.8002	0.8466	0.8221	0.7976
Centro Hospitalar Lisboa Ocidental EPE	CHLO	E	0.7859	0.7697	0.7572	0.7029	0.6951	0.7462	0.7407	0.6972	0.6508	0.6347	0.6439
Centro Hospitalar Médio Ave EPE	CHMA	B	0.8999	0.9391	0.8921	0.8440	0.8505	0.9124	0.8850	0.8792	0.8839	0.8067	0.7775
Centro Hospitalar Médio Tejo EPE	CHMT	C	0.6936	0.7238	0.7438	0.6727	0.6881	0.6844	0.6585	0.6677	0.6347	0.5913	0.6250
Centro Hospitalar Póvoa Varzim Vila Conde EPE	CHPVVC	B	0.9508	0.9743	0.9551	0.9817	0.9469	0.9500	0.8957	0.9077	0.9140	0.8727	0.8534
Centro Hospitalar Tondela Viseu EPE	CHTV	D	0.7678	0.8023	0.8110	0.7984	0.7692	0.7564	0.7475	0.7174	0.6889	0.7284	0.7259
Centro Hospitalar Trás os Montes Alto Douro EPE	CHTMAD	D	0.7585	0.8244	0.7702	0.7261	0.7265	0.7596	0.7551	0.7533	0.7276	0.7441	0.7508
Centro Hospitalar Tâmega Sousa EPE	CHTS	C	0.9900	0.9887	1	1	1	1	1	1	1	0.9649	0.9354
Centro Hospitalar Universitário Algarve EPE	CHUA	D	0.7508	0.7406	0.7573	0.7647	0.7554	0.7602	0.7550	0.7448	0.7346	0.7178	0.7470
Centro Hospitalar Universitário Coimbra EPE	CHUC	E	1	1	1	1	1	1	1	0.9996	0.8732	0.8896	0.9138
Centro Hospitalar Universitário Cova Beira EPE	CHUCB	C	0.6193	0.6313	0.6479	0.6217	0.6516	0.6506	0.6296	0.6209	0.6092	0.5960	0.5923
Centro Hospitalar Universitário Lisboa Central EPE	CHULC	E	0.9660	0.9709	0.9557	0.9011	0.9004	0.9287	0.9242	0.8837	0.8466	0.8293	0.8342
Centro Hospitalar Universitário Lisboa Norte EPE	CHULN	E	0.8751	0.8205	0.8462	0.8318	0.8547	0.9276	0.9164	0.8769	0.7932	0.7785	0.8146
Centro Hospitalar Universitário Porto EPE	CHUP	E	0.8113	0.8076	0.7972	0.8235	0.8099	0.8278	0.8485	0.8476	0.8369	0.8174	0.8037
Centro Hospitalar Universitário São João EPE	CHUSJ	E	1	1	1	1	1	1	1	1	1	1	1
Centro Hospitalar Vila Nova Gaia Espinho EPE	CHVNGE	D	0.9141	0.9308	0.9142	0.8338	0.8491	0.9017	0.9217	0.8787	0.8847	0.9255	0.9042
Hospital Distrital Figueira Foz EPE	HDFF	B	0.9655	0.9511	0.9981	0.9909	1	0.9804	0.9285	0.9687	0.9811	0.9700	0.9648
Hospital Distrital Santarém EPE	HDS	C	0.6176	0.6574	0.6937	0.5903	0.6119	0.5811	0.5710	0.5881	0.6030	0.5953	0.6005
Hospital Espírito Santo Évora EPE	HESE	D	0.5970	0.5979	0.6189	0.6177	0.6324	0.6506	0.6771	0.7233	0.6785	0.6608	0.6806
Hospital Santa Maria Maior EPE	HSMM	B	1	1	1	1	1	1	1	1	1	1	1
Average			0.8431	0.8527	0.8546	0.8271	0.8294	0.8446	0.8401	0.8339	0.8178	0.8051	0.8063
Median			0.8440	0.8332	0.8511	0.8276	0.8295	0.8648	0.8667	0.8622	0.8417	0.8120	0.8006
Minimum			0.5970	0.5979	0.6189	0.5903	0.6119	0.5811	0.5710	0.5881	0.6030	0.5913	0.5923
Number of efficient hospitals			4	4	5	4	5	4	5	3	4	3	3

TABLE B.2. DEA efficiency measures, output-oriented, baseline model (1x1 PCA)

Notes: Balanced sample of 22 EPE hospitals in each year. DEA models with 1 input-1 output, where the inputs and outputs are calculated with PCA (first principal component scores). The PCA of these models uses three input variables (personnel expenses, intermediate consumption, and number of beds) and four output variables (appointments, emergencies, surgeries, and inpatient discharges). Hospital groups are defined according to the ACSS benchmarking exercise of Portuguese hospitals. See `https://benchmarking-acss.min-saude.pt/`.

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Non-technical summary

July 2024

The impact of Brexit on Portuguese-British trade

Laszlo Tetenyi

Brexit, the process of the United Kingdom (UK) leaving the European Union (EU), disrupted existing economic relationships and still reverberates today. For an open economy like Portugal, disruptions to international trade could have serious consequences, decrease access to critical goods, and upset macroeconomic stability and growth. The UK is an important trading partner for Portugal, so studying Brexit is essential and urgent. This paper focuses solely on international trade, acknowledging that many other channels (investment, EU funds, and migration) could also be relevant for Portugal and may warrant further investigation.

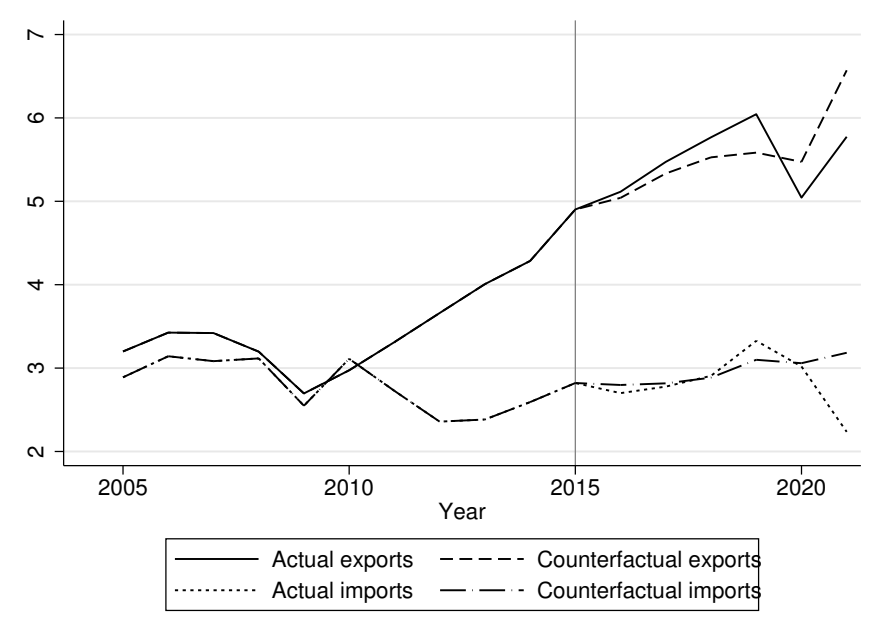

FIGURE 1: Counterfactual trade path

Notes: This figure presents the evolution of the implied counterfactual path of exports and imports for the sum of goods and services with the UK in billions of euros, assuming trade would have evolved as trade with other countries for each firm. Services exclude tourism, as the firm-level service data excludes that sector.

Assessing the evolution of the British-Portuguese trade is possible due to detailed linked firm and trade data. After establishing stylized facts regarding aggregate trends, a "what-if Brexit never happened" path reveals how the British-Portuguese trade would have evolved without Brexit. It assumes that the growth of British-Portuguese trade for each Portuguese firm would have evolved similarly to the pre-2016 period. Finally, this paper documents changes in trade patterns and their impact on firms exporting to the UK.

The analysis suggests a limited impact of Brexit due to trade barriers despite a substantial decline in imports from the UK, with at most an estimated 0.1% of permanent output loss (worth around 250 million euros) for the Portuguese economy in 2021. Figure 1 highlights several reasons for this result. First, while the UK is one of Portugal's most important trade partner countries, it still represents only 10% of all Portuguese total trade, amounting to around eight billion euros in 2021. Second, the services trade, where the UK is Portugal's most important trade partner, is less affected than the goods trade, implying that the predicted path of the Portuguese economy absent Brexit is not too dissimilar to the data. While the overall impact of Brexit on the Portuguese economy remains limited, for Portuguese firms that trade with the United Kingdom, the impact of Brexit is negative.

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The impact of Brexit on Portuguese-British trade

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Banco de Portugal

July 2024

Abstract
This paper evaluates the evolution of British-Portuguese trade from Portugal's perspective, studying the consequences of the Brexit referendum. Using detailed firm balance sheets linked with trade data of goods and services show that despite the importance of the United Kingdom as a trade partner of Portugal and goods and services trade declining substantially, the output loss due to this lost trade is worth at most 0.1% of total output. However, Brexit negatively impacted Portuguese firms that export to the UK, and those still exporting to the UK grew less than those that stopped exporting to the UK. (JEL: D22,F14)

1. Introduction

Brexit, the process of the United Kingdom (UK) leaving the European Union (EU), disrupted existing economic relationships and still reverberates today. The process had various stages and was drawn out, with the UK finally exiting the EU on the 31st of January 2020. However, parts of the EU-UK agreement are still under discussion, and the UK has postponed implementing all the import barriers. Moreover, Brexit impacted various aspects of the economies of UK partners, from trade to investment, EU funds, and migration. This paper aims to evaluate the impact of Brexit on British-Portuguese trade.

For an open economy like Portugal, disruptions to international trade could have serious consequences, decrease access to critical goods, and upset macroeconomic stability and growth. The UK is an important trading partner for Portugal, so studying Brexit is essential and urgent. Although the focus is solely on international trade, many other channels could also be relevant for Portugal and may warrant further investigation.

This paper assesses the evolution of British-Portuguese trade using detailed firm balance sheets linked with trade data and international trade theory. After establishing the facts regarding the aggregate time series of goods and services trade, it is possible

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to construct a counterfactual path for how trade would have evolved absent Brexit. It assumes that the growth of Portuguese-UK trade at the firm level would have evolved similarly to the pre-2016 period. Analyzing the changes in trade patterns and their impact on firms exporting to the UK concludes.

The analysis suggests a limited impact of Brexit due to the trade channel despite a substantial decline in imports from the UK, with at most an estimated 0.1% of permanent output loss. There are several reasons for this. First, while the UK is one of Portugal's most important trade partner countries, it still represents a small fraction of total trade. Second, the services trade, where the UK is Portugal's most important trade partner, is less affected than the goods trade. The impact of Brexit on the trade balance is initially slightly positive as imports of services decline on impact. At the firm level, Portuguese firms exporting to the UK grew more if they left the UK market than those that did not.

Several papers study Brexit (for its impact on the UK, see (Broadbent *et al.* 2023)) and other EU countries ((Bisciari 2019) provides an excellent survey of the literature), including Portugal specifically (Fernandes and Winters 2021). Relative to them, a more extended period is considered here, including some post-Brexit years. The finding here is a permanent output loss of 0.1% for Portugal (the literature finds 0.05-0.17% output loss), much less than some of the worst-case (so-called no-deal Brexit) scenarios considered in (BdP 2019), albeit most of these papers consider multiple channels, not only trade. While these numbers can be considered to be small, they are in line with the trade literature - in comparison, (Arkolakis *et al.* 2012) finds at most 2% loss of output for the United States stopping trade with the rest of the world in 2000. These other channels regarding the effect of the UK leaving the EU include Foreign Direct Investment (McGrattan and Waddle 2020), budgetary concerns and regulation (Dhingra *et al.* 2017), and migration (Langer and Tetenyi 2019). Concerning trade, the focus in (Fernandes and Winters 2021) is on exports to the UK and the beginning of Brexit, and similar to (Ahmad *et al.* 2023), the main mechanism is regarding an anticipation effect, that is, imports immediately decline due to future uncertainty about the trade agreement. In connection with this, exports change more than imports after the UK's exit from the EU. The analysis regarding firm-level effects uses tools from (Roth *et al.* 2023) and is inspired by (Broocks and Van Biesebroeck 2017), albeit for exports.

The remainder of the paper is organized as follows. Section 2 describes the data, and Section 3 contains the empirical results. Section 4 concludes.

2. Data

Multiple data sources are in use for the empirical analysis, each requiring different data-cleaning processes: SCIE for the firm balance sheet, goods trade data, and services trade data. A key consideration is that the firm-level dataset does not allow connecting goods and services data and has to be kept separately.

2.1. SCIE

Sistema de Contas Integradas das Empresas (SCIE) contains yearly accounting data for Portuguese firms since 2004. Excluding sole proprietorships, more than 300 thousand firms per year comprise the universe of the Portuguese corporate sector. Since 2007, firms must submit every year both balance sheet and profit and loss account data under the compulsory survey named *Informação Empresarial Simplificada* (IES). IES reports to the National Statistical Institute (INE), Banco de Portugal, the Minister of Justice, and the Minister of Finance to prevent the duplication of reporting to each of these authorities and is the primary data source of SCIE.

SCIE harmonizes the data from IES to ensure comparability over time. It includes the universe of firms and information beyond standard accounting variables, such as the total number of workers, the number of workers allocated to R&D activities (after 2010 only), entry and exit dummy variables that identify the year of the firm's creation and exit, respectively, and information on nominal exports and imports (goods and services after 2010 only).

2.2. Goods international trade - Intra and Extra-stat

Intrastat and Extrastat provide the trade data for goods and the export and import status of the firm. INE collects goods customs data on intra and extra-EU trade under Intrastat and Extrastat surveys. Intrastat and Extrastat started in 1993 with the introduction of the Single Market. Firms located in Portugal must report this information when reaching an annual reporting threshold, named assimilation value, set yearly. Data is available at a monthly frequency from 1995 to 2021.

It includes information for each firm identified with their tax identification number, an 8-digit combined nomenclature product code, the value of the transaction, the quantity of traded goods (expressed in kilograms), the destination or origin country, the type of transport, the relevant international commercial term and a variable indicating the type of transaction (e.g., transfer of ownership after payment or return of a product). INE imputation of export and import nominal values under fictitious firm identification numbers since 2005 ensures consistency with National Accounts. For intra-EU trade, firms report their activity if they reached the threshold in the current or previous year. As Portugal classified the UK as extra-EU in 2021, the same censoring of UK data will be applied in 2021.

2.3. Services

Data on services transactions for Portuguese firms was obtained from the Balance of Payments Account for Portugal, provided by the Statistics Department of Banco de Portugal, and collected at a monthly frequency. (Amador *et al.* 2019) describe the dataset

in more detail. The data reflect monthly transactions, expressed in euros[1], covering the period from 2005 until 2021. Post-2014, the recording of service transactions was obtained from COPE data collection instead of via commercial banks. No reporting threshold applies specifically to services trade. The threshold is based on the value of all economic, financial, or foreign exchange operations of a firm with non-residents, which must be at least equal to 100 thousand euros. The important variables are industry classification, firm identifier, country of destination, and service category. Industry (CAE) classification at the nine-digit code level categorizes the 21 industries, following the SEC2010 norm. 65 service categories are grouped into 12 major categories at the most detailed classification level. Tourism is important for Portugal, but it is missing from this dataset.

2.4. Descriptives

Table 1 summarizes the two separate datasets. Only a small fraction of firms engaged in international trade, with around 5% exporting and importing goods and export services and less than 3% importing services. Less than 20% of exporters/importers export to and import from the UK. Exporters have substantially higher sales than all firms, showing that exporters are considerably larger than the average firm.

3. Empirical results

3.1. Aggregate analysis

The UK is an important trading partner of Portugal but was never a dominant trade partner; no single country is. Figure 1 shows the evolution of trade in Portugal; both exports and imports of goods and services have increased in nominal terms but only slightly increased as a fraction of GDP. However, services grew in importance, and the UK increased the trade value of services while the value of goods trade declined. Goods trade makes up 80% of all Portuguese trade but less than two-thirds of trade with the UK by 2016. For Portugal, services trade is not only increasingly more important[2] but it is where Portugal has a positive trade balance.

Figures 2 and 3 show that across countries, the UK was the fourth goods export destination, overtaken by the United States in 2020, whereas the UK is still the most important services export destination. The UK was the fourth goods import origin country, overtaken by the US in 2020, and the UK was the second most important services import origin country after Spain.

Figures 4 and 5 show that when trade partners are either the UK, EU members (intra-EU), or all other countries (extra-EU), then intra-EU, treated as a single partner is the most important trade block for Portugal, accounting for 70% as the share of all goods

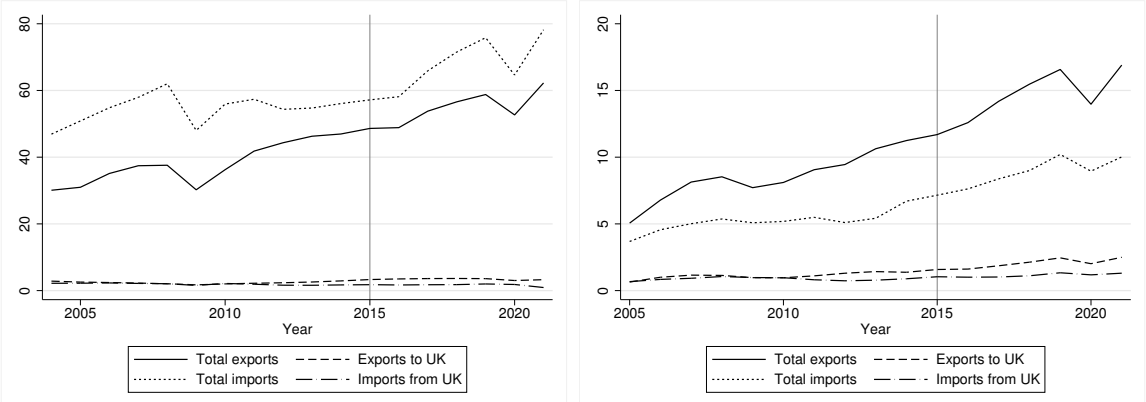
1. Transactions preceding 2014 are all registered as being conducted in euros. Post-2014, they are registered in their original currency but expressed in the corresponding value in euros at the given exchange rate in effect at the time of operation.

2. Note that these graphs do not include any potential impact on tourism, as it is missing from the dataset.

	Goods	Trading goods with UK	Services	Trading services with UK
Firms	434700	5110	102096	5224
Exporters	19554	2967	18722	3606
Importers	22669	2897	11815	2735
Observations	2616496	52789	329386	46792
Exports				
Average (thousands of €)	4967	13200	2619	4277
Median (thousands of €)	779	2462	418	376
Observations	105367	28969	70070	33450
Imports				
Average (thousands of €)	5007	14300	2524	3208
Median (thousands of €)	773	1779	389	262
Observations	132695	28939	43916	26791
Sales (thousands of €)				
Average (thousands of €)	1428	28000		-
Median (thousands of €)	155	4719		-
Employment				
Average	11.2	118.2		-
Median	3	34		-
Capital (thousands of €)				
Average	427	7766		-
Median	21	660		-

TABLE 1. Descriptive statistics.

Notes: This table presents descriptive statistics for the firms in the dataset; observation is defined as a distinct firm-year pair. The balance sheet data for services is not used for this analysis. Exporters/importers are all firms that export/import in any year at least in the value of € 100,000. Exports and imports are only reported across exporters and importers.

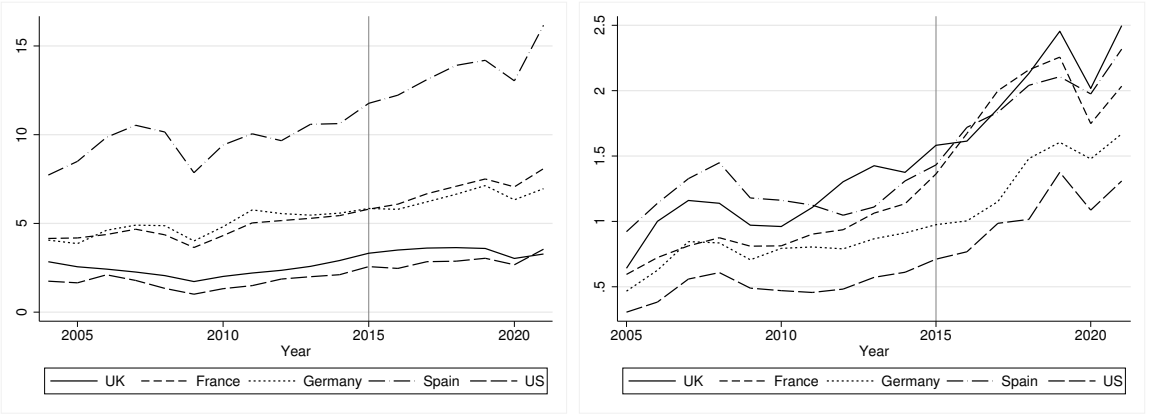


(A) Goods (B) Services

FIGURE 1: Portuguese trade values

Notes: This figure presents the evolution of Portuguese trade (exports and imports, goods and services) values in billions of euros over time. The vertical line signifies the year of the Brexit referendum.

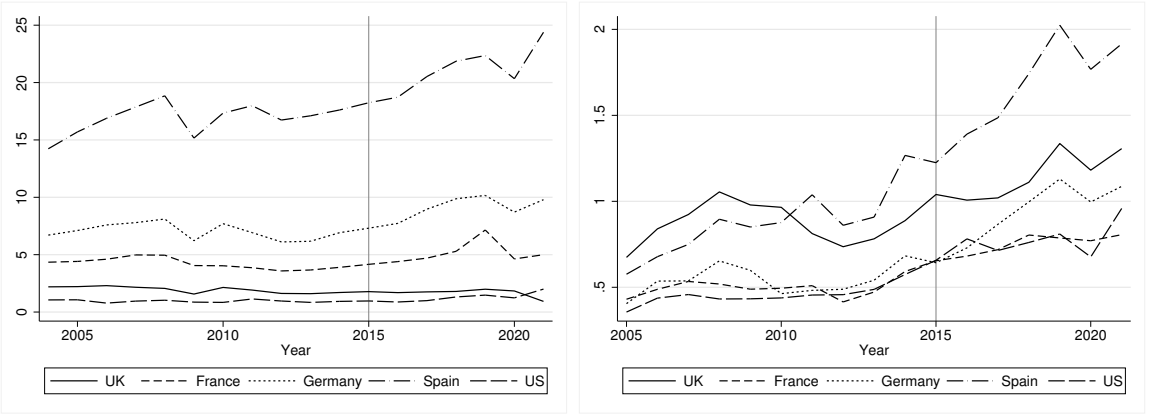
trade and 60% as the share of all services trade. The UK's share of goods trade is small and decreasing, with a decline from 9.5% in 2004 to 7.2% by 2016 to 5.2% by 2021. On the other hand, services exports to the UK have increased slightly since 2016. Goods



(A) Goods (B) Services

FIGURE 2: Main export destinations of Portuguese firms

Notes: This figure presents the evolution of Portuguese exports of goods and services in billions of euros over time across the top five export destination countries.



(A) Goods (B) Services

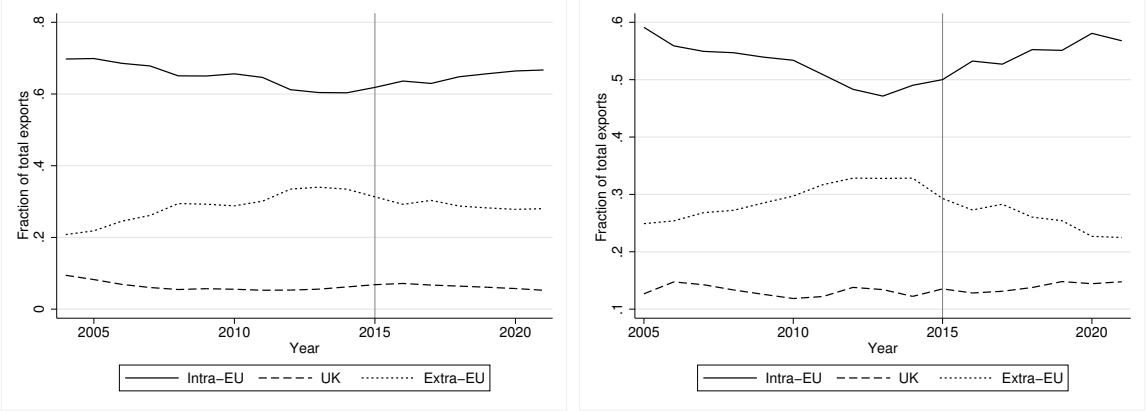
FIGURE 3: Main import destinations of Portuguese firms

Notes: This figure presents the evolution of Portuguese imports of goods and services in billions of euros over time across the top five import origin countries.

imports from the UK have been declining from 4.7% to 2.9% by 2016 to 1.2% by 2021, while services imports from the UK remained stable.

3.2. Output loss from the decline in trade

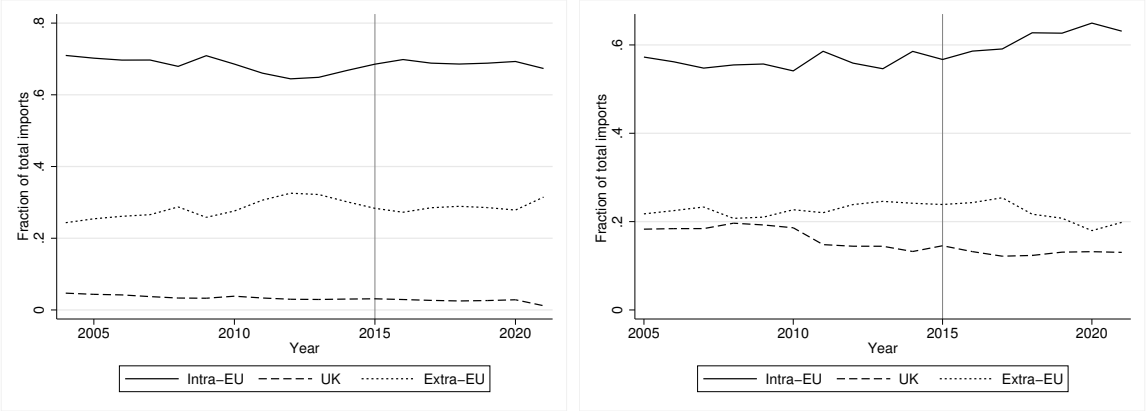
Two steps are necessary to evaluate the effects of Brexit on trade: to assess what amount of trade was lost and then convert this loss of trade to output loss. The first step can be done either by using structural methods, typically with a trade model, or statistical methods. Here, it is the latter, which comes with its limitations and caveats. The benefit of the statistical methods relative to trade models is the ease of use and the transparency of assumptions. In particular, most trade models require the assumption of balanced



(A) Goods (B) Services

FIGURE 4: Export shares of Portugal

Notes: This figure presents the evolution of Portuguese exports of goods and services as shares of total exports over time across destinations categorized into three groups.



(A) Goods (B) Services

FIGURE 5: Import shares of Portugal

Notes: This figure presents the evolution of Portuguese imports of goods and services as shares of total imports over time across destinations categorized into three groups.

trade and a host of data for other countries. The statistical method utilizes firm-level data.

The underlying assumption is that absent Brexit, individual firms' exports and imports to and from the UK relate to their exports and imports to other countries the same way before Brexit as after 2015, and individual firms' exports and imports to and from the UK can be conditionally forecast for the post-2015 period. That is, running the following panel regressions for firm i at time $t \leq 2015$:

$$\Delta \log(EX_{i,t}^{UK}) = \beta_0 + \beta_1 \Delta \log(EX_{i,t}^{EU}) + \beta_2 \Delta \log(EX_{i,t}^{\emptyset EU}) + u_i + \varepsilon_{i,t} \quad (1)$$

$$\Delta \log(IM_{i,t}^{UK}) = \gamma_0 + \gamma_1 \Delta \log(IM_{i,t}^{EU}) + \gamma_2 \Delta \log(IM_{i,t}^{\emptyset EU}) + u_i + \varepsilon_{i,t} \quad (2)$$

where $\Delta \log(EX_{i,t}^{\emptyset EU})$ corresponds to the growth rate of extra-EU exports. Then, the coefficients β_i, γ_i, and u_i allow[3] for the conditional forecast of the exports and imports growth to the UK post-2015. The idea behind comparing growth rates for firms is similar to synthetic controls (Abadie and Gardeazabal 2003) that (Campos *et al.* 2019) apply to the European integration context for countries: absent Brexit, the relationship between Intra-EU/Extra-EU trade and British trade would have remained invariant at the firm level.

There are important limitations, however. First, there is no apparent structural model for which trade growth rates across locations should be similar. While it does not require balanced trade, it does not utilize exchange rate changes or other international macroeconomic theories or data. Moreover, similar assumptions can be made, such as comparing growth rates to the previous years' growth rates instead of concurrent ones, and the assumption here is just one of the possible ones.

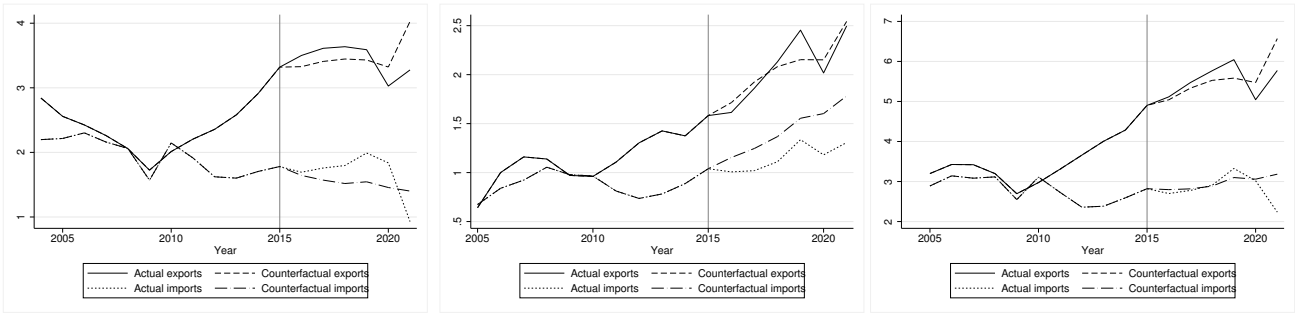
Figure 6 shows the dynamics of the constructed counterfactual path. Goods trade would have been higher absent Brexit. The evolution of exports and imports shows a limited anticipation effect in contrast with (Fernandes and Winters 2021) and (Ahmad *et al.* 2023), only declining after 2019. Services are less affected, with exports above the counterfactual path until 2019, but imports are substantially lower than the counterfactual, with anticipatory decline immediately after 2015. The total lost trade in 2021 worth around two billion euros is primarily (1.5 billion euros) due to the lack of goods trade, with one billion from the lack of goods exports.

Figure 7 shows the implied change for the Portuguese trade balance with the UK. In general, a positive trade balance has a stabilizing impact on the economy, and the bilateral trade balance with the UK is positive, implying that trade with the UK has a stabilizing effect on Portugal. However, absent Brexit, the trade balance would have been even more positive in almost all years after 2015. Services contribute negatively, while goods contribute positively to the (counterfactual) trade balance so that it is not too different from the actual trade balance.

Equipped with the counterfactual trade path in a broad class of trade models, (Arkolakis *et al.* 2012) show that changes in *balanced* trade convert into a permanent output loss using the formula $(\frac{\lambda'}{\lambda})^{\frac{1}{\varepsilon}}$ with λ': corresponding to the new *value-added* domestic expenditure share and ε correspond to trade elasticity, which (Simonovska and Waugh 2014) measure to be approximately -4. While the balanced trade assumption does not hold, this formula provides a useful upper bound when applied to this context. Using the OECD domestic content of export statistic of 70% for Portugal, $\lambda' = 0.755$, $\lambda = 0.758$[4] yields an output loss of 0.10%, in line with the literature surveyed in (Bisciari 2019) that finds an output loss of 0.05–0.17%.

3. See Appendix A for further details in Table A.1. Importantly, however, for firms not exporting outside the EU, the forecast is redone according to a simpler model.

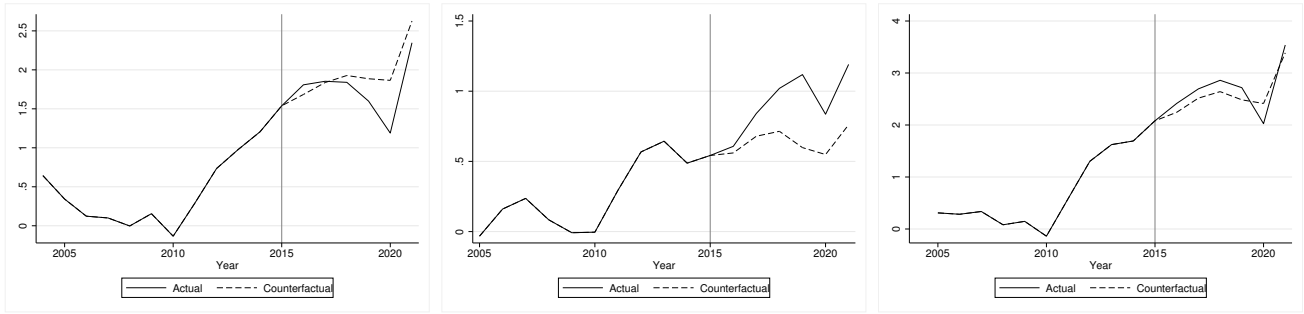
4. This value is obtained as $1 - \frac{88.22+(3.18-2.24)}{255} \cdot 0.7$ in which 88.22 is the nominal value of total imports, 255 is the value of GDP, 3.18 is the total counterfactual imports, 2.24 is the realized imports, all in billions of euros in 2021.



(A) Goods (B) Services (C) Total

FIGURE 6: Counterfactual trade path

Notes: This figure presents the evolution of the implied counterfactual path for goods, services, exports, and imports and the sum of goods and services with the UK in billions of euros, assuming trade would have evolved as trade with other countries for each firm.



(A) Goods (B) Services (C) Total

FIGURE 7: Trade balance of Portugal with the UK

Notes: This figure presents the evolution of the implied counterfactual path for the goods and services trade balance. The counterfactual assumes trade would have evolved as trade with other countries for each firm.

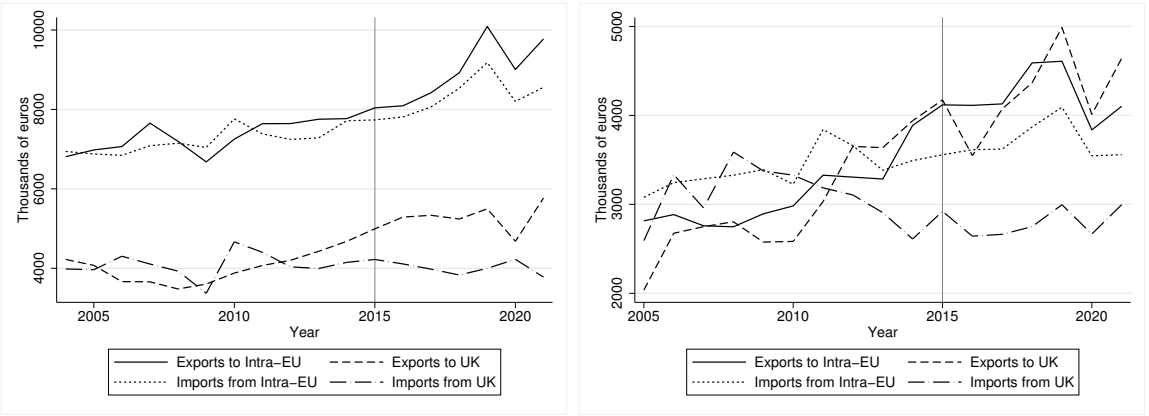
3.3. Changes in the extensive and intensive margins of trade

There are several reasons why exploring other consequences of the trade disintegration may be helpful. First, the output loss in trade models may be greater if some of the required macro-level assumptions[5] in (Arkolakis *et al.* 2012) are relaxed and exit and entry may play a more significant role. Second, the dynamic patterns of the evolution of trade underscore the importance of looking more into firm-level impacts. Difficulties in entering the UK market and the fact that trading with the UK is concentrated, even a slight decline in the number of firms can forecast a persistent decline in trade.

Figure 8 shows the evolution of average exports or imports per trading firm. For goods, exports increase similarly to the UK as to intra-EU (including the 2020 pandemic), but the size of per-firm imports from the UK declines, whereas intra-EU imports

5. These are mainly related to the import demand system and aggregate profits, due to imperfect competition and firm heterogeneity.

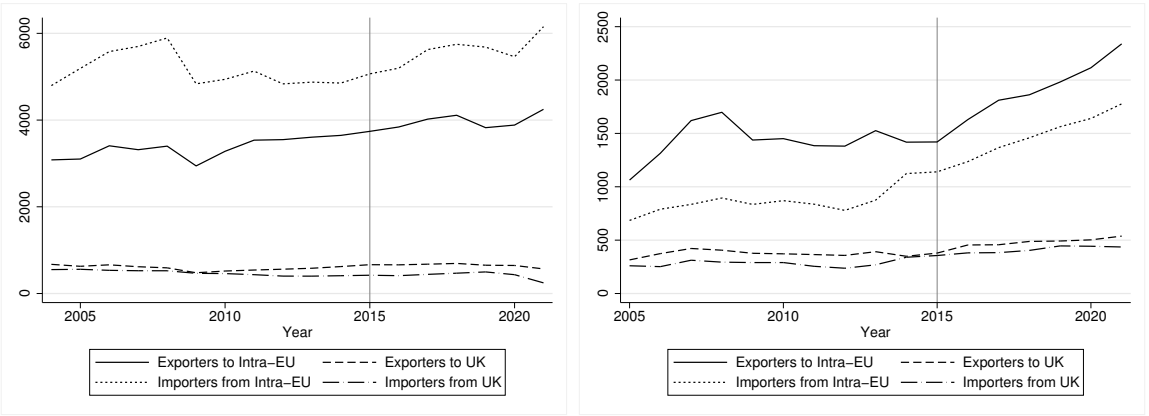
increase. For services, imports per firm plateaued following 2016. Figure 9 shows the change in the number of trading firms. The number of goods exporters and importers to the UK declined. Therefore, goods importers decreased both in numbers and in their average imports. In contrast, the growth in intra-EU goods trade is primarily due to the increase in value, while for services, it is more due to an increase in the number of firms, especially since 2016. Because of the high entry cost into trading, expanding intra-EU services trade in the future is conceivable, whereas UK goods trade is unlikely to recover.



(A) Goods (B) Services

FIGURE 8: Average UK exports and imports of Portuguese firms

Notes: This figure presents the evolution of the average trade (in 1000 euros) per firm engaging in trading (exports or imports of goods or services), with each firm potentially accounted for multiple times.



(A) Goods (B) Services

FIGURE 9: Number of firms

Notes: This figure presents the evolution of the number of firms engaging in the activity (exports, imports of goods or services), with each firm potentially accounted for multiple times. The assumption of only considering firms above 100,000 euros of trade is crucial, especially for the UK.

3.4. Consequences at the firm level

The previous sections implied that Brexit mainly impacted British-Portuguese trade by declining goods exports. The aggregate cost of the decline of exports only matters as much as it impacts imports and is, therefore, limited. Moreover, the extensive margin changes predict, at most, a minor future decrease in exports; the impact can be much larger for firms that already exported from the UK in 2016. Figure 10 depicts the effects of trading with the UK at the firm level, only showing the variables that change significantly for the group of firms identified ("treated") as exporters from the UK[6]. Two classifications are relevant for the analysis to measure the differences in how Portuguese exporters to the UK react.

Figure 10 a) assigns treatment to firms exporting to the UK after 2015, relative to all exporter firms. Revenues and total firm export revenues fall, especially after 2020. Employment increases for exporters while capital growth is unaffected. Therefore, exporters to the UK do not seem to change their production decisions and have not passed through (as of yet) the decline in exports and revenues and potentially even have to increase employment despite the loss of revenue. Treated firms also fail to replace exports to the UK.

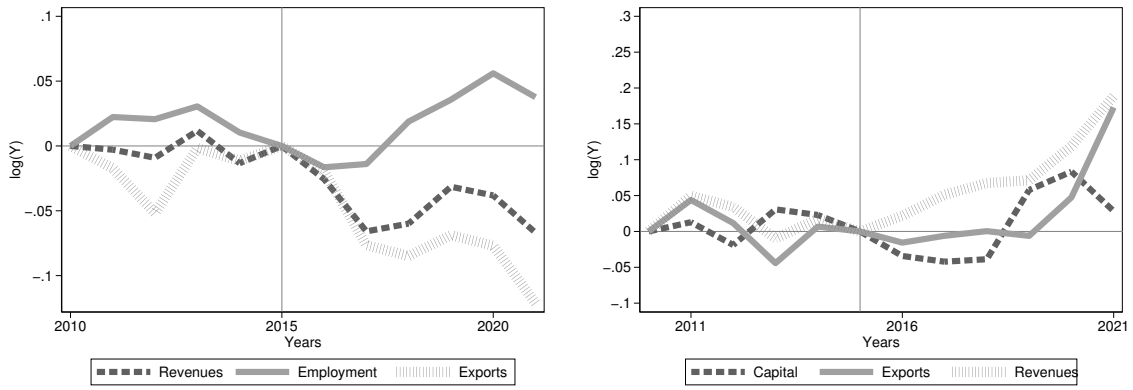
Figure 10 b) assigns treatment to firms that exported to the UK in 2015 but stopped exporting there afterward, relative to firms that did not stop exporting to the UK (and were exporting even in 2015). Here, the effects are much larger, but due to the smaller sample size, so are the confidence bounds. Firms that stopped exporting to the UK experienced a relative increase in their revenue, capital, and total exports relative to those that remained after 2015. These serious consequences of maintaining the exporting relationship with the UK suggest that firms that did so could not easily replace the UK as an export destination.

Finally, these figures should be understood as lower bounds on the impact of Portuguese exporters to the UK because, due to selection, exporters that service more locations are typically more productive — see (De Loecker 2007). Therefore, firms that (still) export to the UK should have a higher growth rate than firms that do not (or no longer) export to the UK.

4. Conclusion

The value of Portuguese services trade to the UK has increased since the turn of the century, reaching a third of total exports to the UK. The UK is the most important service export destination, while Portuguese-UK trade in goods has slowly declined. Following 2016, the Portuguese-UK goods trade decline accelerated, especially for exports, while services trade increased. Overall, exports and imports would have been higher without Brexit, with some anticipation effect for imports for both goods and services. Moreover, the positive goods trade balance with the UK would have been less positive. Thus, losses

6. (Roth *et al.* 2023) also discuss the implication for dynamic lagged variables.



(A) Exported to UK vs. exporters (B) Exited to vs. maintained exporting to UK

FIGURE 10: Effect of exporting to the UK

Notes: This figure represents the coefficients in the regression $log(Y) = \beta_0 + \beta_1 \times t + \beta_2 D_{\text{ex, UK}} + \beta_3 \times D_{\text{ex, UK}} \times t + \beta_4 \text{Controls} + \beta_5 \text{Exports}_{t-1} + \varepsilon$, with $\times t$ for time fixed effects, $D_{\text{ex, UK}}$ is the dummy variable, which is defined differently in the two regressions. Controls include industry and standard errors clustered at the firm level. In a) The population only consists of exporters; treatment is assigned to exporters who export to the UK after 2016 for at least one year. In b) the population only consists of exporters that exported to the UK in 2016, and treatment is assigned to exporters that stop exporting to the UK after 2016 for at least one year. For coefficient estimates and joint significance tests, see Appendix A Table Table A.2.

from Brexit correspond to less than 0.1% of output. Moreover, the number of Portuguese firms that import or export UK goods decreased, projecting that recovery to the pre-Brexit level is unlikely. Finally, for firms that export to the UK, Brexit caused a significant decline in sales, and leaving the UK market after 2016 positively impacted capital and employment growth.

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Appendix: Details of regressions

	Goods				Services			
	Exports		Imports		Exports		Imports	
	Extra-EU	∅ Extra-EU	Extra-EU	∅ Extra-EU	Extra-EU	∅ Extra-EU	Extra-EU	∅ Extra-EU
β_0	-0.00	-0.01	-0.05	-0.06	0.04	0.04	0.08	0.07
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)	(0.02)
β_1	0.13	0.16	0.24	0.25	0.21	0.23	0.20	0.21
	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)
β_2	0.07	-	0.05	-	0.10	-	0.13	-
	(0.01)	-	(0.01)	-	(0.02)	-	(0.02)	-
R^2	0.01	0.01	0.02	0.02	0.05	0.03	0.05	0.04
Number of obs	17091	20056	26207	35404	6369	10953	5608	9783
Number of firms	3544	4227	5877	7894	2169	3778	2035	3694

TABLE A.1. Regressions predicting firm-level trade to the UK

Notes: $\Delta \log(Y_{i,t}^{UK}) = \beta_0 + \beta_1 \Delta \log(Y_{i,t}^{EU}) + \beta_2 \Delta \log(Y_{i,t}^{\emptyset EU}) + u_i + \varepsilon_{i,t}$, with t for time (before 2016), Y is either exports and imports of goods and services. Standard errors are in brackets below the coefficients. The estimates are then used to forecast the evolution of trade at the firm level. The ∅ Extra-EU estimates are only used for forecasting when no trade outside the EU is available. The 100 000 euro threshold is not required for this regression - which is why the number of firms exceeds the number of firms in Table 1.

	Exported from UK vs. exporters					Exited vs remained exporters				
	K	Sales	L	EX	IM	K	Sales	L	EX	IM
β_5	0.60	0.66	0.44	0.90	0.53	0.75	0.81	0.57	0.95	0.82
	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.02)	(0.01)	(0.02)	(0.00)	(0.03)
$\beta_{3,t=2011}$	0.01	- 0.01	0.01	- 0.02	0.05	0.01	0.05	- 0.01	0.04	- 0.02
	(0.04)	(0.02)	(0.02)	(0.02)	(0.04)	(0.13)	(0.06)	(0.08)	(0.04)	(0.11)
$\beta_{3,t=2012}$	0.00	- 0.02	0.01	- 0.05	0.06	- 0.02	0.03	- 0.04	0.01	- 0.03
	(0.04)	(0.02)	(0.02)	(0.02)	(0.03)	(0.13)	(0.06)	(0.08)	(0.04)	(0.11)
$\beta_{3,t=2013}$	0.05	0.01	0.01	- 0.00	0.06	0.03	- 0.01	- 0.02	- 0.04	- 0.10
	(0.03)	(0.02)	(0.02)	(0.02)	(0.03)	(0.13)	(0.05)	(0.08)	(0.05)	(0.10)
$\beta_{3,t=2014}$	0.02	- 0.02	0.01	- 0.01	0.01	0.02	0.02	- 0.02	0.01	- 0.08
	(0.02)	(0.01)	(0.01)	(0.02)	(0.03)	(0.12)	(0.04)	(0.07)	(0.04)	(0.10)
$\beta_{3,t=2016}$	-0.01	- 0.03	- 0.02	- 0.02	- 0.01	- 0.03	0.02	0.02	- 0.02	0.03
	(0.03)	(0.01)	(0.01)	(0.02)	(0.03)	(0.10)	(0.04)	(0.06)	(0.04)	(0.08)
$\beta_{3,t=2017}$	-0.00	- 0.08	- 0.02	- 0.08	- 0.02	- 0.04	0.05	0.03	- 0.01	- 0.01
	(0.03)	(0.02)	(0.02)	(0.02)	(0.03)	(0.11)	(0.04)	(0.06)	(0.04)	(0.09)
$\beta_{3,t=2018}$	0.03	- 0.07	0.02	- 0.09	- 0.06	- 0.04	0.07	0.05	0.00	- 0.00
	(0.03)	(0.02)	(0.02)	(0.02)	(0.03)	(0.12)	(0.04)	(0.06)	(0.04)	(0.09)
$\beta_{3,t=2019}$	0.05	- 0.04	0.03	- 0.07	- 0.02	0.06	0.07	0.06	- 0.01	- 0.03
	(0.04)	(0.02)	(0.02)	(0.02)	(0.04)	(0.12)	(0.05)	(0.06)	(0.05)	(0.10)
$\beta_{3,t=2020}$	0.03	- 0.05	0.04	- 0.08	- 0.12	0.08	0.12	0.05	0.05	0.07
	(0.04)	(0.02)	(0.02)	(0.02)	(0.04)	(0.12)	(0.05)	(0.07)	(0.04)	(0.10)
$\beta_{3,t=2021}$	0.00	- 0.07	0.03	- 0.11	- 0.09	0.03	0.19	0.09	0.17	0.10
	(0.04)	(0.02)	(0.02)	(0.02)	(0.04)	(0.13)	(0.06)	(0.07)	(0.05)	(0.11)
post-trend p-values	0.71	0.01	0.01	0.00	0.00	0.35	0.02	0.73	0.00	0.81
pre-trend p-values	0.20	0.44	0.93	0.06	0.3	0.91	0.82	0.87	0.69	0.72
Number of obs	81713	81902	81902	81902	43871	12838	12838	12838	12717	9210
R^2	0.44	0.61	0.52	0.86	0.45	0.66	0.83	0.71	0.94	0.72

TABLE A.2. Difference in Difference regressions

Notes: $log(Y) = \beta_0 + \beta_1 \times t + \beta_2 D_{\text{im, UK}} + \beta_3 \times D_{\text{im, UK}} \times t + \beta_4 \text{Controls} + \beta_5 \text{Imports}_{t-1} + \varepsilon$, with t for time, $D_{\text{im, UK}}$ is the dummy variable, which is defined differently in the two regressions. Y is capital, revenue, labor, exports, or imports. Controls include industry and standard errors (in brackets below the coefficients) clustered at the firm level. In a) the population only consists of exporters and treatment is assigned to exporters that export to the UK after 2016 for at least one year. In b) the population only consists of exporters that exported to the UK in 2016, and treatment is assigned to exporters that stop exporting to the UK after 2016 for at least one year.

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