EMISSIONS AND THE EMISSIONS TRADING SYSTEM IN RELATION TO AVIATION AND ECONOMIC DEVELOPMENT IN THE CZECH REPUBLIC

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Abstract

Air transport is one of the fastest growing sectors of the world economy. While these developments have a positive economic impact, the growth rates of international aviation do not seem to be environmentally sustainable. This is linked to the focusing on an emission trading system in the air transport sector. This system links environmental and economic aspects of air transport.

The system has been studied in a several of studies in the past, considering its environmental benefits and economic impacts (on carriers, on the economy of European Union and on the economy of member states). It was expected that the introduction of the system would not have significant negative economic impacts. These conclusions should be reassessed in the light of changes in the economy of European Union and of the changes in the economy of European countries. Therefore, the article focuses on the economic links of emissions, the Emissions Trading System in European Union (in focusing on the Czech Republic) with economic development.

Key words: air transport, emission trading system, emissions, gross domestic product

JEL Code: F18, D62, C01

Introduction

Since 2012 emissions produced in aviation are included in the Emissions Trading Scheme (ECT). The purpose of the Emissions Trading System is to reduce greenhouse gas emissions. Cristea, Hummels, Puzzello & Avetisyan (2013) note that the literature focuses largely on emissions from manufacturing, but little attention is paid to emissions from transport. Vespermann & Wald (2011) examine the effects of including air transport in the ETC system. They also state that it is insufficiently researched in this area (Vespermann & Wald, 2011).

1 Literature Review

According to Alonso, Benito, Lonza & Kousoulidou (2014), the transport sector contributes to 23 % of total emissions in the European Union. Specifically, air traffic according to Malina, McConnachie, Winchester, Wollersheim, Pltsev & Waitz (2012) represents approximately 3 % of anthropogenic global warming.

Anger (2010) states that emissions from aviation are not covered by the Kyoto Protocol. The European Union decided to amend this area in 2008. The legislative framework for the emissions trading scheme for aviation at EU level is set out in Directive of the European Parliament and of the Council, under which the EU ETS is extended to the civil aviation sector (since 2012). The ETS, ie the obligation to report CO2 emissions, applies to all flights whose place of departure or landing is in the territory of a Member State of the European Economic Area (EEA).

The system aimed to induce a change in user behavior (Anger, 2010). However, the inclusion of air transport in the system has provoked discussions about possible impacts. The system has direct and indirect effects on the market. According to Costantini, D'Amato, Martini, Tommasino, Valentini & Zoli (2013), the emissions trading system affects economic efficiency. Dong, Dai, Zhang, Zhang & Long (2019) state in their analyzes that the cost increases associated with implementing the system hinder productivity gains and have a negative impact on economic development. Similarly, Than, Siriwardana, Meng & Nong (2019) state, on the example of Australia, that the system in place generally has negative effects on the economy.

We can characterize the system as centralized decision-making, which, according to Efthymiou & Papatheodorou (2019), disrupts the air transport market. Their claim is in line with Hübler, Voight & Löschel (2014), who state that different policy proposals in this area create different sectoral effects. Dong, Dai, Zhang, Zhang & Long (2019) state, with reference to other sources, that research should consider the diversity of sectors involved in the system.

Anger (2010) focused on possible impacts on the aviation industry, CO2 emissions and macroeconomic developments in the European Union. It states that air transport is linked to other sectors of the economy (such as tourism). In the area of macroeconomic impacts, Anger (2010) did not expect negative effects on economic growth in the European Union until 2020. It thus supports previous conclusions from the literature, which state that the impact of the system in air transport on HPD is minimal. It puts this fact in the context of the share of air transport in HPD. According to Anger (2010), it is small in most countries of the European Union. Hübler, Löschel & Voight (2014) evaluate the impacts as same.

Anger & Köhler (2010), with reference to other sources, note that the impacts vary from country to country. The system may have negative effects on the new member states of the European Union. Similarly, Stuhlmacher, Patnaik, Streletskiy & Taylor (2019) state that the system can be significantly linked to economic conditions at the regional level. Yu, Geng, Dai, Wu, Liu, Tian, & Bleischwitz (2018) point out that few studies focus on economic impacts on individual sectors or territories.

Therefore, the article asks the question: is there a relationship between emissions from aviation, price per emission unit within the emissions trading system and economic development (represented by GDP) in the Czech Republic?

2 Methods

The cointegration analysis is a modern method for the analysis of non-stationary variables. Cointegration analysis can be done using numerical tests or graphical methods. The numerical test can be selected – the Engle-Granger test.

Numerical cointegration analysis consisted of two basic steps. The first is a unit root test and the second is a cointegration test of two variables.

The first step is to perform the unit root test. The test can determine whether the time series are stationary or non-stationary. The test can be performed using the Augmented Dickey-Fuller test (ADF), see Formula (1), where y_t is a variable, t is a trend variable, ε approximates the white noise and k is the number of optimal lag length. In practice, three forms of ADF tests are used. The evaluation is based on the assessment of the null hypothesis, where it is tested whether the time series has a unit root, and then we say that the time series is non-stationary. This test is often used.

$$\Delta y_t = \alpha + \beta_t(\rho - 1)y_{t-1} + \sum_{i=1}^{k-1} \theta_i \Delta y_{t-1} + \varepsilon_t \qquad (1)$$

The test can determine non-stationarity. If the input time series are non-stationary and after the differentiation, they obtain a stationarity of the same order, it is possible to perform a cointegration analysis. Cointegration analysis is based on distinguishing between short-term and long-term relationships between time series. Tests for cointegration identify stable, long-run relationships between sets of variables. However, if the test fails to find such a relationship, it isn't proof that relationship doesn't exists— it only suggests that one doesn't exist. The Engle-Granger test can be used, see Formula (2), where e_t are estimated residue, k is the number of optimal lag length and ε_t are residue.

$$\Delta e_t = \varnothing e_{t-1} + \sum_{i=1}^{k} \alpha_1 \Delta e_{t-1} + \varepsilon_t \qquad (2)$$

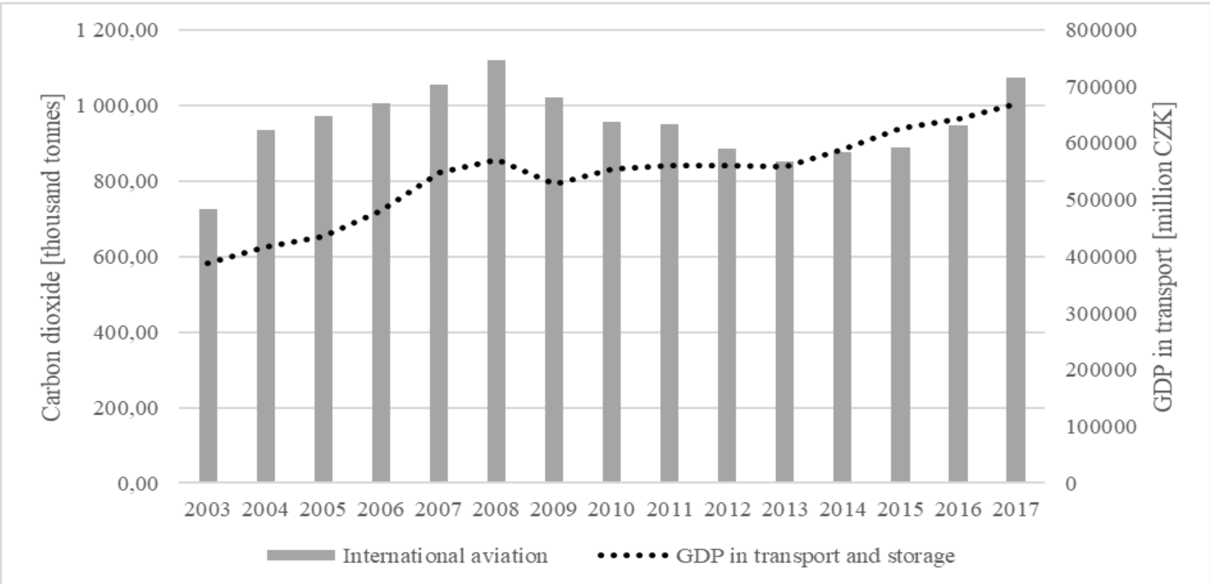
This test assumes non-stationarity of time series and is based on testing the estimated residues from cointegration regression for the presence of a unit root.

3 Data

In accordance with Stuhlmacher, Patnaik, Streletskiy and Taylor (2019) was chosen for analysis a system in the European Union state that contains temporal variability.

Data was obtained from EUROSTAT (the international aviation – carbon dioxide in thousand tonnes) and from The Czech Statistical Office (GDP from transport and storage). These were secondary data. This was a complete dataset for the period 2003-2017 (see Fig. 1). The data in the Fig. 1 is given in million Czech crowns (CZK) and thousand tonnes.

Fig. 1: The development of the emissions from international aviation and of the GDP from transport and storage in the Czech Republic



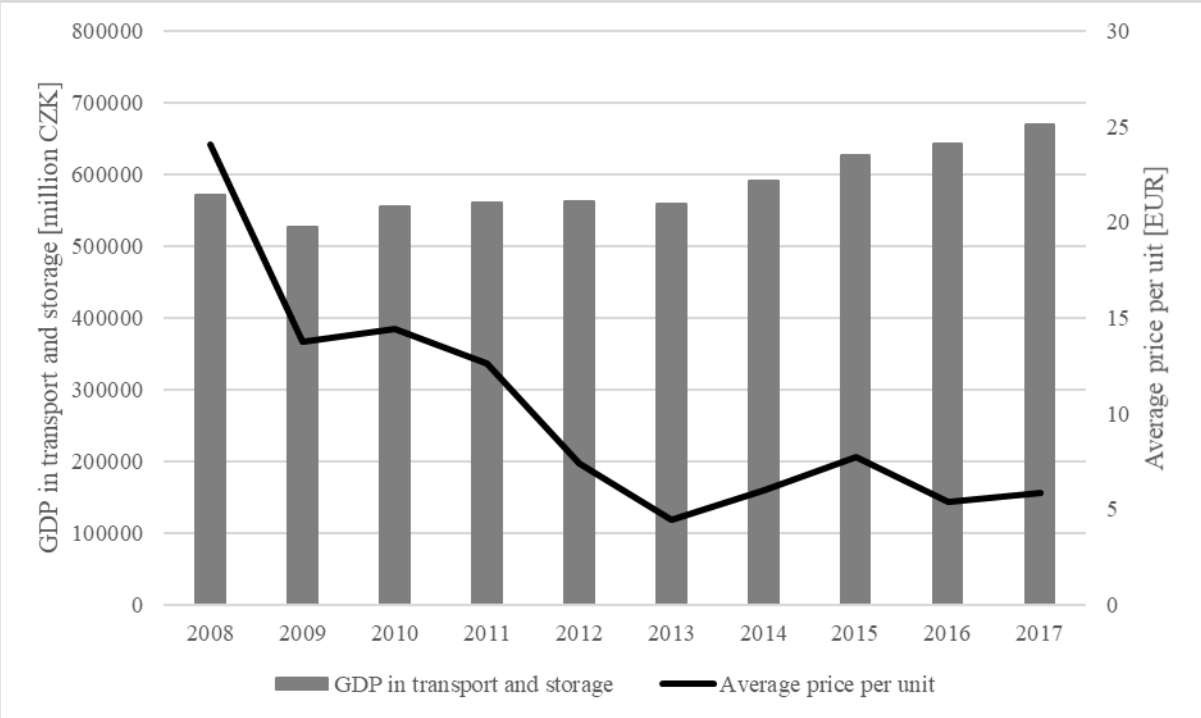
Source: author with use EUROSTAT (2020), The Czech Statistical Office (2020)

The time series of international aviation is characterized by: mean value (950.68 thousand tons), median (948.88 thousand tons), minimum value (726.67 thousand tons) and maximum value (1,118.5 thousand tons).

The time series of GDP from transport and storage is characterized by: mean value (5.4217e+055 million Czech crowns), median (5.5827e+005 million Czech crowns), minimum value (3.8847e+005 million Czech crowns) and maximum value (6.6948e+005 million Czech crowns).

Other input data was obtained from Sandbag (average price per emission unit) and from The Czech Statistical Office (GDP from transport and storage). These were secondary data. This was a complete dataset for the period 2008-2017 (see Fig. 2). The data in the Fig. 2 is given in million Czech crowns (CZK) and EUR.

Fig. 2: The development of the average price per emission unit and of the GDP from transport and storage in the Czech Republic



Source: author with use Sandbag (2020), The Czech Statistical Office (2020)

The time series of the average price per unit is characterized by: a mean value (10,155 EUR), a median (7,5250 EUR), a minimum value (4,4600 EUR) and a maximum value (24,070 EUR).

4 Results

A stationarity test of time series was performed. That optimal lag length (based on the AIC criterion value) was used. The ADF test was used. A zero hypothesis (H0: time series are non-stationary) at 95% significance level was tested. The significance level was compared with the *p*-value (see Tab. 1).

Tab. 1: Results of the ADF test

Variable	*p*-value	H0
International aviation	0,9698	do not reject the null hypothesis
GDP in transport and storage	0,4031	do not reject the null hypothesis
Average price per unit	0,8732	do not reject the null hypothesis

Source: author using the Gnu Regression, Econometrics and Time-series Library

It was necessary to adjust the time series using the first difference. A zero hypothesis (H0: time series are non-stationary) at 95% significance level was tested. The significance level was compared with the *p*-value (see Tab. 2).

Tab. 2: Results of the ADF test (results for adjusted data)

Variable	*p*-value	H0
International aviation	0,000957	reject the null hypothesis
GDP in transport and storage	0,01205	reject the null hypothesis
Average price per unit	0,02046	reject the null hypothesis

Source: author using the Gnu Regression, Econometrics and Time-series Library

The input time series were non-stationary and after adjustment by differentiation they obtained a stationarity of the same order, it was possible to perform a cointegration analysis.

The Engle-Granger test was used. A zero hypothesis (H0: time series are not cointegrated) was tested at a 95% significance level. The Engle-Granger test offers three basic models for cointegration testing. It is a non-constant model, a model with constant, or a model with a constant and trend. For the first data set was selected a model with lowest AIC – for this model the p-value is equal 0,01121. The p-value is lower than the test statistic. It is possible to reject the null hypothesis. There is the cointegration between time series. For the second data set was not the cointegration determined.

5 Discussion

The problem of relationship between emission, emission trading system and macroeconomic determinant is solved by many scientists. There are currently many professional studies that focus on this topic. But there is a limited number of country-specific studies. Similarly, scientists do not focus on the relationship the relationship between the development of the economy and parts of the transport market. Therefore, was the aim of this article to analyse the part of the transport market (aviation) and to focus on this sub-part of the market in relationship to development of economy.

The research question was: whether is there a relationship between emissions and economic development and between average price per emission unit and economic growth after the introduction of the system in the conditions of the Czech Republic. The relationship has been characterised for the Czech Republic in years 2003–2017 for the first data set and in years 2008–2017 for the second data set, based on the research results (Chapter 4). This is partly consistent with Diaz-Rainey & Tulloch (2018). They also used the methods of ADF and causality.

The cointegration between first set of time series has been identified. The cointegration of time series means that the development of individual time series does not deviate in the long run. We can assume that the limitations of the air transport system (due to pressure to reduce emissions) can be linked to change of economic development associated with this area.

It is important to remember that the results are conditional on the data set. They were used annual time series. More detailed data could also be used in future research. GDP of the transport sector has been included in the research; in the future, other macroeconomic determinants could also be used.

Conclusion

Analysis of cointegration is important in economic systems. These systems may be affected by random variances in the short term.

Not all sphere of relationship has been resolved, but the article provides new data. According to Anger (2010), with reference to other sources, air transport is considered the most unsustainable regime now. Anger (2010) states that this is due to the rapid expansion of the sector and globalization. However, Yu, Geng, Dai, Wu, Liu, Tian & Bleischwitz (2018) state that aviation has the least potential for reducing emissions than other modes of transport. This is due to its strong dependence on conventional fuels and many barriers to the use of renewable energy.

It is also appropriate to further analyse the individual parts of the ETS and focus on individual parts of the transport market. A similar situation occurs in the field of maritime freight transport – its global importance is crucial but its impact on climate pollution leads to the introduction of regulatory measures. Here, too, researchers may ask ourselves the question of the link between emissions, economic development and possible involvement in the emissions trading system.

References

Alonso, G., Benito A., Lonza L. & Kousoulidou M. (2014). Investigations on the distribution of air transport traffic and CO2 emissions within the European Union. *Journal of Air Transport Management*. 36(10), 85-93. DOI: 10.1016/j.jairtraman.2013.12.019. ISSN 09696997.

Anger, A. & Köhler J. (2010). Including aviation emissions in the EU ETS: Much ado about nothing? A review. *Transport Policy*. 2010, 17(1), 38-46. DOI: 10.1016/j.tranpol.2009.10.010. ISSN 0967070X.

Anger, A. (2010). Including aviation in the European emissions trading scheme: Impacts on the industry, CO2 emissions and macroeconomic activity in the EU. *Journal of Air Transport Management*. 16(2), 100-105. DOI: 10.1016/j.jairtraman.2009.10.009. ISSN 09696997.

Costantini, V., D'Amato A., Martini C., Tommasiono M. C., Valentini E. & Zoli M. (2013). Taxing international emissions trading. *Energy Economics*. 40, 609-621. DOI: 10.1016/j.eneco.2013.07.019. ISSN 01409883.

Cristea, A., Hummels D., Puzzello L. & Avetisyan M. (2013). Trade and the greenhouse gas emissions from international freight transport. *Journal of Environmental Economics and Management*. 65(1), 153-173. DOI: 10.1016/j.jeem.2012.06.002. ISSN 00950696.

Diaz-Rainey, I. & Tulloch D. J. (2018). Carbon pricing and system linking: Lessons from the New Zealand Emissions Trading Scheme. *Energy Economics*. 2018, 73, 66-79. DOI: 10.1016/j.eneco.2018.04.035. ISSN 01409883.

Dong, F., Dai, Y., Zhang, S., Zhang X. & Long, R. (2019). Can a carbon emission trading scheme generate the Porter effect? Evidence from pilot areas in China. *Science of The Total Environment*. 653, 565-577. DOI: 10.1016/j.scitotenv.2018.10.395. ISSN 00489697.

Efthymiou M. & Papatheodorou A. (2019). EU Emissions Trading scheme in aviation: Policy analysis and suggestions. *Journal of Cleaner Production*. 2019, 237. DOI: 10.1016/j.jclepro.2019.117734. ISSN 09596526.

Hübler, M., Voight S. & Löschel A. (2014). Designing an emissions trading scheme for China—An up-to-date climate policy assessment. *Energy Policy*. 2014, 75, 57-72. DOI: 10.1016/j.enpol.2014.02.019. ISSN 03014215.

Malina, R., McConnachie D., Winchester N., Wollersheim C., Paltsev S. & Waitz I. A. (2012). The impact of the European Union Emissions Trading Scheme on US aviation. *Journal of Air Transport Management*. 19, 36-41. DOI: 10.1016/j.jairtraman.2011.12.004. ISSN 09696997.

Stuhlmacher, M., Patnaik S., Streletskiy D. & Taylor K. (2019). Cap-and-trade and emissions clustering: A spatial-temporal analysis of the European Union Emissions Trading Scheme. *Journal of Environmental Management*. 2019, 249. DOI: 10.1016/j.jenvman.2019.109352. ISSN 03014797.

Tran, T. M., Siriwardana M., Meng S. & Nong D. (2019). Impact of an emissions trading scheme on Australian households: A computable general equilibrium analysis. *Journal of Cleaner Production*. 2019, 221, 439-456. DOI: 10.1016/j.jclepro.2019.02.273. ISSN 09596526.

Vespermann, J. & Wald A. (2011). Much Ado about Nothing? – An analysis of economic impacts and ecologic effects of the EU-emission trading scheme in the aviation industry. *Transportation Research Part A: Policy and Practice*. 45(10), 1066-1076. DOI: 10.1016/j.tra.2010.03.005. ISSN 09658564.

Yu, Z., Geng Y., Dai H., Wu R., Liu Z., Tian X. & Bleischwitz R. (2018). A general equilibrium analysis on the impacts of regional and sectoral emission allowance allocation at carbon trading market. *Journal of Cleaner Production*. 2018, 192, 421-432. DOI: 10.1016/j.jclepro.2018.05.006. ISSN 09596526.

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