

## **Asymmetric Impacts: German, US, and UK Economic Performance on Portuguese Exports**

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### **Abstract**

The present study examined the effects of the economic performance of Germany, the United States and the United Kingdom on Portuguese exports from the first quarter of 2003 to the second quarter of 2024. A series of econometric methodologies were utilized in the analysis, encompassing the Jarque-Bera test, panel unit root tests, Gregory-Hansen cointegration tests, error correction models, Granger causality tests, and impulse response functions. The objective of this comprehensive approach was to ascertain short-run and long-run relationships.

The primary findings indicated a substantial long-term impact of German GDP on Portuguese exports, demonstrating the highest structural sensitivity. In contrast, the US exhibited the fastest dynamic adjustment speed (agility), while the effect of the UK's economy was smaller in magnitude and slower to correct, reflecting its vulnerability to structural shocks such as Brexit.

The analysis at the sector level further indicated that various adjustment speeds were evident across export categories. The results of the study provide policymakers with a valuable set of information regarding the necessity of monitoring the macroeconomic situations of their major trading partners, building trade resilience, and formulating improved strategic plans.

**Keywords:** ECM; Granger causality; Gregory-Hansen cointegration; Impulse response; Portuguese exports.

**JEL Classification:** C22, C32, F15, E20

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#### 1. Introduction

Exports play a central role in any economy, as they contribute significantly to the gross domestic product (GDP) and signal the country's openness to global markets (Sunde, 2017; Sotiros et al., 2022). This study examines the relationship between Portuguese exports and the economic performance of Germany, the United States, and the United Kingdom over the period from 2003 to the second quarter of 2024.

Germany, as the largest European market, accounted for €13.95 billion in goods and services exchanged with Portugal. Most exports comprised of machinery, transportation equipment and industrial supplies. The US, the fourth-largest market for Portuguese exports, received mostly fuels, lubricants, and industrial supplies, which represented €8.94 billion. The UK was the fifth largest market, with exports amounting to €3.64 billion. The product range is diverse, encompassing industrial supplies, machinery and transport equipment.

Despite the fact that Spain is the most significant trading partner of Portugal, the present study focuses on Germany, the United States, and the United Kingdom due to their structural and strategic roles in world economic relations. The three economies in question can be said to represent different macroeconomic settings: Germany, as the largest EU economy, the US, as a global economic powerhouse outside the EU, and the UK, as a valuable European partner in the post-Brexit environment. It facilitates a more comprehensive understanding of how Portuguese exports are influenced by external economic shocks to large and diversified economies outside of regional proximity and historical trade intensity. Moreover, the emphasis on non-Iberian economies enables the examination of effects that are not driven by geographic or historic proximity.

This study aims to investigate the relationship between Portuguese exports and the GDP of its major trading partners. The evaluation process incorporates econometric techniques, including augmented Dickey–Fuller (ADF) unit root tests, Gregory-Hansen cointegration tests, Error Correction Model (ECM), and Granger causality tests, in order to maintain reliability.

Although the econometric evidence should be pointing to strong long-run relationships, it is also the case that some of the effects identified will be picking up broader cycles in international demand rather than purely bilateral influences. For instance, Germany's role as an anchor economy in European value chains suggests common shocks are likely to be amplified across a number of countries. Therefore, the results must be read as portraying the relative health of Portugal's primary trading partners, rather than as abstract causal relationships.

Further research is called for to extend the present analysis by introducing additional variables. These may, but do not necessarily, include global trade indices, exchange rates, and changes in trade policy. The addition of these additional variables would enable one to better identify the specific causal channels linking external demand and Portuguese exports.

The structure of the article is as follows: The subsequent section will offer a concise synopsis of the extant literature on the subject. The study's methodology is examined in section three. Section four presents the results and discussions. The final section presents concluding remarks and policy recommendations.

## 2. Literature Review

### 2.1. Theoretical Framework

The investigation of long-term interactions among macroeconomic variables, such as those determining global trade flows, is typically undertaken using time series methods (Engle et al., 1987; Johansen, 1988; Stock & Watson, 1988). However, a common issue in time series analysis is the potential non-stationarity of the subject variables, with the series potentially exhibiting stochastic trending and lacking constant mean or variance over time (Phillips & Durlauf, 1986; Carone, 1996).

Empirical studies have frequently analysed variables such as gross domestic product (GDP) and exports (Athanasoglou & Bardakas, 2022; Baláž and Hamara, 2016; Bosworth & Collins, 2008; Carone, 1996; Escaith et al., 2011; Krkošková, 2021; Taušer et al., 2015). It is evident that such processes characteristically exhibit first-order non-stationarity properties, that is to say, they are  $I(1)$ . The presence of a unit root is typical of a non-stationary series (Engle et al., 1987; Campbell & Perron, 1991; R. Davidson & Mackinnon, 1993; Boswijk et al., 1997). The employment of non-stationary time series in univariate regression models, or more simply in regressions in differences which do not satisfy certain requirements, has been demonstrated to result in spurious regressions (Engle et al., 1987; R. Davidson & Mackinnon, 1993).

The spurious regression phenomenon is characterised by the presence of an apparent statistical relationship that does not align with any authentic long-term economic relationship (Engle et al., 1987). The phenomenon itself was first identified by Granger & Newbold, (1974) when they considered econometric regressions constructed out of time series and observed instances in which they had a very high multiple correlation coefficient ( $R^2$ ) yet incredibly low measures on the Durbin-Watson statistic. It was hypothesised that even cases exhibiting non-extreme values would be entirely spurious. The characteristics of non-stationary series deviate from the prevailing assumptions within econometric theory (Engle et al., 1987), resulting in biased parameter standard errors and the inability to employ normal significance tests. Consequently, it is more probable that statistical relationships that do not accurately reflect long-run economic reality will be identified (Granger & Newbold, 1974; Granger, 1986; Engle et al., 1987). Therefore, it is necessary to distinguish between stationary and non-stationary series, since ignoring the likelihood of non-stationarity equates to methodological weakness in standard regression estimates (Granger, 1986; Engle et al., 1987).

In the field of econometrics, the cointegration test technique is employed in the context of tests for long-run association among non-stationary time series (Engle et al., 1987; Johansen, 1988; Stock & Watson, 1988). The integration of a series of time series is indicative of a long-run relationship equilibrium between them (Engle and Granger, 1987; Carone, 1996). The Granger Representation Theorem (Granger, 1986; Engle et al., 1987) provides a compelling evidence-based model for the long-run relationship between cointegrated series. The theorem demonstrates that, in the presence of cointegration, the long-run relationship can be characterised by an Error Correction Model (ECM). This assertion is further substantiated by the works of Sargan (1964), Davidson et al (1978), and Engle et al. (1987). As posited by Granger (1986), an ECM facilitates the representation of both the long-run relationship and the short-run adjustment mechanism by a deviation-correction term from the long-run equilibrium. The parameter employed in this error correction term reflects the speed at which variables converge to restore long-run equilibrium after a short-run shock (Granger 1986). Empirical research of economies with close ties to

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larger partners is prone to utilizing cointegration techniques to analyse the long-run relationship (Taušer et al., 2015; Baláž & Hamara, 2016; Krkošková, 2021).

## 2.2. Empirical Studies

The relationship between a country's export performance and the economic activity of its trading partners has long been a central focus in international trade research. Ramos (2001), in his historical analysis of the Portuguese economy, identified complex feedback mechanisms among exports, imports, and GDP, suggesting a dualistic economic structure. Liu et al., (2002) examined the causal relationships between economic growth, trade, and inward FDI in China using quarterly data within a cointegration framework. Applying the Johansen and Juselius approach (Johansen & Juselius, 1990) and a restricted VECM with Granger causality tests, the authors identified long-run relationships and found bi-directional causality between growth, exports, and FDI. Their findings suggest that these variables are mutually reinforcing under China's open-door policy, highlighting the importance of integrated growth and trade strategies in transition economies.

Chinn (2005) examined U.S. trade flows from 1975 to 2001, identifying a stable export demand function but a structural break in import demand around 1995. Using the VECM framework and Johansen's cointegration approach, the study concludes that dollar depreciation alone is insufficient to reduce trade deficits without a realignment of growth trends. The findings underscore the importance of accounting for structural breaks and long-run dynamics in international trade models. More recent contributions, such as Majeed & Ahmad (2006), highlight the positive correlation between export performance and the economic growth of partner countries, reinforcing the notion that increasing GDP levels typically drive higher import demand.

Bosworth and Collins (2008) underscored the strategic relevance of partner GDP through their comparative study on US-China trade flows, suggesting that even marginal GDP shifts in large economies can significantly alter export dynamics. Within the European context, Andraz & Rodrigues (2010) analysed the causality relationships between exports, foreign direct investment (FDI) inflows and economic growth in Portugal from 1977 to 2004. Using Johansen-Juselius cointegration test, a vector error correction model (VECM) and Granger causality tests, they confirmed that FDI and exports stimulate long-run growth. In the short run, a bi-directional causal relationship exists between FDI and economic growth, while FDI also Granger-causes exports. These findings underline the strategic role of FDI in boosting Portugal's growth performance, both directly and through its influence on export dynamics.

Building on these foundations, Baláž & Hamara (2016) and Taušer et al. (2015) provided evidence of co-integrated relationships between German GDP and the export performance of smaller EU economies such as Slovakia and the Czech Republic. Baláž & Hamara (2016) examined the extent to which Slovak exports depend on Germany's economic performance. Using cointegration analysis via the Engle-Granger methodology, along with Error Correction Models (ECM) and Autoregressive Distributed Lag (ADL) models, the study identified a strong and persistent long-run equilibrium relationship between Slovak exports and both German GDP and internal demand. The findings confirm that German economic activity is a key determinant of Slovakia's trade performance and international competitiveness. Taušer et al. (2015) analysed the relationship between Czech exports and German GDP by disaggregating the components of German economic activity. Applying Engle-Granger cointegration analysis, ADL models, and an ECM, the authors found that Czech exports are closely linked not only to German domestic demand but also to

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German exports. Their results suggest that the Czech Republic largely functions as an outsourced supplier within German export channels, underscoring the complexity and depth of bilateral trade integration between the two economies.

Ali & Jameel, (2021) investigated the impact of foreign direct investment (FDI) on economic growth in Iraq during the period 2006–2015, using FDI net inflows and GDP data from the World Bank. Applying ADF unit root tests and the Johansen cointegration approach, the study found no long-term relationship between FDI and GDP. However, Granger causality tests indicated a short-run unidirectional causal link from FDI to GDP. These results suggest that, in the Iraqi context, FDI plays a short-term role in stimulating economic activity, though structural challenges may hinder long-run integration.

Krkošková (2021) showed contrasting degrees of economic interdependence among integrated EU countries, emphasizing the importance of bilateral trade structures. Krkošková (2021) compared the relationship between exports of goods and services from the Czech Republic and Slovakia to German GDP, using time series econometrics, including ADF tests, Engle-Granger cointegration, ECMs, and impulse-response analysis, the study found a long-run cointegration relationship for Czech exports but not for Slovak exports. These results suggest that Czech trade is more closely integrated with the German economy, while Slovakia exhibits weaker long-term trade dependence despite Germany being a major trading partner for both countries.

Emikönel et al. (2022) further contextualized Portugal's position by demonstrating the long-run positive influence of Spain's GDP on Portuguese exports. They analysed the impact of Spain's economic performance on Portugal's growth using the ARDL bounds testing approach and an error correction model. Focusing on bilateral trade between neighbouring countries, the study found that Spanish GDP, imports, and exports exert a positive influence on Portuguese per capita income in both the short and long run. The results suggest strong economic integration, with long-run convergence confirmed by the error correction mechanism. The findings reinforce the idea that economic spillovers from large neighbouring economies can significantly support the growth trajectories of smaller countries. Leitão (2023) expanded on this by confirming that partner country GDP, proximity, and low risk are critical drivers of Portuguese trade, in line with the gravity model of trade.

While the existing literature provides solid evidence of GDP-export relationships, several gaps remain. First, there is a lack of updated empirical studies that cover the post-Brexit and post-pandemic periods, particularly in the context of Portugal's trade with the UK and the US. Second, few studies have applied advanced time series techniques such as Gregory-Hansen cointegration with structural breaks or dynamic impulse response functions to Portuguese export data. Third, while Spain is frequently analyzed, the combined long-run and short-run effects of Germany, the US, and the UK on Portuguese exports remain underexplored, especially in a unified econometric framework.

Therefore, the goal of this study is to expand upon existing literature on linking GDP and export performance by employing co-integration techniques and causality tests to estimate Portugal's export dependence on its major trading partners' economies.

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## 3. Methodology

### 3.1. Data

The present study examines the correlation between Portuguese exports and the GDP of three significant trading partners: Germany, the United States, and the United Kingdom. The study utilised data collected on a quarterly basis, commencing from early 2003 (2003:Q1) and concluding in mid-2024 (2024:Q2). The information was gathered from reliable sources such as the Portuguese National Statistics Institute (INE), the Bank of Portugal (BdP), the Macrobond database, and the Ministry of Economy's Strategy and Studies Office (GEE).

For analytical purposes, each time series was subject to seasonal adjustment using the X-12 ARIMA method. The required calculations and statistical analysis were conducted using the EViews and Stata software applications.

### 3.2. Methodology

The empirical approach adopted in this research endeavour is designed to estimate both the short-run and long-run relationships between Portuguese exports and the GDP of three major trading partners: Germany, the United States, and the United Kingdom. The analysis starts with the use of descriptive statistical methods to describe the dynamics of trade between Portugal and the three countries mentioned above. The assessment of the distributional characteristics of the data is facilitated by the use of the Jarque-Bera test (Jarque & Bera; 1980), a procedure which provides valuable contributions to the understanding of skewness, kurtosis, and the normality assumption.

The econometric technique explores long- and short-run interactions among the exports of Portugal and the GDP of Germany, the United States, and the United Kingdom. Initially, a series of panel as well as individual unit roots tests were performed to ascertain the presence of unit roots. These included those proposed by Breitung (2000), Levin A, Lin and Chu (2002) Im et al. (2003), Dickey & Fuller (1981), and Phillips & Perron (1988). The data exhibited an order of integration of one, a property that rendered cointegration analysis a suitable methodology.

The Gregory and Hansen cointegration test (1996) was utilised in order to analyse long-run equilibrium relationships, with the consideration of structural changes. The test was shown to be more suitable than traditional methods (e.g., Johansen, Engle-Granger) due to its ability to endogenously detect individual structural breaks in the cointegrating relationship, a relevant feature in light of economic shocks in 2003-2024.

In the course of the research, the analysis of a subperiod was also conducted, with the aim of retrieving heterogeneous dynamics across different contexts of history. The subperiods examined in this study span from 2003 to 2007, encompassing the pre-crisis boom and the subsequent boom following the dot-com bubble; from 2008 to 2012, during the subprime and sovereign debt crises; from 2013 to 2019, during the recovery phase; and from 2020 to 2024, during the ongoing pandemic of the Coronavirus, the war in Ukraine, and the war in the Middle East.



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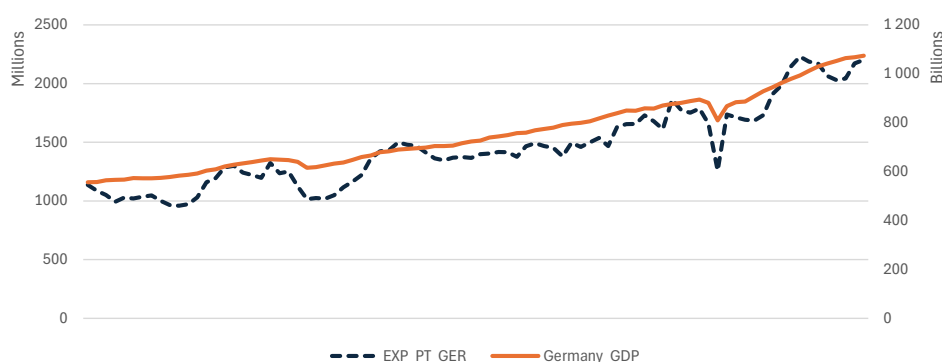
Short-run dynamics were subsequently captured through the use of an Error Correction Model (ECM). The test of significance of the error correction term confirmed cointegration. The dynamic impacts of GDP shocks on exports were analysed using Impulse Response Functions (IRFs) derived from a Vector Autoregressive (VAR) system. In order to ascertain the direction and strength of the relationships, Granger causality tests and block exogeneity Wald tests were also employed.

## 4. Results and Discussions

### 4.1. Descriptive statistics

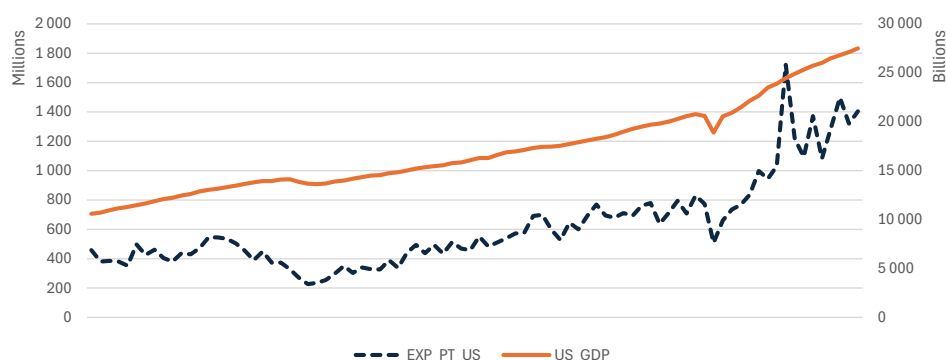
Figures 1-3 show the time series of GDP for Germany, the US, the UK, and Portuguese exports over the period from 2003:Q1 to 2024:Q2.

**Figure 1 – Portuguese exports to Germany (left axis) and Germany GDP (right axis)**



Source: Eurostat

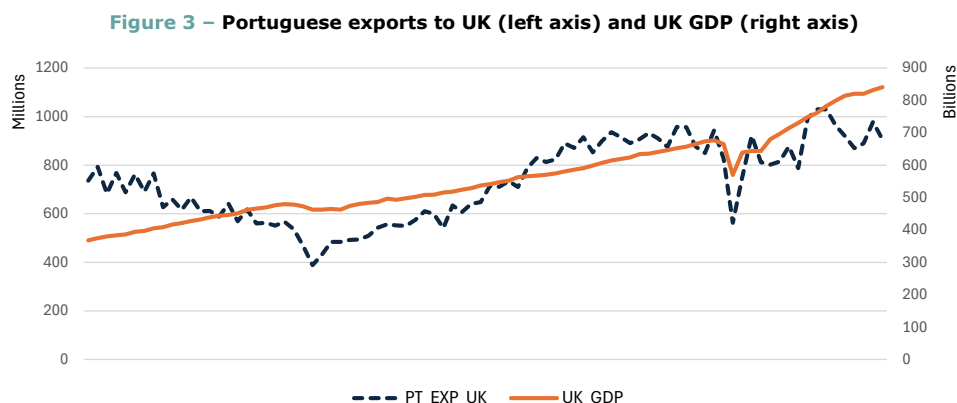
**Figure 2 – Portuguese exports to US (left axis) and US GDP (right axis)**



Source: Eurostat

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The results of the stationarity tests indicate that all the time series analysed are non-stationary at their levels. However, they are integrated of order I(1), as summarised in Table 1.

**Table 1 – Unit Root Test of the Seasonal Adjusted Time Series and of the First Differences for the entire period**

| ADF test                |           |                  |            |
|-------------------------|-----------|------------------|------------|
| Variable                | Level     | First Difference | Conclusion |
| Germany GDP             | -1.145140 | -9.751980 ***    | I (1)      |
| Spain_GDP               | -1.089152 | -9.640659 ***    | I (1)      |
| UK_GDP                  | -1.436382 | -11.19650 ***    | I (1)      |
| US_GDP                  | 0.415796  | -9.960543 ***    | I (1)      |
| Portugal_Export_Germany | -0.548680 | -10.73386 ***    | I (1)      |
| Portugal_EXP_Spain      | -2.372950 | -10.43119 ***    | I (1)      |
| Portugal_Exp_UK         | -2.690422 | -9.767756 ***    | I (1)      |
| Portugal_Exp_US         | -0.835630 | -5.808774 ***    | I (1)      |
| Phillip–Perron test:    |           |                  |            |
| Variable                | Level     | First Difference | Conclusion |
| Germany GDP             | -1.103077 | -9.775487 ***    | I (1)      |
| Spain_GDP               | -1.011731 | -9.654131 ***    | I (1)      |
| UK_GDP                  | -1.338062 | -11.15972 ***    | I (1)      |
| US_GDP                  | 0.603470  | -9.931579 ***    | I (1)      |
| Portugal_Export_Germany | 1.028354  | -10.59726 ***    | I (1)      |
| Portugal_EXP_Spain      | -2.288634 | -10.44279 ***    | I (1)      |
| Portugal_Exp_UK         | -2.591618 | -10.06603 ***    | I (1)      |
| Portugal_Exp_US         | -0.375882 | -15.05282 ***    | I (1)      |



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**Table 2 – Unit Root Test of the Seasonal Adjusted Time Series and of the First Differences for the sub-periods**

| ADF test                |                         |                  |                         |                  |            |
|-------------------------|-------------------------|------------------|-------------------------|------------------|------------|
| Variable                | Subperiod 1 (2003-2007) |                  | Subperiod 2 (2008-2012) |                  | Conclusion |
|                         | Level                   | First Difference | Level                   | First Difference |            |
| Germany GDP             | -0.743246               | -3.866236 **     | 1.531981                | -2.357490 **     | I (1)      |
| UK_GDP                  | 0.842448                | -4.486268 ***    | 0.675850                | -6.483929 ***    | I (1)      |
| US_GDP                  | -1.101642               | -5.097296 ***    | 3.366689                | -1.819442 *      | I (1)      |
| Portugal_Export_Germany | -1.342732               | -4.879946 ***    | 0.195414                | -2.648704 **     | I (1)      |
| Portugal_Exp_UK         | -3.203856               | -16.21349 ***    | -1.035446               | -3.618821 ***    | I (1)      |
| Portugal_Exp_US         | -2.236498               | -5.425470 ***    | -2.207528               | -3.830688 ***    | I (1)      |
| Phillip–Perron test:    |                         |                  |                         |                  |            |
| Variable                | Level                   | First Difference | Level                   | First Difference | Conclusion |
| Germany GDP             | 2.148276                | -3.229430 **     | 1.149633                | -2.357490 **     | I (1)      |
| UK_GDP                  | 0.003544                | -13.15884 ***    | -1.684191               | -3.958616 **     | I (1)      |
| US_GDP                  | -1.611028               | -4.407424 ***    | 2.130351                | -1.935691 **     | I (1)      |
| Portugal_Export_Germany | 0.083948                | -2.562720 **     | -0.096605               | -2.636182 **     | I (1)      |
| Portugal_Exp_UK         | -1.947030               | -28.45390 ***    | -1.119883               | -4.842508 ***    | I (1)      |
| Portugal_Exp_US         | -2.316023               | -5.431276 ***    | 0.458553                | -2.955440 *      | I (1)      |

| ADF test                |                         |                  |                         |                  |            |
|-------------------------|-------------------------|------------------|-------------------------|------------------|------------|
| Variable                | Subperiod 3 (2013-2019) |                  | Subperiod 4 (2020-2024) |                  | Conclusion |
|                         | Level                   | First Difference | Level                   | First Difference |            |
| Germany GDP             | -2.979344               | -7.199963 ***    | 2.972800                | -19.37315 ***    | I (1)      |
| UK_GDP                  | -2.187036               | -5.553219 ***    | -0.670669               | -18.94096 ***    | I (1)      |
| US_GDP                  | -0.563967               | -4.328333 **     | 0.012972                | -1.824212 ***    | I (1)      |
| Portugal_Export_Germany | 0.247141                | -6.578123 ***    | -2.570667               | -7.705928 ***    | I (1)      |
| Portugal_Exp_UK         | -0.227102               | -8.317052 ***    | -3.156477               | -6.033056 ***    | I (1)      |
| Portugal_Exp_US         | -1.279731               | -4.751046 ***    | -1.102257               | -5.687572 ***    | I (1)      |
| Phillip–Perron test:    |                         |                  |                         |                  |            |
| Variable                | Level                   | First Difference | Level                   | First Difference | Conclusion |
| Germany GDP             | -0.404258               | -7.355500 ***    | 0.120494                | -13.77672 ***    | I (1)      |
| UK_GDP                  | 0.369448                | -5.655979 ***    | -0.048393               | -15.79701 ***    | I (1)      |
| US_GDP                  | 1.903916                | -4.111804 ***    | 0.031075                | -12.30574 ***    | I (1)      |
| Portugal_Export_Germany | -0.561535               | -15.76032 ***    | -1.072657               | -6.869251 ***    | I (1)      |
| Portugal_Exp_UK         | -2.488710               | -10.61666 ***    | -2.159900               | -6.018500 ***    | I (1)      |
| Portugal_Exp_US         | -1.242527               | -17.80019 ***    | -1.507871               | -11.18711 ***    | I (1)      |

Significance levels are indicated by: \*  $p < 0.10$ , \*\*  $p < 0.05$ , and \*\*\*  $p < 0.01$ . Augmented Dickey–Fuller (ADF) tests are reported with the model specification used (none, constant or constant plus linear trend). Critical values depend on the chosen specification and sample size. For the total sample ( $N = 86$ ), the MacKinnon (1996) critical values are  $-3.510$  (1%),  $-2.896$  (5%), and  $-2.585$  (10%) with constant,  $-4.069$  (1%),  $-3.463$  (5%), and  $-3.158$  (10%) with constant plus trend, and  $-2.607$  (1%),  $-1.946$  (5%), and  $-1.615$  (10%) with none. For Subperiods 1 and 2 ( $N = 20$ ), the corresponding critical values are  $-4.223$ ,  $-3.189$ , and  $-2.730$  (constant),  $-4.988$ ,  $-3.865$ , and  $-3.383$  (constant plus trend), and  $-2.668$  (1%),  $-1.972$  (5%), and  $-1.602$  (10%) with none. For Subperiod 3 ( $N = 28$ ), the critical values are  $-3.700$ ,  $-2.976$ , and  $-2.628$  (constant),  $-4.395$ ,  $-3.612$ , and  $-3.243$  (constant plus trend), and  $-2.636$  (1%),  $-1.956$  (5%), and  $-1.613$  (10%) with none. For Subperiod 4 ( $N = 18$ ), the critical values are  $-4.332$ ,  $-3.233$ , and  $-2.749$  (constant),  $-5.118$ ,  $-3.918$ , and  $-3.411$  (constant plus trend), and  $-2.679$  (1%),  $-1.976$  (5%), and  $-1.619$  (10%) with none. In all cases, we report the test statistic and the MacKinnon (one-sided)  $p$ -value; for robustness, we also report Phillips–Perron (PP) results using the same exogenous specification.

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#### 4.2. Cointegration test

Despite the consideration of structural breaks, the Gregory–Hansen cointegration test results (Table 3) reveal the existence of long-term correlations between Portuguese exports and the GDP of its primary trading partners. Given that exogenous shocks, such as the pandemic caused by the SARS-CoV-2 virus and the UK's exit from the European Union, have the potential to disrupt global trade and alter the factors that determine global supply and demand, it is imperative to take these breaks into account. The results of the test show that these structural breaks indicate a rebalancing of the long-run equilibrium rather than a collapse of the trade-GDP relationship.

##### Germany

For the entire sample period, Q2:2014 marks the main structural break in Germany. This occurred during a period of subdued external demand and weak domestic consumption, resulting in a minor GDP contraction of 0.2%. The break reflected the government's balanced budget approach, which constrained public investment, even as the ECB lowered interest rates into negative territory (Chris Williamson, 2014; The Guardian, 2014; Demiralp et al., 2019). Given Portugal's reliance on German industrial production, this disruption is viewed as a recalibration rather than a breakdown.

The deceleration in Q2:2005 can be traced back to the uncertainties generated by the "Agenda 2010" reforms, which suppressed domestic demand and slowed construction (EUROPEAN COMMISSION, 2005; Privitera, 2013). The economic downturn in Q4:2011, registering a slight contraction in GDP, is attributed to the Eurozone debt crisis (Reuters, 2012b), though this did not eliminate interdependence in trade. A break in Q2:2019 registered a contraction of 0.1% in GDP, driven by factors such as a deepened industrial downturn and reduced foreign demand (Bundesbank, 2019). The strong 1.5% GDP rise in Q2:2021, following the fall during pandemic lockdown, indicates the strength of the relationship. This upturn was driven by synchronised stimulus policies, such as the German government's Kurzarbeit fiscal policy and the ECB's PEPP expansionary monetary policy (Aiyar & Dao, 2021; ECB, 2021a, 2021b; German Federal Statistical Office, 2021).

##### United States

For the US, the break from the Gregory–Hansen test across the entire period during Q1:2021 is substantiated by a substantial GDP recovery of 6.4%, representing the strongest quarterly growth since 1984. This recovery was driven by a significant fiscal stimulus from the government (the American Rescue Plan) and the ultra-expansionary monetary policy of the Federal Reserve (Fed) (FED, 2021; Luhby & Lobosco, 2021).

The emergence of these breaks in the sub-periods provides supplementary context. In Q4:2003, the break can be attributed to low interest rate policies implemented to stimulate consumption and investment following the dot-com bubble and the 2001 recession (FED, 2003). The decline in Q3:2008 reflects the post-Subprime Crisis environment, resulting in a sudden 0.5% fall in GDP and marking the onset of the deepest recession since the Great Depression (BEA, 2008a). Q3:2014 captures the period when the US economy adapted to the cessation of the Fed's quantitative easing (QE) programme, signalling a transition toward a more restrictive monetary Outlook (BEA, 2014; Moore, 2014). In the subperiod analysis, the structural break is detected in Q3:2021, reflecting the deceleration of growth due to rising inflation, supply-

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side constraints and energy price shocks (Furman & Powell III, 2021). In contrast, in the full sample, the break appears in Q1:2021, highlighting the extraordinary rebound from the pandemic recession. This illustrates that the timing of breaks is sample-dependent: the total period captures the most significant shift overall, while subperiods isolate breaks relevant to more localized dynamics.

#### United Kingdom

For the whole sample period, Q1:2021 is the most important structural break, capturing a 1.5% loss of GDP for the continued pandemic and the UK's departure from the EU. Government fiscal support eased the economic hit, sustaining the economy's stability (Francis-Devine & Ferguson, 2021; ONS, 2021).

Subperiod analysis gives additional insight. Q4:2003 witnessed 0.9% GDP growth, driven by strong domestic demand and active services sector, supported by Bank of England policies to drive post-dot-com recovery (Low, 2004). In addition to the Bank of England's strategy of maintaining the benchmark interest rate at 3.75% to stimulate investment and consumption (Bank of England, 2003; Hann, 2003). The economic slowdown in Q1:2009 was prompted by the subprime crisis, which began in the United States in Q3:2008 and spread to the British financial system, resulting in a 1.9% fall in GDP (BEA, 2008b; The Guardian, 2009).

The break experienced in Q1:2016 was later linked to the prevailing political uncertainty surrounding the Brexit referendum, which slowed GDP growth to 0.4% and resulted in a freeze on company investment (ONS, 2016) indicative of an economic stabilization phase, following the response of the Bank of England to the prevailing high inflation and internal political instability (Bank of England, 2022a, 2022b).

Gregory-Hansen test provides evidence that long-run structural breaks in Portuguese export economies and the GDP of their partners are not jointly time-dated across the three economies. This heterogeneity captures the manner in which global shocks are transmitted asymmetrically, depending on the institution arrangements, fiscal policy mixes, and composition of sectors in specific nations.

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**Table 3 – The Gregory-Hansen cointegration test**

| <b>Total</b>         |             |        |      |            |            |
|----------------------|-------------|--------|------|------------|------------|
| Variables            | t-statistic | Method | Lags | Break Date | Results    |
| PT_EXP_GER / GER_GDP | -5.25 **    | Regime | 3    | 2014:Q2    | Integrated |
| PT_EXP_US / US_GDP   | -6.01 ***   | Regime | 3    | 2021:Q1    | Integrated |
| PT_EXP_UK / UK_GDP   | -5.07 **    | Trend  | 0    | 2021:Q1    | Integrated |
| <b>Subperiod 1</b>   |             |        |      |            |            |
| Variables            | t-statistic | Method | Lags | Break Date | Results    |
| PT_EXP_GER / GER_GDP | -5.60 ***   | Regime | 3    | 2005:Q2    | Integrated |
| PT_EXP_US / US_GDP   | -4.95 **    | Regime | 3    | 2003:Q4    | Integrated |
| PT_EXP_UK / UK_GDP   | -13.34 ***  | Regime | 2    | 2003:Q4    | Integrated |
| <b>Subperiod 2</b>   |             |        |      |            |            |
| Variables            | t-statistic | Method | Lags | Break Date | Results    |
| PT_EXP_GER / GER_GDP | -5.46 ***   | Trend  | 0    | 2011:Q4    | Integrated |
| PT_EXP_US / US_GDP   | -6.69 ***   | Regime | 5    | 2008:Q3    | Integrated |
| PT_EXP_UK / UK_GDP   | -5.13 **    | Trend  | 0    | 2009:Q1    | Integrated |
| <b>Subperiod 3</b>   |             |        |      |            |            |
| Variables            | t-statistic | Method | Lags | Break Date | Results    |
| PT_EXP_GER / GER_GDP | -6.82 ***   | Regime | 0    | 2019:Q2    | Integrated |
| PT_EXP_US / US_GDP   | -5.44 **    | Regime | 3    | 2014:Q3    | Integrated |
| PT_EXP_UK / UK_GDP   | -6.20 ***   | Regime | 1    | 2016:Q1    | Integrated |
| <b>Subperiod 4</b>   |             |        |      |            |            |
| Variables            | t-statistic | Method | Lags | Break Date | Results    |
| PT_EXP_GER / GER_GDP | -6.20 ***   | Regime | 2    | 2021:Q2    | Integrated |
| PT_EXP_US / US_GDP   | -5.24 **    | Regime | 1    | 2021:Q3    | Integrated |
| PT_EXP_UK / UK_GDP   | -5.37 **    | Regime | 4    | 2022:Q4    | Integrated |

Notes: Data processed by the authors (software: Stata). The Gregory-Hansen test for cointegration with regime shifts was applied using the “Change in Regime” model (level and slope shift). The Akaike Information Criterion (AIC) was used to select the optimal lag length. The critical values were obtained from Gregory and Hansen (1996). For the ADF and Zt statistics, the critical values are: -5.47 (1%), -4.95 (5%), and -4.68 (10%). For the Za statistic, the critical values are: -57.17 (1%), -47.04 (5%), and -41.85 (10%). Statistical significance is denoted by \*\*\*, \*\*, and \* for the 1%, 5%, and 10% levels, respectively

The financial crisis of 2008 is a case in point. The United States experienced an initial disruption, with its structural break in Q3:2008, when its recession began (BEA, 2008a). Portugal's export flows to the US were hence influenced by a sharp contraction in American demand, combined with financial stress and pressures to deleverage. The United Kingdom experienced its disruption in Q1:2009, which was also the trough of its domestic recession and lagging behind that of the US (The Guardian, 2009). For Germany, convergence was delayed with a hiatus in Q4:2011, reflecting the chronic effects of the Eurozone sovereign debt crisis and EU-wide structural rebalancing (Reuters, 2012a). Such heterogeneity serves to reinforce that while the shocks were global in origin, transmission and effects on Portuguese exports were transmitted through policy action and country-specific vulnerabilities.

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The same can be observed when referring to the COVID-19 pandemic. The United States also witnessed a structural break during Q1:2021, associated with a robust revival of GDP growth, led mainly by fiscal stimulus packages and a sudden acceleration in household consumption (Lundh, 2021). The United Kingdom also witnessed a break during the same quarter but under very different circumstances: its growth trajectory was constrained by Brexit-related trade tensions and regulatory uncertainty, and supply chain disruptions (Freeman et al., 2022). Germany exhibited a more gradual and steady recovery, supported by a revival in external demand for manufactured goods, with the help of the revival of external demand for manufacturing goods, though still short of pre-pandemic levels.

Collectively, these observations suggest that long-run equilibrium between Portuguese exports and partner GDPs are not erased due to shocks, but rather realigned towards new equilibria

#### 4.3. Error Correction Model

The ECM results are expressed in accordance with the following equation:

$$\Delta y_t = \alpha + \sum_{i=1}^p \beta_i \Delta x_{t-i} + \sum_{j=1}^q \delta_j \Delta y_{t-j} + \gamma e_{t-1} + \varepsilon_t$$

The ECM estimation for Germany presents a strong and well-defined long-run relationship over the entire period. The long-run coefficient is 0.0023, indicating that an increase of one unit in German GDP (e.g., 1 million euros) is associated with an increase of approximately 2,300 euros in Portuguese exports. This linear relationship highlights the importance of German economic activity for Portugal's export performance. The error correction term coefficient is -0.334, which is highly significant and confirms the presence of a stable long-run equilibrium. This coefficient tells us that approximately 33.4% of any disequilibrium is corrected each quarter, implying that the system converges back to its long-run path in around three quarters.

For the United States, ECM analysis reveals a long-run elasticity of 0.000063. The magnitude of the coefficient is minimal, indicating that the long-run effect of US GDP on Portuguese exports is far weaker than that of the UK or German market. However, the error correction term is highly significant at -0.464. This coefficient implies a fast speed of adjustment, with about 46.4% of the disequilibrium being corrected on a quarterly basis. The relationship is expected to be back in equilibrium within roughly two quarters, thus exhibiting the fastest adjustment of all the markets.

The UK ECM estimates have the long-run elasticity as 0.00098, significant and positive. The coefficient validates the presence of a stable long-run relation. The error correction term is -0.174, statistically significant but smallest in magnitude among the three countries. This implies a significantly longer adjustment period with just 17.4% of the disequilibrium being adjusted every quarter. Consequently, it takes the relationship approximately six quarters to return to its long-run equilibrium, thereby qualifying it as the slowest-adjusting market.

The long-run sensitivity (coefficients) obtained through ECM analysis also show striking distinctions. The United States has been found to have consistently low sensitivity, which implies that an increase of 1% in its GDP results in a much smaller absolute growth in Portuguese exports as opposed to those of Germany

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or the United Kingdom. As a contrast, the German market records a much higher rate of sensitivity, highlighting its pivotal contribution to triggering long-run growth in Portuguese exports. The outcome shows that the exports of Portugal are more sensitive to variations in the GDP of Germany compared to the US and UK exports.

The American market has been found to have the highest rate of adjustment in subperiods, which implies that shocks are absorbed well, and the relationship returns quicker to equilibrium than other groupings.

The UK market adjustment speed is less stable; it has a very quick adjustment in Subperiod 1, then slows down in Subperiod 3 when it is trying to cope with uncertainty caused by Brexit.

The German market, even though offering a constantly high ECT, typically displays an intermediate adjustment rate (around 3 quarters). This finding means that the trade relationship between Germany and Portugal requires a moderate period of adjustment in order to revert to its long-run equilibrium following an external shock.

Overall, while all three markets share a long-run cointegrated relationship with exports from Portugal, the nature of these relationships is highly asymmetric. The US shows a less sensitive but rapidly adjusting relationship, the UK shows a very low long-run predictability and a political-shock-sensitive trade process, and Germany shows a more sensitive but moderately adjusting trade relationship.

**Table 4 – The Error Correction Model**

| Subperiod   | Market  | Long-run Elasticity | ECT coef | Adjustment Speed (1/ECT) |
|-------------|---------|---------------------|----------|--------------------------|
| Total       | Germany | 0.0023              | -0.334   | ≈ 3 Quarters             |
|             | US      | 0.000063            | -0.464   | ≈ 2 Quarters             |
|             | UK      | 0.00098             | -0.174   | ≈ 6 Quarters             |
| Subperiod 1 | Germany | 0.0029              | -0.301   | ≈ 3 Quarters             |
|             | US      | 0.0000261           | -0.611   | ≈ 2 Quarters             |
|             | UK      | -0.00196            | -1.585   | ≈ 1 Quarters             |
| Subperiod 2 | Germany | 0.00515             | -0.240   | ≈ 4 Quarters             |
|             | US      | 0.000109            | -0.845   | ≈ 1 Quarters             |
|             | UK      | 0.00281             | -0.709   | ≈ 1 Quarters             |
| Subperiod 3 | Germany | 0.00237             | -0.850   | ≈ 1 Quarters             |
|             | US      | 0.0000607           | -0.764   | ≈ 1 Quarters             |
|             | UK      | 0.00185             | -0.358   | ≈ 3 Quarters             |
| Subperiod 4 | Germany | 0.00294             | -0.428   | ≈ 2 Quarters             |
|             | US      | 0.000106            | -1.087   | ≈ 1 Quarters             |
|             | UK      | 0.000995            | -0.639   | ≈ 2 Quarters             |

The analysis reveals broad asymmetries in the long-run Portuguese trade relationships with its primary trading partners, namely Germany, the US, and the UK. The asymmetries are for both structural stability and dynamic adjustment. Though all three relationships are characterized by a long-run equilibrium relationship, the timing and the nature of shocks driving them are significantly disparate.

#### 4.4. Impulse Response Function

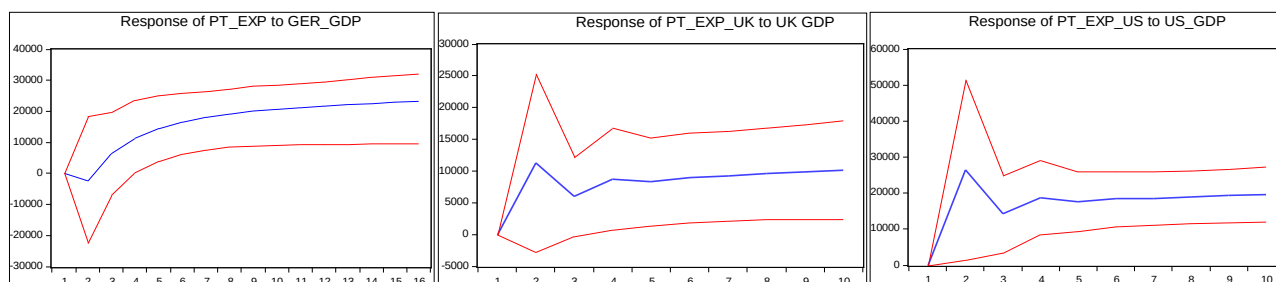
The Impulse Response Function analysis (Figure 4) illustrates the dynamic response of Portuguese exports to a one standard deviation shock in the GDP of Germany, the US, and the UK.

The response of exports to Germany is initially negative in the short run, with a sharp decline observed in the first quarter. This can be attributed to short-term rigidities or adjustment costs. Following the initial decline, the trajectory of Portuguese exports shows a gradual recovery, shifting into positive territory by the fourth quarter. This suggests that German economic growth exerts a lagged but persistent effect on the demand for Portuguese exports.

For exports to the United States, the analysis reveals an immediate and substantial increase, with the response peaking in the second quarter. This indicates a strong short-term sensitivity of Portuguese exports to fluctuations in US economic activity. After the peak, the response gradually converges to a steady state, pointing to a positive and stable long-run relationship.

The response of exports to the United Kingdom to a shock in UK GDP shows a pronounced and enduring influence. The effect is evident from the first quarter and reaches its peak in the second, similar to the US case. From the third quarter onward, the response gradually moderates and stabilizes, ultimately converging to a higher long-run export level. The confidence intervals confirm the robustness of this relationship, as they remain broadly positive.

Figure 4 – Impulse Response Function analysis for the entire period



#### 4.5. Granger Causality Test

As shown in Table 5, the outcomes of the Granger causality tests show that Portuguese exports are significantly influenced by German and American GDP, while the influence of UK GDP is weaker and only marginally significant. In all cases, no evidence of reverse causality is found. This implies that while foreign economic activity affects Portuguese exports, the reverse does not hold—Portuguese exports do not appear to exert a significant influence on the GDP of these countries.

The results indicate that German GDP Granger-causes Portuguese exports to Germany, with statistical significance. The hypothesis suggests a direct causal relationship between the economic fluctuations of Germany and the volume of exports from Portugal to Germany. It is evident that a substantial feedback effect is not observed, given that exports to Germany do not exert considerable influence on the GDP of Germany.



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A similar pattern is observed for the United States. The results confirm that changes in US GDP Granger-cause variations in Portuguese exports to the US. Once again, no evidence of reverse causality is detected, indicating a unidirectional causal relationship from US economic performance to Portuguese exports.

Regarding the United Kingdom, the causality relationship is weaker and only borderline significant. Nonetheless, the test does not detect any significant reverse causality, suggesting that Portuguese exports to the UK do not have a measurable impact on UK GDP.

**Table 5 – Granger Causality Test Results for the entire period**

| Null Hypothesis:                              | Obs | F-Statistic | Prob.  |
|-----------------------------------------------|-----|-------------|--------|
| GERMANY_GDP does not Granger Cause PT_EXP_GER | 84  | 6.05306     | 0.0036 |
| PT_EXP_GER does not Granger Cause GERMANY_GDP |     | 0.85332     | 0.4299 |
| US_GDP does not Granger Cause PT_EXP_US       | 84  | 7.75575     | 0.0008 |
| PT_EXP_US does not Granger Cause US_GDP       |     | 0.14500     | 0.8653 |
| UK_GDP does not Granger Cause PT_EXP_UK       | 84  | 2.86437     | 0.0630 |
| PT_EXP_UK does not Granger Cause UK_GDP       |     | 0.01180     | 0.9883 |

This underscores the importance for Portugal to meticulously observe macroeconomic conditions in these pivotal partners when formulating export and trade policies. In contrast, Portuguese exports do not appear to impact the GDP of these countries, thereby underscoring Portugal's limited influence in the context of bilateral trade dynamics.

## 4.6. Analysis of the main exported commodities

### 4.6.1. Cointegration between the export products of Portugal and the Countries GDP

All the variables in question exhibit properties of first-order nonstationarity I(1). Consequently, the existence of long-run co-integration relationships between these variables and the GDP of Germany, US and UK is a conceivable outcome.

As shown in Table 6, a co-integration relationship can be observed between export products of Portugal and GDP of Germany, US and UK.

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**Table 6 – Cointegration test products exported**

| Germany                                       |             |        |      |            |                |
|-----------------------------------------------|-------------|--------|------|------------|----------------|
| Variables                                     | t-statistic | Method | Lags | Break Date | Results        |
| Machinery equipment                           | -6.24 ***   | Regime | 0    | 2014:Q2    | Integrated     |
| Chemicals and chemical products               | -4.16       | Regime | 0    | ***        | Non-integrated |
| Medical and precision optical instruments     | -6.17 ***   | Regime | 3    | 2017:Q4    | Integrated     |
| Motor and vehicles and trailers               | -6.50 ***   | Regime | 0    | 2012:Q1    | Integrated     |
| Radio, television and communication_equipment | -4.89 *     | Regime | 0    | 2015:Q4    | Integrated     |
| Rubber and plastic products                   | -6.42 ***   | Regime | 4    | 2010:Q3    | Integrated     |
| US                                            |             |        |      |            |                |
| Variables                                     | t-statistic | Method | Lags | Break Date | Results        |
| Chemicals and chemical products               | -8.99 ***   | Regime | 2    | 2021:Q1    | Integrated     |
| Refined petroleum products                    | -7.72 ***   | Regime | 1    | 2011:Q2    | Integrated     |
| Food_products and beverages                   | -6.46 ***   | Regime | 5    | 2015:Q4    | Integrated     |
| Machinery equipment                           | -4.79 *     | Regime | 1    | 2020:Q4    | Integrated     |
| Rubber and plastic products                   | -7.35 ***   | Regime | 0    | 2020:Q4    | Integrated     |
| Textiles                                      | -4.87 *     | Regime | 5    | 2006:Q1    | Integrated     |
| UK                                            |             |        |      |            |                |
| Variables                                     | t-statistic | Method | Lags | Break Date | Results        |
| Fabricated_metal_products_except_machinery    | -5.30 **    | Regime | 0    | 2013:Q4    | Integrated     |
| Motor and vehicles and trailers               | -7.41 ***   | Regime | 0    | 2009:Q4    | Integrated     |
| Other mining and quarrying products           | -10.51 ***  | Regime | 0    | 2021:Q1    | Integrated     |
| Wood and products of wood                     | -5.63 ***   | Regime | 4    | 2013:Q3    | Integrated     |
| Pulp paper and paper products                 | -5.60 ***   | Regime | 2    | 2010:Q1    | Integrated     |
| Rubber plastic products                       | -6.54 ***   | Regime | 4    | 2018:Q4    | Integrated     |

#### 4.6.2. 4.6.2 Sectoral Error Correction Terms (ECTs) and Adjustment Dynamics

The estimation of sectoral ECT coefficients reveals heterogeneous adjustment dynamics across Portuguese export sectors, reflecting structural characteristics, sectoral resilience, and varying sensitivity to partner countries' economic conditions. These results underscore the varying degrees of sensitivity of export sectors to economic conditions in partner countries and highlight the pace at which disequilibria are corrected toward long-run equilibrium.

#### Germany

The adjustment rates of Portuguese exports to Germany vary across sectors, reflecting both structural characteristics and sensitivity to macroeconomic conditions. Machinery and Equipment exhibits the fastest adjustment, correcting 47.3% of any disequilibrium per quarter, converging within approximately two quarters. The structural break in Q2:2014 highlights the sector's strong dependence on German investment cycles, which was reinforced by the ECB's accommodative monetary policy, despite domestic fiscal constraints that limited government investment. Motor Vehicles, Trailers, and Semi-Trailers display a moderate adjustment speed of 25.3% per quarter, implying convergence to equilibrium in roughly four

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quarters. The Q1:2012 break illustrates the impact of the Eurozone Debt Crisis on consumption and industrial value chains, while the sector's resilience is supported by the stability of major German manufacturers. Rubber and Plastic Products adjust at 16.5% per quarter, requiring around six quarters for full reversion to equilibrium; this reflects sensitivity to the pace of recovery in Germany's industrial base following the Global Financial Crisis. Medical, Precision, and Optical Instruments is the slowest-adjusting sector, with only 11.5% of disequilibrium corrected per quarter, implying an adjustment period of roughly eight and a half quarters. The Q4:2017 break indicates structural insulation from short-term shocks, owing to long research and development cycles, regulatory constraints, and long-term contracts.

#### United States

Portuguese exports to the US adjust at varying speeds across sectors, reflecting structural characteristics and sensitivity to macroeconomic conditions. Chemicals and Chemical Products adjusts rapidly, with an ECM coefficient of -0.7536, indicating that approximately 75% of disequilibrium is corrected quarterly. The Q1:2021 break highlights a strong dependence on US economic recovery and fiscal stimulus (American Rescue Plan), as well as the Fed's ultra-expansionary monetary policy, which supported investment and consumption. Refined Petroleum Products displays strong adjustment dynamics (-0.9194 per quarter) with a break in Q2:2011, reflecting exposure to post-Eurozone Debt Crisis oil market volatility and the stabilizing role of US energy policies. Food Products and Beverages adjusts at -0.3936 per quarter, converging over roughly three quarters, with the Q4:2015 break indicating sensitivity to domestic consumption patterns and monetary policy tightening following the Fed's gradual normalization. Machinery and Equipment (-0.479 per quarter) and Rubber and Plastic Products (-0.3159 per quarter) demonstrate medium adjustment speeds, with structural breaks in Q4:2020, reflecting the industrial recovery after pandemic disruptions and responsiveness to fiscal and monetary support. Textiles exhibits rapid adjustment (-0.487), with the Q1:2006 break linked to sector-specific dynamics and sensitivity to US consumer demand.

#### United Kingdom

Portuguese exports to the UK adjust at varying speeds across sectors. Fabricated Metal Products adjusts rapidly, with an ECM coefficient of -0.3698, indicating that approximately 37% of disequilibrium is corrected quarterly. The Q4:2013 break highlights dependence on post-financial crisis industrial recovery and the Bank of England's accommodative policies to stimulate domestic demand and investment. Motor Vehicles and Trailers display moderate adjustment (-0.3439 per quarter), with a break in Q4:2009, reflecting exposure to the global financial crisis and the stabilizing effect of government fiscal support. Other Mining and Quarrying Products adjusts slowly (-0.0673 per quarter), with the Q1:2021 break linked to the 1.5% GDP contraction due to the pandemic and Brexit, mitigated by fiscal support measures that helped maintain economic stability. Wood and Wood Products (-0.190 per quarter) and Pulp, Paper, and Paper Products (-0.1906 per quarter) show moderate adjustment speeds, with breaks in Q3:2013 and Q1:2010, reflecting post-crisis stabilization and the Bank of England's efforts to support growth through low interest rates. Rubber and Plastic Products exhibits slower adjustment (-0.1206 per quarter), with a Q4:2018 break associated with Brexit-related uncertainty and structural dependencies in industrial supply chains. These patterns indicate that Portuguese exports to the UK are sectorally sensitive to economic and political shocks, while long-term equilibrium is supported by monetary and fiscal policy responses.

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#### Short-Term GDP Effects

The short-term relationship between GDP movements and Portuguese exports varies by country and industry. In Germany, exports of rubber and plastic products are the only sector that exhibits a significant short-term reaction to quarter-to-quarter changes in GDP; they are sensitive to short-term business cycles, while others move more gradually. In the United States, GDP shocks have an immediate impact on exports of food, beverages and tobacco, as well as rubber and plastic products, due to their high sensitivity towards US demand. The remaining US sectors are mainly driven by long-term GDP trends. In the UK, none of the sectors exhibit significant short-term reactions, which is consistent with long-term export adjustments influenced by structural factors such as industrial cycles, Brexit and post-pandemic recovery.

## 5. Conclusion

The present study provides empirical evidence that GDP changes in Portugal's principal trading partners – the United Kingdom, the United States, and Germany – have a considerable impact on Portuguese exports. The German GDP exerts the most immediate impact and exhibits the highest levels of impact, implying that Portugal's exports demonstrate the greatest responsiveness to Germany's economic conditions. Despite Germany's lack of preeminence in terms of export volume, its substantial and diversified economy appears to exert an influence on demand trends across a number of Portuguese export industries.

The US GDP exerts a positive long-term effect on Portuguese exports, but with a fast adjustment rate (the fastest of the three partners), reflecting the relative sophistication and agility of transatlantic trade relations. The economic cycle of the United Kingdom exerts a discernible yet comparatively negligible influence on Portuguese exports, a phenomenon that is particularly evident in the post-Brexit era.

The estimate also demonstrates that Portuguese exports exhibit differential responses according to sector. In the German economy, the machinery and equipment sector has been observed to exhibit the fastest response, with a convergence period of approximately two quarters. In contrast, the medical, precision, and optical instruments sectors have been noted to demonstrate a more protracted response time, indicating a distinct insulation from short-run shocks. For the US, chemicals and chemical products account for approximately 75% of disequilibrium on a quarterly basis, while textiles exhibit a strong adjustment rate, similar to other major US industrial sectors, reflecting sector-specific sensitivities. In the UK, the adjustment of fabricated metal products is rapid, in contrast to the more gradual adjustment of other mining and quarrying products, particularly during periods of political and economic uncertainty, such as that occasioned by Brexit.

It is recommended that future research be directed towards a more detailed examination of the Portuguese export sector, with a view to identifying specific vulnerabilities and strengths, and the incorporation of additional macroeconomic variables, including but not limited to exchange rates, consumer price indices, tariffs, interest rates, and investment in industrial infrastructure.

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