IMPACT OF BIODIESEL EXPORTS AND IMPORTS ON NATIONAL ECONOMY OF LATVIA

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Abstract. This study examines the impact of biodiesel imports and exports in Latvia on the national economy, focusing also on the economic impact and role in the EU total market. Latvia faces significant challenges in the deployment of renewable energy sources, with only 1% of transport energy coming from renewable sources, compared to an EU average of 11%. This gap shows that Latvia urgently needs strategies to boost biodiesel production and usage. At the same time, the country is not making full use of its export opportunities, as biodiesel exports make up just 0.9% of the EU total. However, the impressive average annual growth rate of 8.8% from 2012 to 2023 suggests increasing opportunities in this sector. The study uses econometric methods, such as co-integration analysis and the Vector Error Correction Model (VECM), to investigate the short- and long-term interdependencies between biodiesel exports, imports, consumption and GDP. The Granger causality test shows that biodiesel exports play a key role in boosting Latvia's GDP growth in the short term. In 2023, the sector contributed 1% to the country's total merchandise exports, showing a clear positive link between export growth and GDP. The conclusions highlight the need to increase export capacity and sector efficiency to strengthen Latvia's biodiesel sector, reduce dependence on fossil fuels and achieve the EU climate goals. Furthermore, the use of local resources, such as rapeseed oil, not only supports sustainable resource management but may also contribute to job creation, economic resilience and environmental benefits.

Keywords: biodiesel export, GDP correlation, economic impact, renewable energy.

Introduction

Today's rapid industrial and urban development has led to an increasing demand for energy resources that are predominantly derived from fossil fuels. The scarcity of fossil resources and the greenhouse gas (GHG) emissions resulting from their use have had a significant impact on climate change, demanding more sustainable energy solutions [1]. Biofuels, in particular biodiesel, have become a viable alternative to fossil fuels due to their carbon neutral nature and their ability to reduce GHG emissions [2]. Hence, it is possible to contribute to the circular economy of natural resources by using recycled resources such as waste and by-products, reducing waste and promoting sustainable production. Biofuels are classified according to their feedstock into three main categories. First generation biofuels are produced from food and feed crops such as rapeseed, sunflower and soybean oil as well as bioethanol from cereals, sugar beet and other similar sources. Advanced biofuels, derived from waste and non-food biomass, offer a more sustainable alternative by reducing land use competition and improving resource efficiency [3]. The sustainability of biodiesel also depends on its impact on food and water security, as production factors vary by region [3]. The revised Renewable Energy Directive (RED II) promotes biofuels from waste oils, animal fats, algae and lignocellulosic materials to enhance sustainability while limiting the role of conventional biofuels [4]. In the EU, biodiesel accounts for a significant share of renewable energy used in the transport sector, with production reaching 13.7 mln tonnes in 2022 [5]. In Latvia, the biofuels sector has the potential to contribute to the country's energy independence by increasing the use of renewable resources and reducing imports of fossil fuels [6]. In Latvia, biofuels are produced from rapeseed oil extracted from locally grown rapeseed. Although biodiesel offers significant environmental benefits, its production is still characterised by technical and economic challenges. These include high production costs, complex logistical processes and resource sustainability [7]. Moreover, Latvia lags behind other Northern European countries in bioenergy technological advancements, emphasizing the need for greater investments and policy support [8]. In addition, there is an increasing focus on the development of second and third generation biofuels based on non-food feedstocks (lignocellulosics and microalgae) [9]. Hence, the aim of this paper is to analyse the impact of biodiesel exports and imports on the economy of Latvia and role in the EU common market.

Materials and methods

The analysis of export and import trends is based on secondary data obtained from Eurostat and the Central Statistical Office (CSO) of Latvia and structured according to the CN classification. The dynamics of exports and imports is characterised using descriptive statistical methods and exponential

growth averaging. A correlation analysis was carried out to assess the statistical interrelation between biodiesel exports and GDP changes. Cointegration analysis and Vector Error Correction Model (VECM) were applied to determine the economic impact on GDP, which allowed to identify short- and long-term relationships between biodiesel exports, imports, consumption and GDP. The chosen methods are particularly appropriate as they identify interactions and equilibrium relationships between economic variables. A Granger causality test was carried out to determine whether biodiesel exports cause changes in GDP or whether these effects work in the opposite direction.

Results and discussion

In the EU transport sector in 2023, the share of renewables was significantly uneven, averaging to only 11% of energy consumption, while in Latvia it was among the lowest at just 1% (Fig. 1).

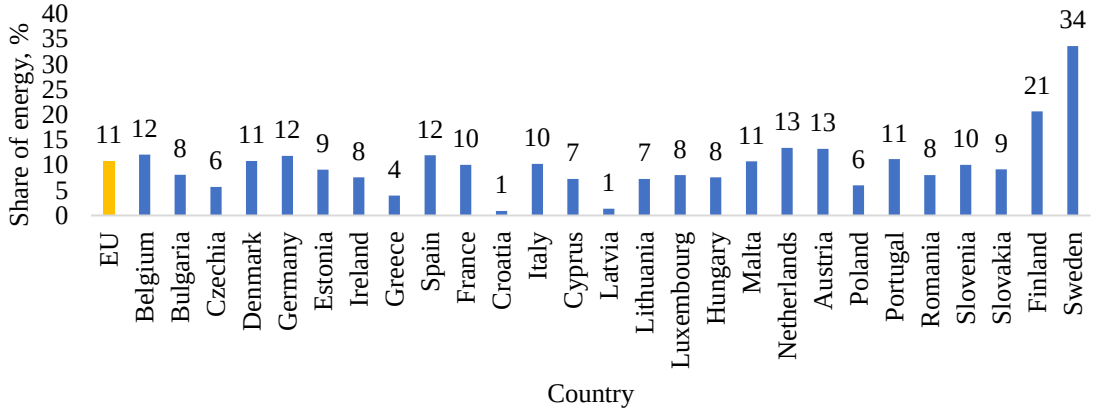

Fig. 1. **Share of energy from renewable sources in the EU transport sector in 2023, % [10]**

This difference points to significant potential for improvement in Latvia, especially with regard to policies and technologies that promote the use of renewable energy. Sweden and Finland, in contrast, stood out as leaders with 34% and 21% share of renewables in transport respectively, showing significant progress. In 2021, 92.5% of energy consumption in the EU road and rail sector was provided by fossil fuels, while renewables accounted for only 7.5%. Of this, 4% were biofuels and biogas produced from food and feed crops, while advanced biofuels and biogas accounted for only 0.8% of total consumption [5]. The use of biofuels in transport represents only 1.6% of total fuel consumption in 2022, a significant decrease from 4.4% in 2021, which underlines the need to promote the use of biofuels [11]. In Latvia, the use of biofuels in transport is regulated by the Cabinet Regulations No 332, which stipulate the conformity assessment of petrol and diesel fuels. According to these regulations, diesel fuel shall be supplemented with at least 6.5% biofuel that meets the sustainability criteria. In turn, petrol of 95 grade shall contain at least 9.5% bioethanol. Such rules promote the use of renewable energy sources and the reduction of greenhouse gas emissions in the transport sector [12]. Biodiesel exports in the EU grew at an average annual rate of 16.3% between 2012 and 2023, reaching EUR 22 003 mln (Fig. 2). In 2023, biodiesel production was forecasted to reach EUR 22 mln.

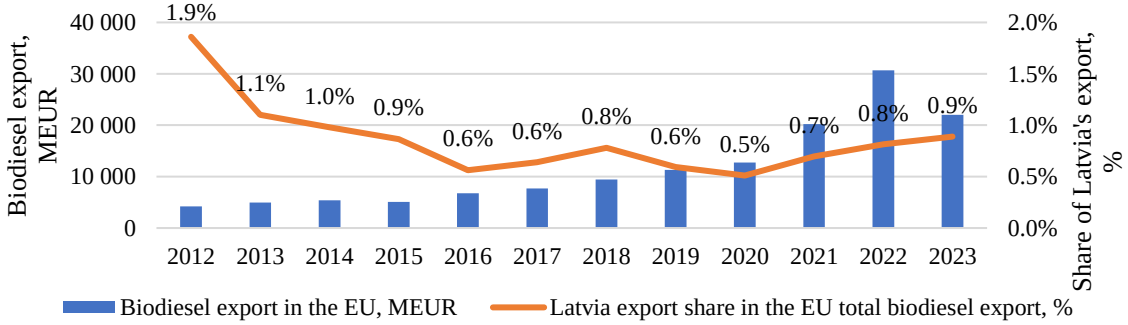

Fig. 2. **Biodiesel export in the EU and Latvia's export share in total EU biodiesel export in 2012-2023, EUR mln and% [13]**

In Latvia, the average annual growth rate over the period was 8.8%, reaching 0.9% of total EU biodiesel exports in 2023, or EUR 196 mln. In Latvia, biodiesel exports increased not only in absolute terms but also as a percentage of total merchandise exports between 2012 and 2023, reaching 1% in 2023 (Fig. 3).

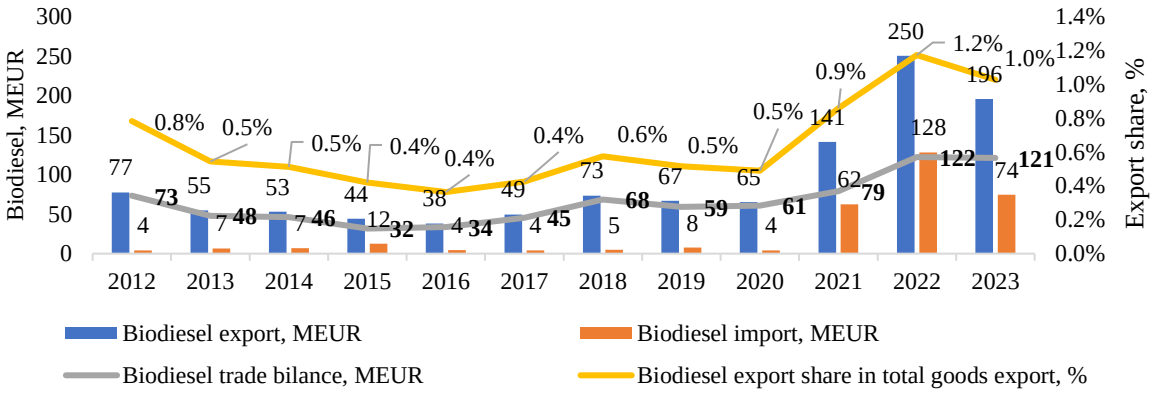

Fig. 3. **Biodiesel export, import, trade balance and share in total goods export in Latvia between 2012 and 2023, EUR mln and% [14; 15]**

These dynamics point to the growing importance of the biodiesel sector in Latvia's exports, linked to the increased demand for sustainable energy resources in the EU and other markets. The rapid growth in exports is a testament to the sector's ability to adapt to demand and effectively exploit Latvia's strategic advantages such as favourable conditions for rapeseed cultivation and advanced production infrastructure as well as the country's participation in the European Green Deal policy. However, biodiesel export volumes are still small in the total EU biodiesel market, which indicates the need to promote the development of the industry by increasing production capacity and export market share. Nevertheless the import of biodiesel in Latvia increased from EUR 4.1 mln in 2012 to EUR 60.4 mln in 2023, the export indicators exceed the import indicators within the entire period and the trade balance remains positive reaching EUR 121 mln in 2023 (Fig. 3). The growing import indicators, with imports reaching 61% of the export value in 2023, indicate the insufficient capacity of local production and the need to increase the capacity of local production.

The main biodiesel export countries are Lithuania, Sweden, the Netherlands and Finland [14]. The volume of exports to Lithuania in 2023 constituted 42% of the total volume of exports, increasing from EUR 37 mln in 2012 to EUR 81 mln in 2023. The volume of exports to Sweden in 2023 constituted 26% of total volume of exports, with an average annual increase of 20.2% from 2012, which indicates a rapid increase in demand in this market. At the moment, exports are focused only on a few countries; yet, increasing the production capacity would allow expanding the range of export countries, diversifying the market and reducing dependence on the demand of only a few countries.

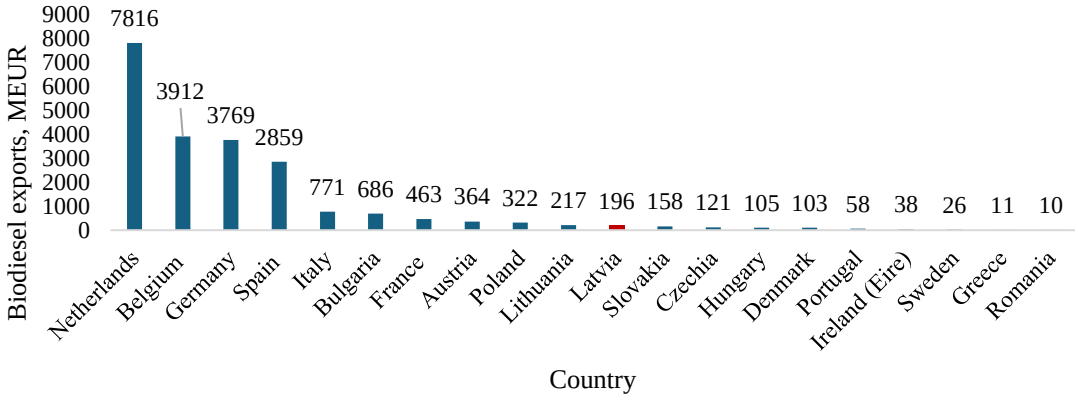

Fig. 4. **Biodiesel exports in the EU in 2023, EUR mln [13]**

In 2023, biodiesel export volumes varied significantly across the EU countries (Fig. 4), reflecting both production capacity and demand fluctuations in different markets. The Netherlands was the largest exporter of biodiesel, reaching EUR 7.8 bln, followed by Belgium (EUR 3.9 bln) and Germany (EUR 3.8 bln). France and Spain exported EUR 2.9 and EUR 2.8 bln worth of biodiesel respectively. Latvia, with exports of EUR 196 mln, lags significantly behind the largest EU biodiesel producers; however, it positions itself as a mid-level player in the region, ahead of countries such as Portugal (EUR 58 mln) and Czechia (EUR 121 mln) but significantly behind neighbouring Lithuania (EUR 217 mln). However, several EU countries, including Estonia, Croatia, Cyprus, Luxembourg, Malta, Slovenia and Finland, did not register biodiesel exports in 2023 and are thus not shown in the graph (Fig. 4). These data indicate Latvia's potential to increase its biodiesel export market share by investing in production capacity and strengthening competitiveness at the EU level.

The share of biodiesel in total GDP was calculated in EUR and as% of total GDP (Fig. 5) using the expenditure approach to GDP. This method describes GDP as the result of all economic activities of a country, including consumption, investment, government spending, exports and imports as the main components [16]. The method was adapted to the context of the biodiesel sector, focusing on the sector's export, import and consumption data, assuming that investments in Latvia in this sector were insignificant and hence not included in the calculation. This approach allows assessing the role of the biodiesel sector in Latvia's economy considering the specificities of the sector and the available statistical data.

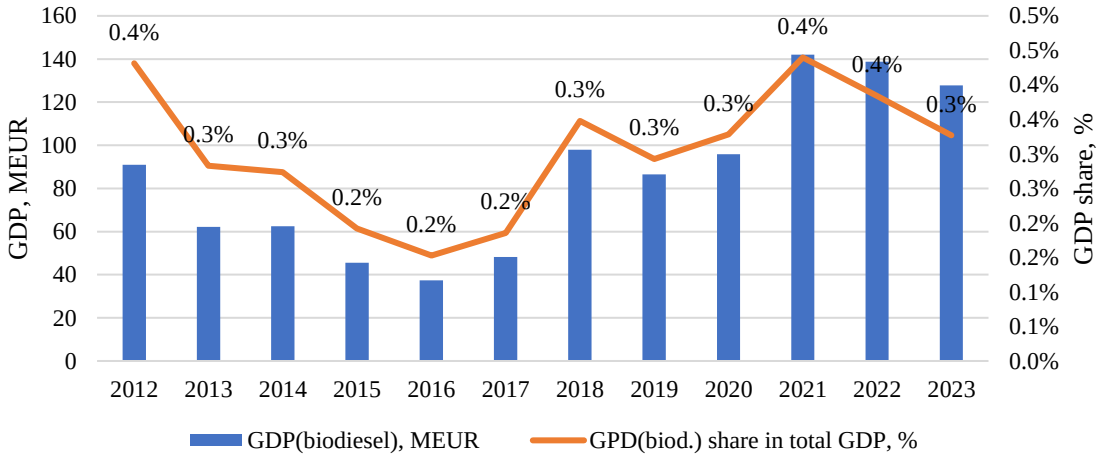

Fig. 5. **Biodiesel sector GDP contribution and its share in total Latvia's GDP in 2012-2023, EUR mln and% [14; 17]**

The contribution of the biodiesel fuel sector to Latvia's GDP in the period from 2012 to 2023 has remained stable, averaging to 0.3% of the total GDP indicator (Fig. 5). The decrease in the impact of biodiesel fuel to 0.2% of GDP from 2014 to 2016 indicates a slower development of the sector. Starting from 2017, a recovery phase is observed, which reaches its highest point in 2021, i.e. 0.4% of GDP. Although in 2022 and 2023, the contribution of the sector decreases slightly, in general, the biodiesel sector demonstrates a stable but limited contribution to the development of Latvia's economy.

Correlation analysis was carried out to assess the statistical correlation between biodiesel exports and GDP changes. Based on the correlation analysis of stationary data between export and GDP derivatives, a positive correlation coefficient of 0.5712 was obtained. This result indicates a moderate positive linear relationship between biodiesel exports and GDP changes in Latvia, implying that an increase in exports is generally followed by an increase in GDP, and that this relationship is linear (Fig. 6). The calculations were performed in Google Colab notebook (Python).

In order to analyse the impact of biodiesel exports on Latvia's economy in detail, co-integration analysis and Vector Error Correction Model (VECM) were applied to examine the short- and long-term relationships between exports, imports, GDP and consumption, identifying their interactions and significance. These methods were chosen because examination of the data using ADF and KPSS tests showed that the data were not stationary. The chosen methodology demonstrates that biodiesel exports in Latvia are an important factor in both short- and long-term economic growth. In the short-term

analysis of VECM, the export coefficient L1.log_export = 0.1758 ($p < 0.001$) in the log gdp. equation indicates a statistically significant and positive impact on GDP in the short term. This confirms the importance of export growth in the economic development, while the short-term impact of imports (L1.log_import = -0.0025, p = 0.765) and consumption (L1.log_consumption = -0.0015, p = 0.866) on GDP are not statistically significant. The long-term impact of exports is also confirmed by the co-integration relationship. Export loading coefficient ec1 = - 0.1285 (marginal significance level, p = 0.055) indicates that export responds to balance deviations and structurally contributes to economic stabilization and development. This coefficient shows that an increase in the volume of exports by 1 unit reduces the balance deviation by about 12.85%; thus, demonstrating the adjustment and stabilizing role of exports.

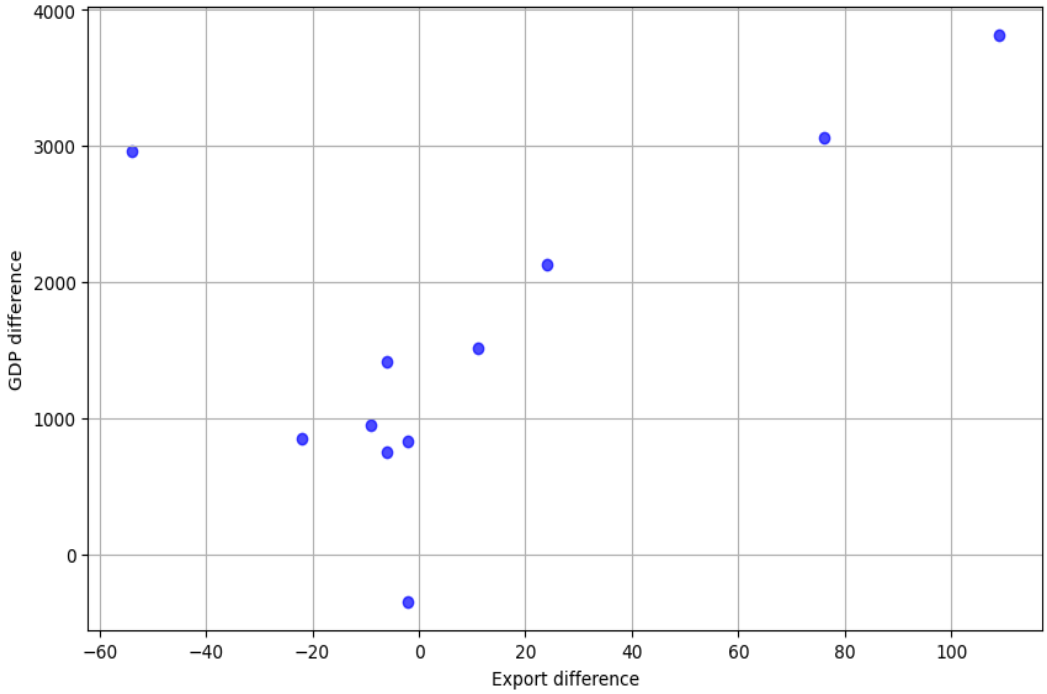

Fig. 6. **Correlation graph between stationary export and GDP data [14; 17]**

This confirms that the increase in biodiesel exports has a structural impact on economic development and helps return to equilibrium. The positive value of the long-term coefficient of export and its importance confirm the strategic role of export in the development of the biodiesel sector. The short-term positive effect of exports on GDP confirms that the development of the biodiesel industry is directly related to exports, which contributes to the economic growth. These results underline the need to increase the strategic role of exports in order to strengthen the contribution of the biodiesel sector to the country's economic development. In order to assess the correlation between biodiesel exports and GDP, an additional Granger causality test was carried out. First order differencing was applied in the study to ensure stationarity of the time series. The test was performed with a maximum lag level of lag = 2 based on the data structure and time period. The results of the Granger causality test indicate that changes in exports statistically significantly "cause" changes in GDP. The p-value for the first lag (lag = 1) was 0.0037, while the p-value for the second lag (lag = 2) was 0.0112, both of which are below the 0.05 significance level. These results confirm that changes in exports have a significant impact on short-term GDP changes. The results provide statistically significant evidence that biodiesel exports are an important factor in Latvia's economic development, both in the short term and strategically. When testing for the reverse relationship – whether changes in GDP affect biodiesel exports - the results showed no statistically significant relationship. This indicates that biodiesel exports are an independent factor in Latvia's economy, driven mainly by external market factors and demand, rather than the overall level of development of the national economy. This analysis highlights the need to increase the capacity and efficiency of biodiesel exports in order to boost economic growth and strengthen Latvia's position on the international market. These results offer an essential basis for further development strategy and policy making of the biodiesel industry.

Conclusions

1. The results of the study show that the increase in biodiesel exports is a statistically significant factor with a positive impact on GDP in the short term, confirming that export dynamics is one of the main drivers of economic activity in the biodiesel sector. The short-term analysis using the Vector Error Correction Model (VECM) found that the export coefficient L1.log_export = 0.1758 ($p < 0.001$) indicates a strong and statistically significant effect on GDP. Furthermore, in 2023, the biodiesel sector contributed 1% to Latvia's total merchandise exports, reinforcing the link between export growth and economic expansion.
2. The study shows that biodiesel exports play an important structural stabilising role in the long run, contributing to adjustment and to the achievement of a steady state in the economy, pointing to the importance of biodiesel exports as a contributor to economic resilience. The co-integration analysis confirms this role, with an export loading coefficient of -0.1285 ($p = 0.055$), indicating that an increase in export volumes by 1 unit reduces the balance deviation by approximately 12.85%, reinforcing the stabilizing effect of biodiesel exports on the economy.
3. The study shows that changes in exports have a statistically significant effect on GDP, confirming the strategic importance of biodiesel exports for Latvia's economy.
4. The results confirm the need to strengthen the export capacity and efficiency of the biodiesel sector in order to ensure a stable contribution to Latvia's economic development and to enhance the country's competitiveness on international markets. The results of the study provide important evidence for policy making to promote the growth of the biodiesel sector.

Author contributions

Conceptualization, G.M.; methodology, T.H. and A.C.; software, T.H.; investigation, G.M., T.H. and A.C.; data curation, T.H. and A.C.; writing - original draft preparation and visualization, T.H. and A.C.; writing - review and editing, G.M.; project administration, G.M. All authors have read and agreed to the published version of the manuscript.

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