Decoupling of greenhouse gas emission and economic performance of the accommodation and food services section in Hungary

A szálláshely-szolgáltatás és vendéglátás szektor üvegházhatású gázkibocsátásának és gazdasági teljesítményének szétválása Magyarországon

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Abstract: There is a twofold relationship between the tourism industry and climate change. On one hand, tourism affects climate through e.g., energy consumption, but on the other hand, tourism is affected by the climate, as e.g., weather plays a role in choosing a destination. This study aims to investigate the link between the economic performance (using the economic indicator of Gross Value Added) and the greenhouse gas emissions of the Hungarian national economy and the section of Accommodation and Food services (Section I), keeping in mind that it does not cover the entire tourism industry. For the sake of the environment, the absolute decoupling of economic performance (in this study GVA) and environmental pollution (in this study the total GHG emissions) is desirable, and in Hungary, the national economy did achieve absolute decoupling during the period 1995–2019. Decoupling can be analysed first by the trends of the economic indicator and the total GHG emission, and second, calculating the Tapio's decoupling elasticity index. Both methods indicate that the Hungarian economy shows decoupling, in other words: the rise of the economic indicator (GVA) is accompanied by the decrease of the total GHG emission. When sectioning the timespan under analysis, strong, weak and recession types of decoupling can be detected. In the case of Section I, however, there were inconclusive, though not totally successful or consistent, attempts at decoupling. Short periods of coupling could be detected (1997–1999, 2003–2005, 2009–2011). It is unfavourable in the aspect of climate change. In Section I, the biggest greenhouse gas emitter is energy consumption, and so it would seem that the best way to achieve and stabilize absolute decoupling in Section I would be increases in energy efficiency and a higher rate of renewable energy use.

Keywords*: decoupling, greenhouse gas emission, Hungary, Section I*

Összefoglalás: E tanulmány célja, hogy feltárja a magyar nemzetgazdaság, valamint a szállás- és vendéglátóipari ágazat (I. ágazat) gazdasági teljesítménye és üvegházhatású gázkibocsátása közötti összefüggéseket, még ha nem is fedi le a turisztikai ágazat egészét. A turisztikai ágazat és az éghajlatváltozás között kettős kapcsolat áll fenn. Egyrészt az idegenforgalom hatással van az éghajlatra, például az energiafogyasztás révén, másrészt viszont az éghajlat is hatással van az idegenforgalomra, mivel például az időjárás szerepet játszik az úti cél kiválasztásában. A környezet védelme érdekében kívánatos a gazdasági teljesítmény és a környezetszennyezés abszolút szétválasztása, és Magyarországon a nemzetgazdaság egészében véve valóban elérte az abszolút szétválasztást az 1995–2019 közötti időszakban (a kutatásban vizsgált időszak, amelyben az üvegházhatású gázok kibocsátására helyeződik a hangsúly). Az I. szekció esetében azonban voltak ugyan szétválasztási kísérletek, de azok nem voltak teljesen sikeresek vagy következetesek. Az I. szektorban a legnagyobb üvegházhatású gázkibocsátó az energiafogyasztás, ezért úgy tűnik, hogy az I. szektorban az abszolút szétválasztás elérésének és stabilizálásának legjobb módja az energiahatékonyság növelése és a megújuló energiaforrások nagyobb arányú felhasználása lenne.

***Kulcsszavak**: decoupling, üvegházhatású gázok kibocsátása, Magyarország, I szektor*

1 Introduction

It is beyond any debate that climate change is one of the most urgent issues that humanity will have to face in the near and long-term future. An extensive list could be written of the possible effects of climate change on the atmosphere-water-soil system and, in consequence, on our way of life, added to which is the fact that changes in climate conditions often cause cascade impacts.

There is no doubt that anthropogenic activities have added to the increase in atmospheric greenhouse gas content, a direct cause of present climate change (Sun et al., 2014). The Kyoto Protocol adopted in 1997 (UNFCCC) targets the reduction of the greenhouse gas emissions. China recently overtook the USA to become the biggest GHG emitter (World Bank Data, 2020). The European Union's commitment to the reduction of GHG emissions has wide support. Between 2008 and 2020 declines in emissions are noticeable in all economic activity in the EU according to the Eurostat database. *In 2020, emissions of greenhouse gases generated by the economic activities of EU resident units stood at 3.5 billion tons of CO_2 equivalents, nearly 24% lower than in 2008* (EUROSTAT, 2022, *https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Greenhouse_gas_emission_statistics_-_air_emissions_accounts*). The sectors with the greatest emissions in the EU are the supply of electricity, gas, and steam, and air conditioning (EUROSTAT, 2022), and in the USA these are transportation and electric power generation (US-EPA, 2020).

The aim of this study is to examine the association between economic performance (the total amount of produced Gross Value Added (GVA) of the national economy) and greenhouse gas emissions in the Hungarian national economy and the Section of Accommodation and Tood Services (Section I), even if it does not cover the entire tourism industry. There is a dual relationship between the tourism industry and climate change. The absolute decoupling of economic performance and environmental pollution is desirable, and the goal of this research is to discover when this absolute decoupling can be achieved. The topic introduced has strong environmental science's link beside its importance in environmental economy. It is strongly associated with climate change, as it explores decoupling of greenhouse gas emission from economic performance.

1.1 Connection between environmental damage and economic growth

It is commonly accepted that there is a correlation between economic growth and environmental pollution. During industrialisation, growth is linked to pollution, therefore, more production will require increasing expenditure on environmental protection. This, however, is usually only valid up to a certain point; beyond this point, a certain level of economic well-being, the tendency reverses. This is known as the environmental Kuznets curve. The basic concept is that without environmental pollution, there cannot be economic growth. The most common shape is the inverse U-shape described above, but other forms exist; Németh-Durkó (2020) found an inverse N-shape environmental Kuznets curve for CO_2 emissions in Hungary between 1982 and 2016, expanding the model with energy, financial, and demographic macro processes.

Another method to investigate the connection between environmental pollution and economic growth is to determine the degree of decoupling between them. "*Decoupling is when resource use or some environmental pressure either grows at a slower rate than the economic activity that is causing it (relative decoupling) or declines while the economic activity continues to grow (absolute decoupling)"* (UN-IRP, 2017; p. 22.). These are the two basic forms of decoupling (Vavrek and Chovancova, 2016). A third category, absolute decoupling within limits, is suggested by Fedrigo-Fazio et. al. (2016) that regards Earth as a closed system and supports the achievement of sustainability goals.

Wang and Wang (2019) investigated the decoupling in the USA and stated that economic growth had been compatible with carbon reduction since 2007. The environmental effect of EU-28 consumption showed decoupling between 2005 and 2014 (Sanyé-Mengual et al., 2019). Chen et al. (2018) conducted a decoupling analysis for the OECD and found that intensity of energy use and per capita GDP are the main factors driving changes in CO_2 emissions. Wenbo and Yan (2018) evaluated the effectiveness of China's environmental policy using decoupling theory.

1.2 Aspects of tourism

Tourism is defined by UNWTO (Glossary of Tourism Terms) as follows: "Tourism is a social, cultural, and economic phenomenon which entails the movement of people to countries or places outside their usual environment for personal or business/professional purposes. These people are called visitors (which may be either tourists or excursionists; residents or non-residents) and tourism has to do with their activities, some of which involve tourism expenditure" *(https://www.untourism.int/glossary-tourism-terms)*. Large numbers of tourists at a destination may lead to risk of environmental damage (Franzoni, 2015), and the rise in global tourism volume contributes to GHG emissions (Sun, 2016). The GHG emissions from tourism are primarily from highly developed regions (Yu-guo and Zhen-fang, 2014). Tourism, as is the case with other economic activities, adds to the greenhouse gas emissions of a country, but on the other hand, it is vulnerable to climate change and extreme weather events (e.g., floods, heavy precipitation, heat waves). The role of tourism is twofold in terms of climate change, a vector and a victim at the same time (Njoroge, 2015). The contribution of tourism to global greenhouse gas emissions is about 8% (Lenzen et al., 2018). The relationship between tourism and climate change is gaining prominence and exciting increasing scientific interest (Koçak et al., 2020).

Lee and Brahmasrene (2013) stated that tourism stimulates national economic growth. Economic growth leads to rise in CO_2 emissions, partly through higher energy consumption, but increased tourism does not necessarily have to lead to increased emissions in EU, because with appropriate policies and practice, tourism may be made more environmentally friendly.

As, however, tourism is not an independent economic sector as represented in national economic statistics, measuring its performance is problematic (Hinek, 2020), because most products and services consumed by tourists are not exclusive to tourism (Neger et al., 2021). As China became the biggest GHG emitting country and tourist sector is growing, a great deal of research can be found that investigates the relationship between GHG emissions and the tourism industry (e.g., Tang et al., 2014; Wu et al., 2015).

The economic sector of tourism is important for several points: based on previous studies, this sector does not show decoupling on long term (Szilágyi and Kocsis, 2026) in Hungary, but the sector plays a huge role in the economy's performance, and it is in the centre of the economic strategy. Referring to the results of Szilágyi and Kocsis (2026) detailed insight to the progress of decoupling is needed for section I, as on long term, decoupling can't be seen. The aim of this study is to investigate the progress of decoupling in the economic section of Accommodation and food services, even though it covers only a part of the Tourism.

2 Materials and Methods

2.1 Data sources

The data of the open-access database of EUROSTAT (open-source database) have been used, and the data of Gross Value Added (GVA), and Greenhouse Gas Emission (GHG) were downloaded for the period of 1995-2019 in case of the Hungarian national economy and Section I (Accommodation and food services). The end of the chosen period is 2019, when the COVID pandemic seriously affected tourism, and the distorting effect caused by lockdowns became a factor. The data were available as annual sums. It should be emphasized that Section I is not identical with tourism itself, but comparable data are provided only for Section I. Section I covers just a part of tourism, which normally contains not only accommodation and food services, but also e.g., the transport connected to tourism, as counted by the TSA (Tourism Satellite Account), and accommodation, food and drink are only components of the whole tourism industry (EEA SOER, 2015). The TSA contains all the gross domestic product in the sector, but there is no comparable data source for emissions. Data availability is a limitation of the calculations. As data of GHG emission is available only for section I (accommodation and food services), decoupling can be calculated from this limited part of the tourism, nevertheless GDP data are available from the Tourism Satellite Account (TSA). GVA data was used because it doesn't contain subsidies and taxes as GDP, just the pure produced added value of the sector.

Linear trend computed by the ordinary least squares method (OLS) was applied to determine the tendencies of GVA and GHG emissions for the examined period of 1995-2019. To identify potential structural changes in the time series, the Bai–Perron multiple breakpoint test (Bai and Perron, 1998) was applied. This method allows the detection of multiple structural breaks. Time series analysis examines just the progress over time but not answer the question of the driving forces. This can be a limitation regarding the conclusions.

2.2 Decoupling elasticity index

The theory of the decoupling elasticity coefficient (*DI*) was proposed by Tapio (2005) and since then has been widely used to demonstrate the delink between environmental pollution and economic growth (e.g., Wenbo and Yan, 2018; Wang and Wang, 2019; Hao et al., 2019). In the present research, this model is used to explore the relationship between the economic growth of the Hungarian national economy and Section I (Accommodation and food service activities) (NACE Rev. 2, 2008) and their greenhouse gas (GHG) emissions. *DI* (1) can be estimated as a

ratio of the change in GHG emission (*%ΔC*) to the change in the economic indicator (*%ΔG* – in the present study, gross value added, GVA) (Tang et al., 2014; Hu et al., 2017).

$$DI = \frac{\%\Delta C}{\%\Delta G} \tag{1}$$

%ΔC is computed as (2) and *%ΔG* as given in (3):

$$\%\Delta C = \frac{(C_t - C_b)}{C_b} \tag{2}$$

$$\%\Delta G = \frac{(G_t - G_b)}{G_b} \tag{3}$$

where C_t is the GHG emission of the current period, C_b is the GHG emission of the base period, G_t is the GVA of the current period, and G_b is the GVA of the base period. The whole examined period was divided in 3-year-long sections to better understand the processes.

According to the grade classification of decoupling suggested by Tapio (2005) (Hu et al., 2017; Li et al., 2021), the following categories were used (*Table 1*). Among the decoupling categories, recession decoupling and weak decoupling may be considered favourable, while from an environmental perspective strong decoupling represents the most desirable outcome.

Table 1 Grade classification of decoupling between GHG emission and GVA (Hu et al., 2017; Tapio, 2005)

Category	%ΔC	%ΔG	DI
Weak negative decoupling	<0	<0	0<DI<0.8
Strong negative decoupling	>0	<0	DI<0
Growth negative decoupling	>0	>0	DI>1.2
Recession decoupling	<0	<0	DI>1.2
Strong decoupling	<0	>0	DI<0
Weak decoupling	>0	>0	0<DI<0.8
Recessive coupling	<0	<0	0.8<DI<1.2
Growth coupling	>0	>0	0.8<DI<1.2

The overall trends were examined for the whole period, and decoupling elasticity indices were determined following Hu et al. (2017) for 3-year periods with a 1-year overlap. Detailed insight to the progress of decoupling is needed for section I, as on long term, decoupling can't be proven (see the work of Szilágyi and Kocsis, 2026). Three years overlapping periods are the smallest periods, where there is sense to calculate the decoupling index. This sectioning of the time series is based on the work of Hu et. al. (2017). With one year overlapping the smallest change can be detected in decoupling.

3 Results

3.1 National Economy

From 1995 to 2019 the linear correlation ($r = -0.78$) between the Gross Value Added of the national economy of Hungary and the GHG emission is negative and ($p < 0.001$). A significant ($p < 0.001$) increasing trend can be observed for the GVA and a significant declining tendency ($p < 0.001$) can be found for GHG emissions over the examined period (*Fig.1.*). It may be supposed that the growth of the national economy is not accompanied by the total GHG emissions, and absolute decoupling can be observed. To gain a deeper insight, 3-year periods were adopted for the computation of the decoupling elasticity index (*DI*). All of these periods showed decoupling, either weak or strong (*Table 2*). Stepwise examination demonstrates that a continuous decoupling was realized between 1995 and 2019 in Hungary.

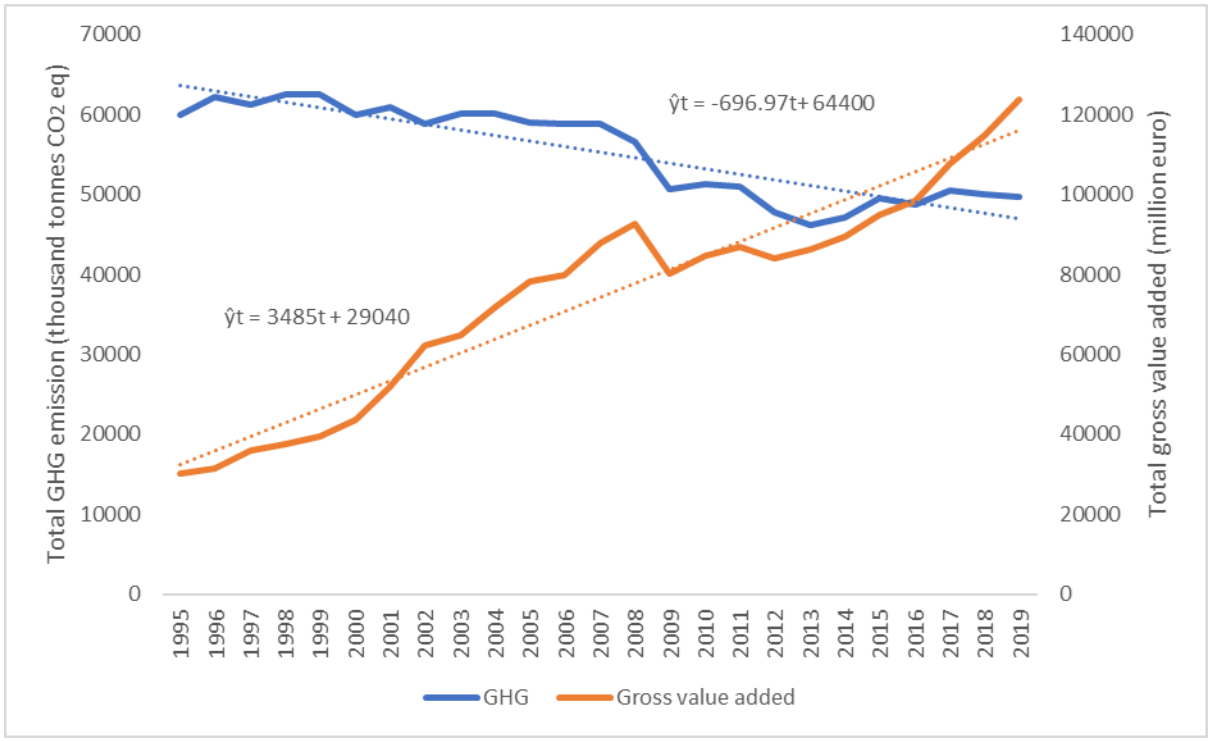


Figure 1 *Tendencies of the total GVA and GHG emissions of the Hungarian national economy (1995–2019)*

Table 2 Decoupling elasticity indices for 3-year periods with a 1-year overlap for the national economy (favourable decoupling categories are in italics)

	%ΔC	%ΔG	DI	Form of decoupling
1995–1997	0.020	0.200	0.101	*weak*
1997–1999	0.023	0.096	0.237	*weak*
1999–2001	−0.027	0.313	–0.086	*strong*
2001–2003	−0.014	0.250	–0.056	*strong*
2003–2005	−0.016	0.208	–0.078	*strong*
2005–2007	−0.004	0.123	–0.031	*strong*
2007–2009	−0.139	–0.088	1.580	*recession*
2009–2011	0.005	0.082	0.059	*weak*
2011–2013	–0.094	–0.008	12.371	*recession*
2013–2015	0.073	0.102	0.714	*weak*
2015–2017	0.019	0.134	0.144	*weak*
2017–2019	–0.015	0.149	–0.100	*strong*

3.2 Section of Accommodation and food services (I)

Tourist consumption and environmental performance depend on many factors and can be highly variable in a brief period as well as in long term. The share of Section I within the GVA of the national economy is 1.92% on average in the period of 1995-2019, with a range of 0.77%. The share rate declines until 2013, then begins to rise (*Fig.2.*). The share of Section I in the total GHG emissions is 0.32%, with a range of 0.15%. This share alternated between growing and decreasing on almost a yearly basis, and a significant tendency cannot be identified (*Fig.2.*). The share of the latest years (2018-2019) was similar to that of the beginning of the period examined (1996–1997).

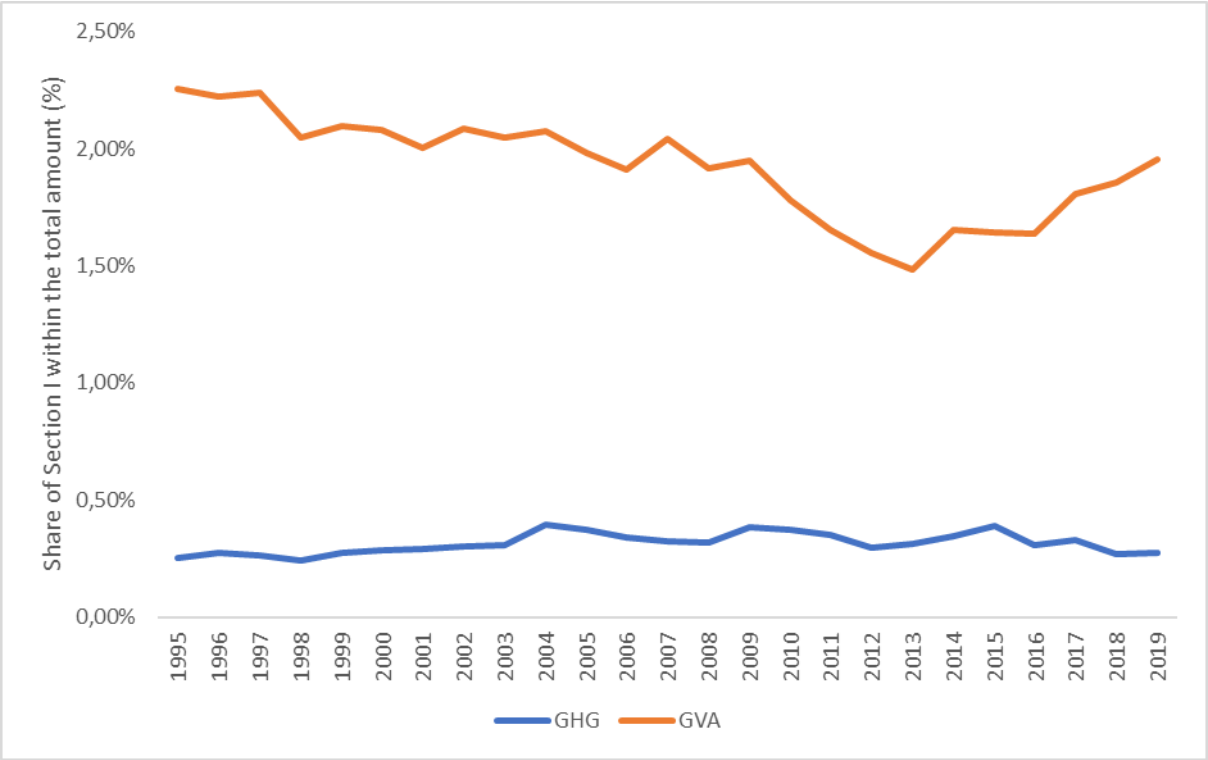


Figure 2. *Share of Section I in the total GVA and GHG emissions*

The correlation between GVA and the GHG emissions of Section I is positive, but not significant ($r = 0.011$, $p = 0.957$). GVA produced by Section I shows a significant increasing tendency between 1995 and 2019 ($p < 0.001$). The GHG emissions of Section I do not, however, demonstrate any significant linear trend ($p = 0.255$) (*Fig. 3.*), but until 2004 there was an emerging tendency. Therefore, a polynomial trend was used to describe the tendency, and it has a better fit than the linear one (*SSE linear = 14358*; *SSE polynomial = 7493*). The polynomial trend suggests that there was a change point, and after the peak in GHG emissions of Section I, a declining tendency can be observed. This turning point can be detected visually on *Figure 3* around 2004 and its existence was confirmed by the Bai–Perron structural break test. It is not the approved reason of the structural breakpoint in the time series, but it might be that it was the year when Hungary joined the European Union and the implementation of the European legislation on energy and environmental policy. Hungary joined the European goals for improving the rate of renewable energy production and its use in the energy mix and implemented the strict rules of environmental protection of the EU. A law for energy tax was issued in this year that enhance this process. From 2004 an intensive rise can be seen in the energy production from renewable energy sources. According to the data available in the database of the Hungarian Central Statistical Office, an increase of 220.4% occurred in the volume of the energy produced from renewable sources and thermal recovery of waste from 2004 to 2019. As Section I is a big consumer of energy, these facts may facilitate the decrease of GHG emissions by the section after 2004. The variability of the GHG emissions emphasizes the need to look deeper and use the decoupling elasticity indices of 3-year steps. Decoupling can be identified in the following short periods: 1995–1997, 1999–2001, 2001–2003, 2005–2007, 2011–2013, 2015–2017, 2017–2019. Between 2003 and 2005 the GHG emissions were linked to the growing economic performance and between 2009 and 2011 to the declining GVA. A stronger positive link can be seen between 1997 and 1999 and between 2013 and 2015.

Between 2007 and 2009 a strong negative decoupling can de observed while economic performance was declining accompanied by the growing GHG emissions of the Section (*Table 3*).

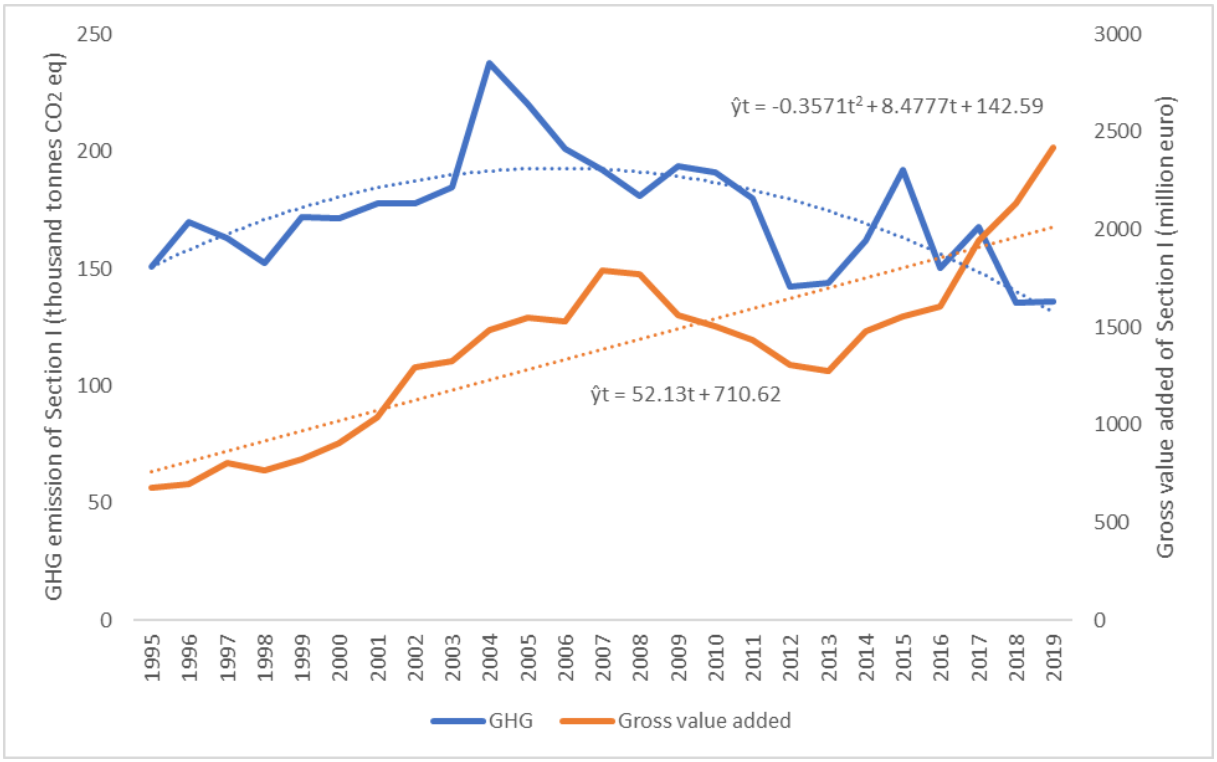


Figure 3 *Tendencies of GVA and GHG emissions of Section I in Hungary (1995-2019)*

Table 3 Decoupling elasticity indices for 3-year periods with a 1-year overlap for Section I (favourable decoupling categories are in italics)

	%ΔC	%ΔG	DI	Form of decoupling
1995–1997	0.080	0.191	0.420	*weak*
1997–1999	0.056	0.027	2.082	growth negative
1999–2001	0.032	0.254	0.125	*weak*
2001–2003	0.041	0.278	0.147	*weak*
2003–2005	0.192	0.170	1.127	growth link
2005–2007	–0.129	0.156	–0.827	*strong*
2007–2009	0.010	–0.129	–0.075	strong negative
2009–2011	–0.072	–0.081	0.893	recession connection
2011–2013	–0.199	–0.110	1.809	*recession*
2013–2015	0.331	0.219	1.512	growth negative
2015–2017	–0.126	0.247	–0.512	*strong*
2017–2019	–0.190	0.246	–0.774	*strong*

4 Discussion

Tourist activity has strategic value in the global economy. However, the tourism activities are related to increased emissions, due to the sector's energy intensity (Pablo-Romero et al., 2023). The tourism industry has become a key sector of the European economy (EEA SOER, 2015), and it is an emerging sector in the Hungarian economy, as well. Tourism is a sector that is suffering from the effects of climate change, but its GHG emissions are also an important element in generating climate change. There is an interactive relationship between the tourism industry and climate change. In order to protect the environment, the decoupling of economic performance and environmental pollution is required. In Hungary, focusing on the overall national economy, absolute decoupling can be detected during the examined period 1995–2019.

Data availability is a limitation of the calculations regarding Section I. As data of GHG emission are available only for section I (Accommodation and Food services), decoupling can be calculated from this limited part of the Tourism, nevertheless GDP data are available for the Tourism Satellite Account (TSA). In the case of Section I (Accommodation and Food services), decoupling was inconclusive and not valid for the entire period. Strong decoupling is observable at the end of the period, coinciding with the outbreak of the COVID pandemic. The biggest GHG emitter of Section I is probably energy consumption. Pablo-Romero et al. (2023) showed a positive, increasing relationship, between energy consumption and tourist arrivals for 15 countries between 2000 and 2019. These activities are heating and cooling rooms, air-conditioning, ventilation, lightning, hot water use, swimming pools and other facilities, and food preparation (EEA ETC/ULS Report, 2018). The higher rate of renewable energy consumption (e.g., photovoltaic energy) and the development of energy efficiency can help stakeholders in Section I to achieve greater decoupling of economic performance from GHG emissions. Hungary's total energy consumption has been trending downward, while electricity demand has increased. The renewable electricity generation has been growing steadily since 2013. In 2024, the amount of electricity generated from renewables exceeded that from fossil fuels for eight months (from March through October) (KSH, 2024). The carbon-intensity of the primary energy consumption is declining (Our World in Data). Total energy supply per unit of GDP (PPP) in Hungary changed by –44% in the period of 2000–2024 (IEA). Metrics of energy use are improving in Hungary, but further investigation should focus on the energy efficiency of Section I, and improvement may help stabilizing decoupling.

Chang and Lee (2026) demonstrated significant macro-level absolute decoupling for EU-27 counties: a 1% rise in international tourism receipts correlates with a 0.184% decline in aggregate CO_2 emissions in the period of 2010–2024. Xu et al. (2023) investigated the factors that affect decoupling of tourism in China and highlighted the importance of large numbers of visitors, high levels of per-person tourism spending, and low passenger traffic volume per unit of energy consumption as key positive factors. Driha et al. (2025) examined the decoupling of tourism sector across the EU states (27). The Tapio analysis revealed heterogeneous decoupling paths among member states in the period 2008–2022, with strong decoupling observed in countries such as France, Portugal, and Sweden. In Eastern Europe a weak or negative decoupling was revealed in several countries. They suggested the need for integrated mitigation strategies that combine technological innovation, spatial planning, and sustainable infrastructure development. EU Tourism Platform points out the importance of circular economy models, and sustainable food practices that can help decarbonisation of tourism, e.g. reduce of food waste and promote plant-based, locally sourced menus, investing directly in on-site emission reduction through renewable energy, efficient heating and cooling, and smart water management, upgrades to energy-efficient buildings and implementing improved waste and water systems.

5 Conclusions

Hungary achieved decoupling in the national economy, while Section I (Accommodation and food services) exhibited unstable and inconsistent decoupling. Decarbonization of Accommodation and Food service activities should be improved to achieve a continuous and stable decoupling of this sector. Further investigation would be needed to explore the driving factors of the GHG emissions.

In the case of the tourism sector, it is important to make available a targeted source of subsidies for energetic modernization, which would enable or even require the use of renewable energies and the installation and development of the necessary equipment and infrastructure. Reducing energy demand and meeting it from renewable energy sources could significantly reduce greenhouse gas emissions. Although the COVID epidemic had a significant impact on the tourism sector (and Section I as well), there are also striking changes in the preceding periods that might have significant impacts on the decoupling index. One such event might be Hungary's accession to the EU in 2004. The impact of the 2008 economic crisis is also probable for short periods, in which, although there was a fall in revenues in the Section of Accommodation and Food services, this was not accompanied by a fall in GHG emissions. In the long term, energy greening could bring about the decarbonization of the sector, which would require significant support.

The limitation of this research is that in Section I (Accommodation and food services), many externalities caused by tourism cannot be considered. Other limitation of the study is that the results show the state of art of decoupling, but the underlying reasons cannot be given exactly, and they may vary from period to period resulting in synergistic outcome.

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