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AIR FREIGHT, ECONOMIC GROWTH AND EMISSIONS: IS THERE A STABLE BALANCE?

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AIR FREIGHT, ECONOMIC GROWTH AND EMISSIONS:

IS THERE A STABLE BALANCE?

Du Xin

Marc Dragon

Mark Goh

Robert de Souza

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SUMMARY

Economic growth helps in the growth of the air freight industry of a country and a region which in turn stimulates the overall economic growth. It is thus instinctive to study the relationship between economic growth and air freight development. Since air freight produces much higher carbon emissions than any other transportation mode, and carbon emissions has a critical impact on the environment, this paper also focuses on examining whether an economy has been growing at the expense of environmental sustainability. Singapore is chosen for this study.

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1. INTRODUCTION

1.1 Air Freight and Global Economy

As the economy develops and globalization strengthens, the efficiency and effectiveness of supply chains are drawing greater attention. Many new technologies and systems, such as RFID (Radio Frequency Identification) and ERP (Enterprise Resource Planning) have been developed, and more strategic collaborations formed to build more efficient and robust global supply chains. The intent is to provide visibility without compromising on speed to market. Though expensive, air freight is growing rapidly due to its fast speed thus shorter lead time, which is especially important for the electronics industry, cold chain cargo, and other time sensitive goods. The air cargo industry is now a crucial part of the global economy. In 2011, this sector handled more than 35% in the value of goods traded internationally, while accounting for only 0.5% in volume (IATA, 2012).

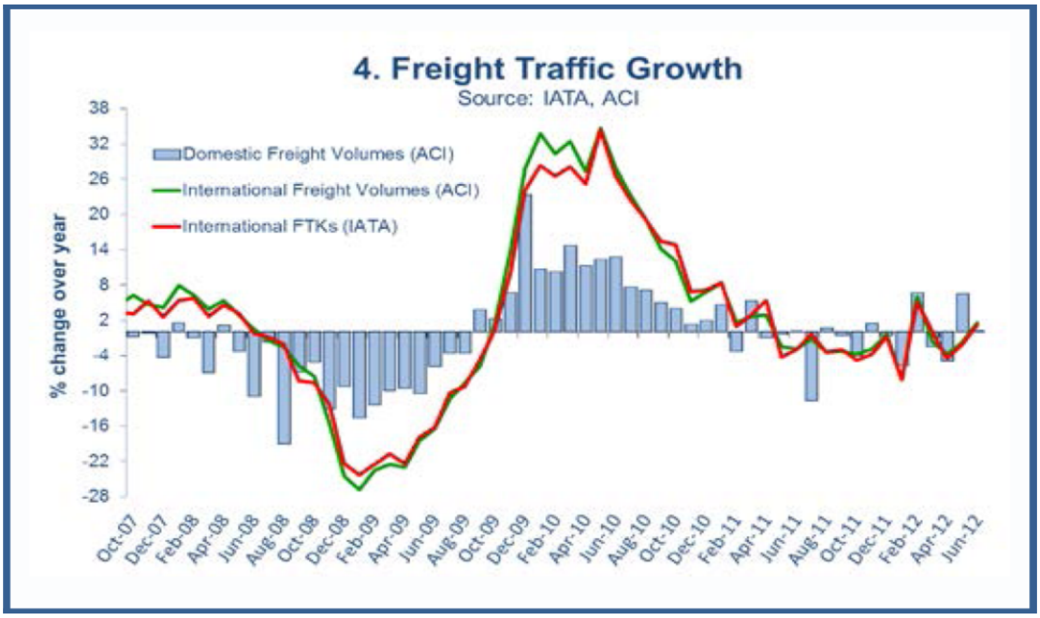

Figure 1 Air Freight Traffic Growth (IATA Economics, 2012)

While the growth of the air freight industry drives economic development, the global economy also affects the growth of the air freight industry. As suggested by various professional services houses, the air freight traffic serves as a clear indicator of the macroeconomic environment (IATA, 2009). As indicated in Figure 1, it shrank quickly during a recession, bounced back when the economy recovered, and started to drop again when the economic expectations became pessimistic.

1.2 Economy Growth and Sustainability

According to the World Bank, economic and social sustainability, and social and environmental sustainability have been found to be compatible and complementary. However, it is not so for economic and environmental sustainability as indicated by the dotted line in Figure 2. The long held argument is that economic growth comes at the expense of the environment (World Bank, 2012).

Figure 2 Sustainable Development (World Bank, 2012)

According to the Ecologic Institute, energy input and transport contribute most to greenhouse gas (hereafter we use CO_2) emissions for the EU from 2000 to 2007 as shown in Figure 3. Also transport is reported to be the only source where greenhouse gas emissions will continue to increase (Melanie, 2010).

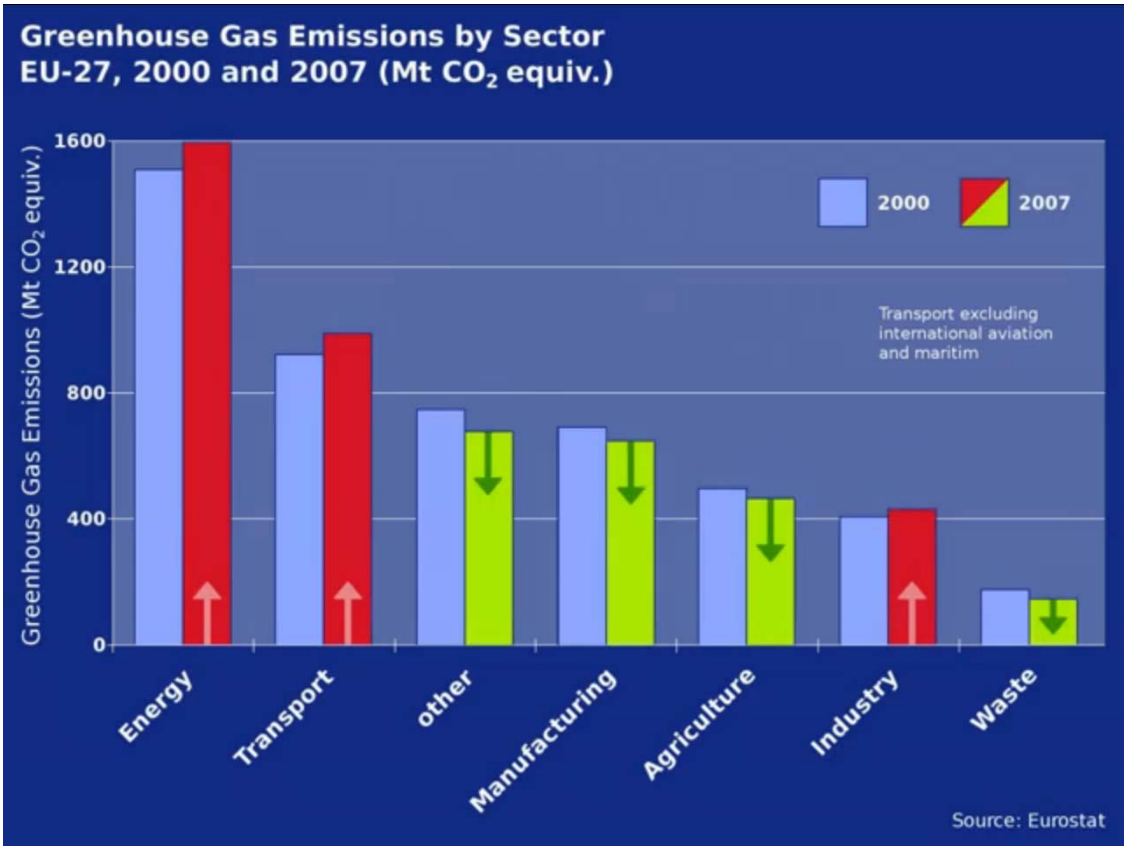

Figure 3 Greenhouse Gas Emissions by Sector EU-27, 2000 and 2007

As more and more people realize the importance of sustainable growth, governments, international organizations and many corporations have started the initiative to go green. Carbon footprint control is one common step towards environmental sustainability. To examine the effect of carbon emissions control on economic growth, the concept of 'decoupling' is introduced. According to the OECD, decoupling occurs when the growth rate of an environmental pressure is less than that of its economic driving force (e.g. GDP) over a given period and this can be either *absolute* or *relative*. Absolute decoupling is said to occur when the environmentally relevant variable is stable or decreasing while the economic driving force is growing. Decoupling is said to be relative when the growth rate of the environmentally relevant variable is positive, but less than the growth rate of the economic variable (OECD, 2001). Figure 4 shows the relative locations of the EU member countries with respect to the CO_2 emissions from transport and their GDP from 2000 – 2007.

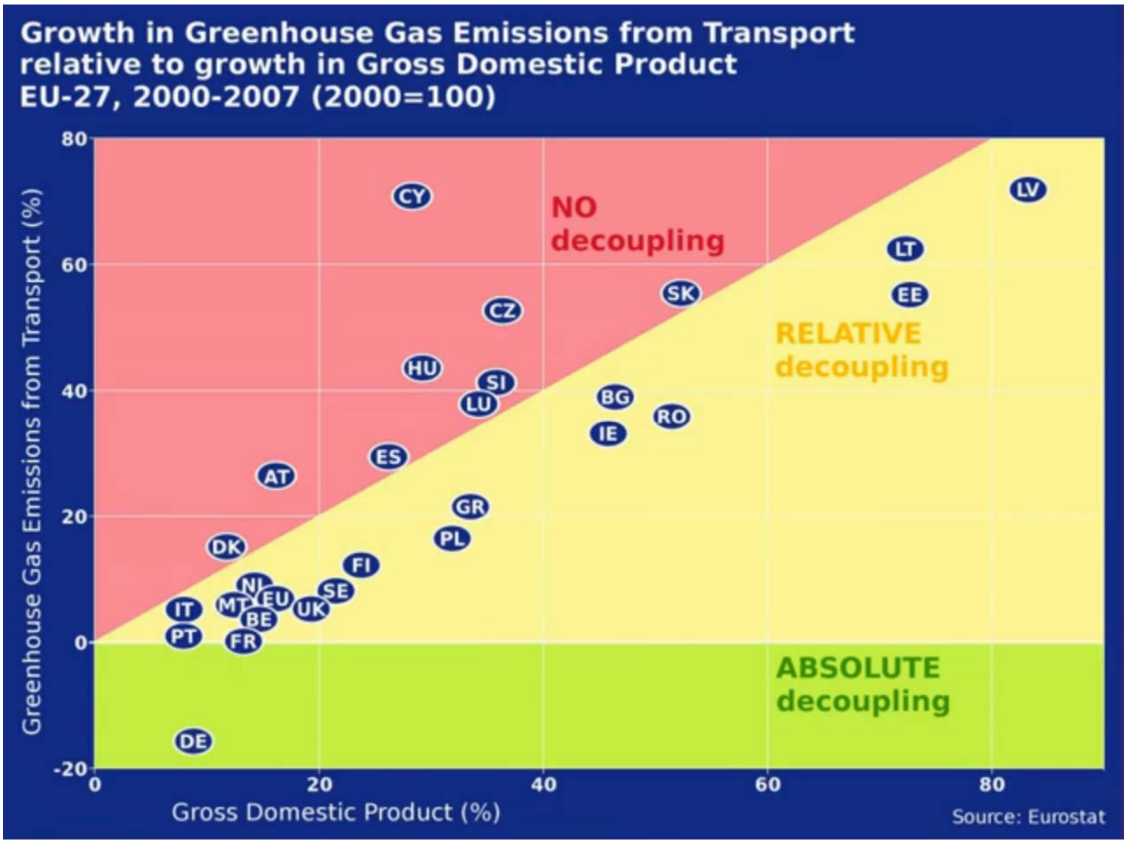

Figure 4 Growth in GHG Emissions from Transport vs. GDP EU-27, 2000-2007

In this paper, we look specifically at Singapore's situation. Since the main transport modes for Singapore are ocean and air freight, and air freight is deemed the main contributor of carbon emissions (Wolfe, 2011), we focus on examining the relationship between air freight tonnage and the economy, and whether the economy has been growing at the expense of environmental sustainability. Here air freight tonnage is a proxy for the air freight industry, and environmental sustainability is indicated by CO_2 emissions. Section 2 explains the methodology used, while Section 3 presents the data analysis results. Section 4 provides further discussions and Section 5 concludes the paper. Some more relevant studies are provided in academic reading list at the end of the paper.

2. METHODOLOGY

2.1 Data Processing

The daily freight tonnage data are provided by Insycn[1], whereas the macroeconomic indicators are retrieved from the Singapore Department of Statistics website[2] and OAG[3]. Since GDP, trade value (import plus export) and Total Production Index are all available only in quarterly data form, the tonnage weights are also consolidated to quarterly data in order to compute the relevant correlation and build the predictive models.

The great circle distances between the airport pairs (origin – destination) are used to calculate carbon emissions. According to Defra/DECC standard (Hill, Walker, Choudrie, & James, 2012), the study on the EU air freight carbon emissions divided the flight distance into three categories, i.e. Domestic, Short-haul and Long-haul, where each category corresponds to a different emission factor. The same categories are applied here, where we adopt 'domestic' as short-haul flight distances, and the original 'short-haul' to be medium-haul flight distance for Singapore, as Singapore is only a small island, and for ease of expediency, we choose to stay within the Defra/DECC standard.

Table 1 Air Freight CO_2 Emission Factor

Flight Type	Distance Range	Emission Factor (kgCO_2/tkm)
Short-haul	< 1000 km	2.04
Medium-haul	1000-3700 km	1.23
Long-haul	> 3700 km	0.63

The CO_2 emissions can then be calculated using:

$$kgCO2 = kgCO2_{per\ ton\ km} \times distance \times freight\ tonnage$$

[1] http://www.insycn.com/
[2] http://www.singstat.gov.sg/
[3] http://www.oag.com/

2.2 Indicator Selection

There are many macroeconomic indicators, such as GDP, PMI (Purchasing Managers Index), CPI (Consumer Price Index), Production Index and trade value, and so on. It is then important to decide which factors to use for the predictive model. If the correlations between the candidate factor pairs are high, then only one instead of all factors will be used. It turns out that those macroeconomic indicators are highly correlated with each other, so only GDP is chosen for the predictive models. (Behar & Venables, 2010)

2.3 Predictive Model

After selecting the key factor to use, i.e. GDP, two predictive models are built using linear regression: (i) GDP vs. Tonnage and (ii) Carbon Emissions vs. GDP. Since the daily datasets are from January 2009 to June 2012, we have 14 data points to perform the analysis. The regression results are analyzed to study the relationship between GDP and tonnage, and GDP and carbon emissions.

3. RESULT AND ANALYSIS

All the results presented in this section are specific to Singapore.

3.1 Correlation between factors

There are 14 quarterly data points starting from January 2009 as shown in Table 2 below.

Table 2 Values of Key Factors

	Air Freight Tonnage (tons)	GDP at current market price (million SGD)	CO_2 (tons)
09Q1	153556.14	62270.80	727056.26
09Q2	172421.32	65431.53	796157.66
09Q3	188143.70	69079.75	990510.62
09Q4	212706.10	73230.62	988959.50
10Q1	215115.22	74322.90	991838.60
10Q2	219091.77	77209.20	1034831.94
10Q3	216808.12	77438.40	1030457.05
10Q4	224665.17	81066.30	1073686.84
11Q1	209737.72	81558.70	1111291.67
11Q2	218300.36	80146.70	1149470.62
11Q3	204813.03	81002.90	961331.12
11Q4	198382.99	84124.10	1023354.86
12Q1	194225.14	83867.40	921866.76
12Q2	198421.47	83438.30	926170.00

To examine the time effects, cross-correlation was used. The maximum allowed lead/lag effect is 1 year, i.e. 4 time periods.

In Table 3, the first column indicates the leading/lagging period. For example, -4 indicates the correlation between tonnage this period and GDP 4 periods ago. Columns 2 to 4 show the cross-correlations between tonnage and macroeconomic indicators and the last three columns show the cross-correlation within the macroeconomic indicators.

Table 3 Cross-Correlations between Factors

lag	Tonnage[4] vs. GDP	Tonnage vs. Total Trade	Tonnage vs. P_Index[5]	GDP vs. Total_Trade	GDP vs. P_Index	Total_Trade vs. P_Index
-4	-0.3604	-0.3308	-0.3336	0.0402	0.0259	0.0503
-3	-0.3173	-0.2758	-0.3136	0.2145	0.315	0.393
-2	-0.0493	-0.0096	-0.0265	0.4281	0.4806	0.5089
-1	0.2548	0.329	0.2742	0.6839	0.6785	0.631
0	**0.6561**	**0.7425**	**0.6157**	**0.9582**	**0.9189**	**0.9152**
1	0.5685	0.6173	0.5568	0.748	0.6767	0.7054
2	0.4958	0.4985	0.5158	0.5326	0.4888	0.4021
3	0.4005	0.3983	0.4696	0.3081	0.313	0.1752
4	0.3649	0.2716	0.2326	0.1586	0.1236	0.0566

As clearly indicated in Table 3, the macroeconomic indicators are highly correlated with each other when the leading/lagging effects are not involved. This is intrinsic since the macroeconomic indicators should be a good reflection of the economic environment for a particular period. Thus, it only makes sense to choose one indicator to avoid auto-correlation effects. GDP is then chosen to study the relationship between air freight tonnage and the economy.

3.2 GDP vs. Air Freight Tonnage

Figure 5 shows the change in GDP and air freight tonnage over time. As indicated, GDP and air freight tonnage start to deviate from each other after Q2 of 2011. One explanation is that the economic environment started to worsen after Q2 2011.

[4] Tonnage refers to Singapore Air Freight Tonnage.
[5] P_Index stands for Total Production Index.

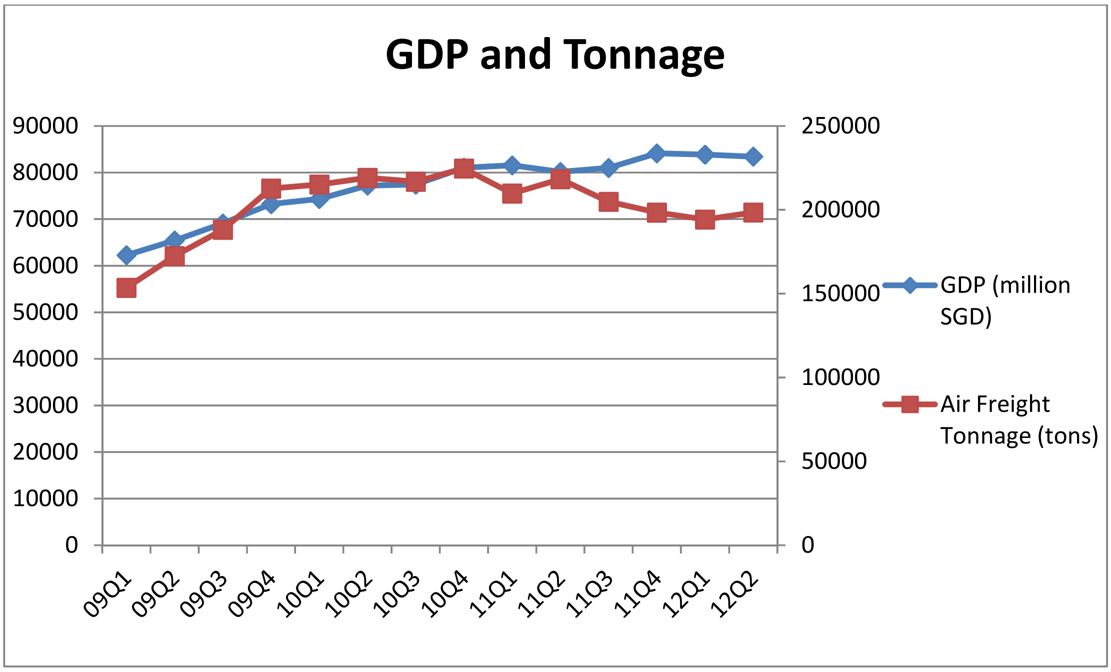

Figure 5 GDP and Air Freight Tonnage value from 09Q1 to 12Q2

Since the correlation between GDP and air freight tonnage is 0.656, we perform a regression analysis, with GDP as the dependent variable and tonnage as the independent variable. Table 5 in Appendix 1 shows the regression results.

From Table 5, we have the following results:

- R^2 = 0.43, indicating that though GDP and air freight tonnage are highly correlated, only a moderate part of the change of GDP comes from the change in tonnage. This is probably because GDP is also largely affected by other factors such as monetary policies and foreign direct investments.
- s.e. = 5497, which is around 7% of the dependent variable value.
- Significance F = 0.011, showing that we can reject the null hypothesis at the 98% confidence level.

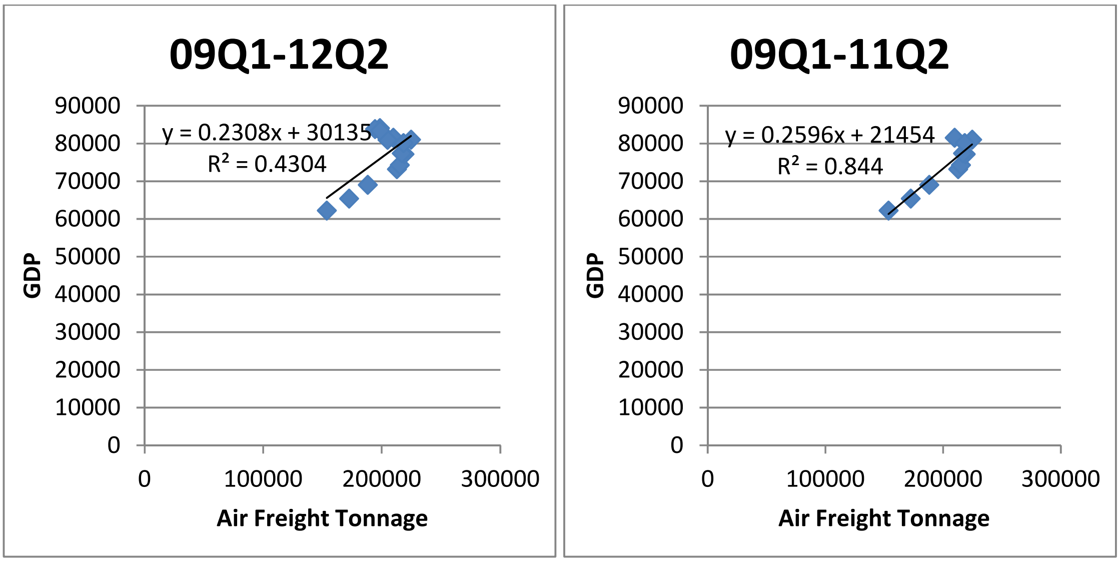

Figure 6 Regression of GDP against Air Freight Tonnage

Thus though GDP and air freight tonnage correlate, the results show better linearity once we remove the data points after Q2 2011 as shown both in Figure 6 and Table 6.

- R^2 increased from 0.43 to 0.84, indicating a much better fitted line showing the relationship between GDP and air freight tonnage;
- s.e. reduced from 5497 to 2801, indicating an improved estimation/prediction;
- and Significance F reduced from 0.011 to 0.00017, meaning we can increase the confidence interval from 98% to 99.9%.

Hence we posit that GDP moves closely with air freight tonnage when the economy is good. This relationship weakens when there is a pessimistic expectation of the economy. This may result from the fact that air freight tonnage increases as economy develops since time and efficiency are more important. As economy worsens, it drops quickly due to its high cost of storage and transit.

3.3 GDP vs. Carbon Emissions

Figure 7 summaries the CO_2 emissions from air freight using the formula presented in Section 2.1 and the values of GDP. There is a similar pattern as Figure 5, and we run a regression of CO_2 against GDP.

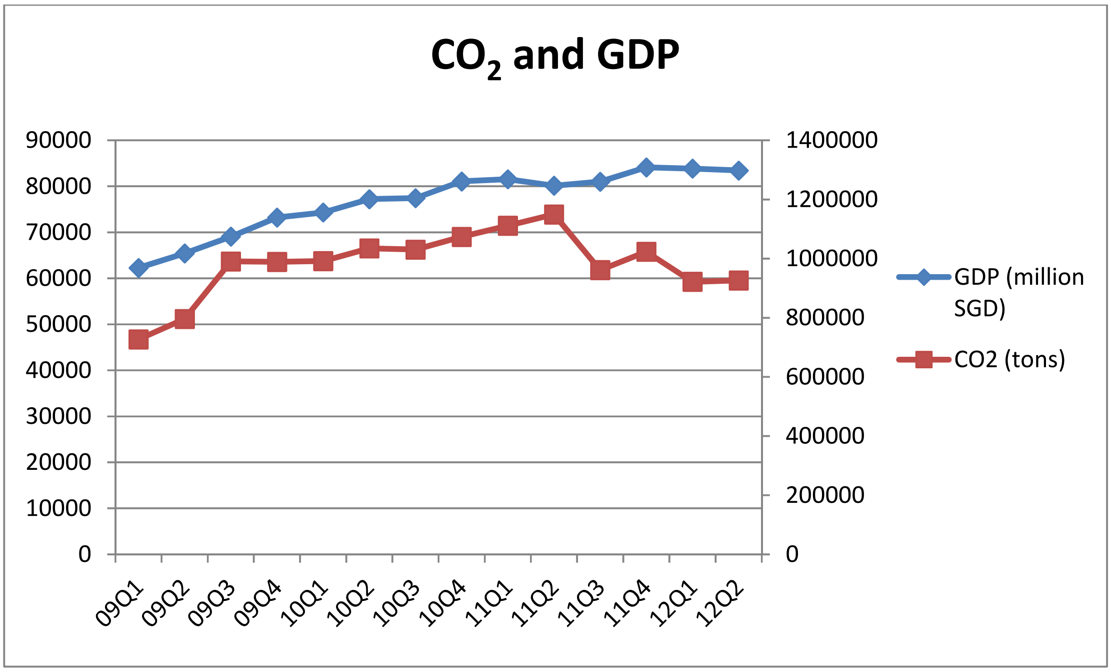

Figure 7 GDP and CO_2 value from 09Q1 to 12Q2

The regression results between GDP (independent variable) and CO_2[6] (dependent variable) is presented in Table 7 in Appendix 2.

From the regression, we can have the following:

- R^2 = 0.428, indicating that only a fair portion of the movement of CO_2 emission comes from a GDP change.
- s.e. = 89229, which is around 9% of the average CO_2 value during the studied period.
- Significance F = 0.011, showing that we can reject the null hypothesis at 98% confidence level.

Hence, though economic development may increase the CO_2 emissions and the economy is growing at the expense of sustainability, other factors may affect the emissions. For example, as can be seen in Figure 7, the CO_2 emission reduced significantly in 2011 and 2012, while the GDP remained relatively stable. We perform another regression test with data points from 2009 Q1 to 2011 Q2 as presented in Figure 8 and Table 8.

[6] CO2 emission from air freight.

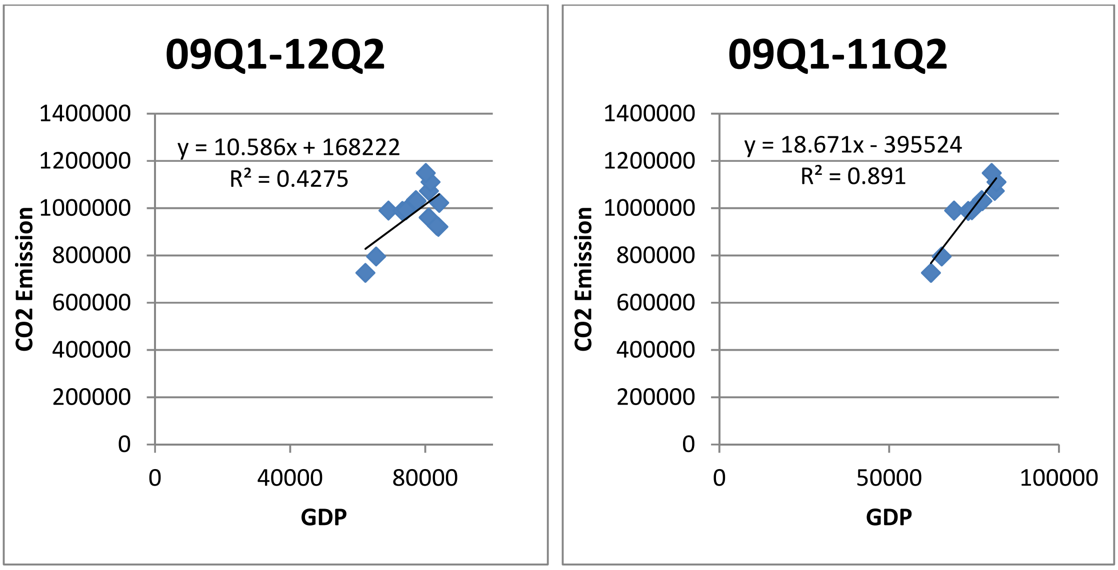

Figure 8 Regression of CO_2 against GDP

Similarly, we can observe a great improvement from the regression results:

- R^2 is increased from 0.428 to 0.891, indicating a better fit;
- s.e. reduced from 89229 to 46327, indicating an improved prediction;
- and Significance F reduced from 0.011 to 0.00004, an equivalent of increase of confidence interval from 98% to 99.9%.

Clearly the change in regression results is very similar to that of the GDP vs. tonnage case, and this may be due to the fact that carbon emissions is closely related to air freight tonnage, hence GDP will be more resistant to economy downturns than CO_2 emissions while the two moves more closely during an economic boom.

4. DISCUSSION

Section 3 shows that GDP is highly correlated with air freight tonnage and CO_2 emissions during the growth cycle of an economy, i.e. from 2009 to 2011 Q2, but the relationship weakens during an economic downturn (after mid 2011). This is mainly because both air freight tonnage and CO_2 emissions dropped rapidly after 2011 Q2. Taking into consideration Singapore's economic environment and trade openness, the phenomenon can attribute to the switch of transportation mode from air freight to cheaper ocean freight in expectation of a weakening economy, since purchasing managers usually prefer to consume storage of goods on hand first and slow down the incoming order during economy downturns; air freight, which provides speed and efficiency during a demand boom, is now less palatable due to its high cost. We thus posit that GDP is less sensitive to economic downturns than air freight tonnage and air freight CO_2 emissions for Singapore.

As shown in Figure 9, the total trade value did not collapse as air freight tonnage or air freight CO_2 emission did. This suggests that the freight mode is switched from air freight to ocean freight.

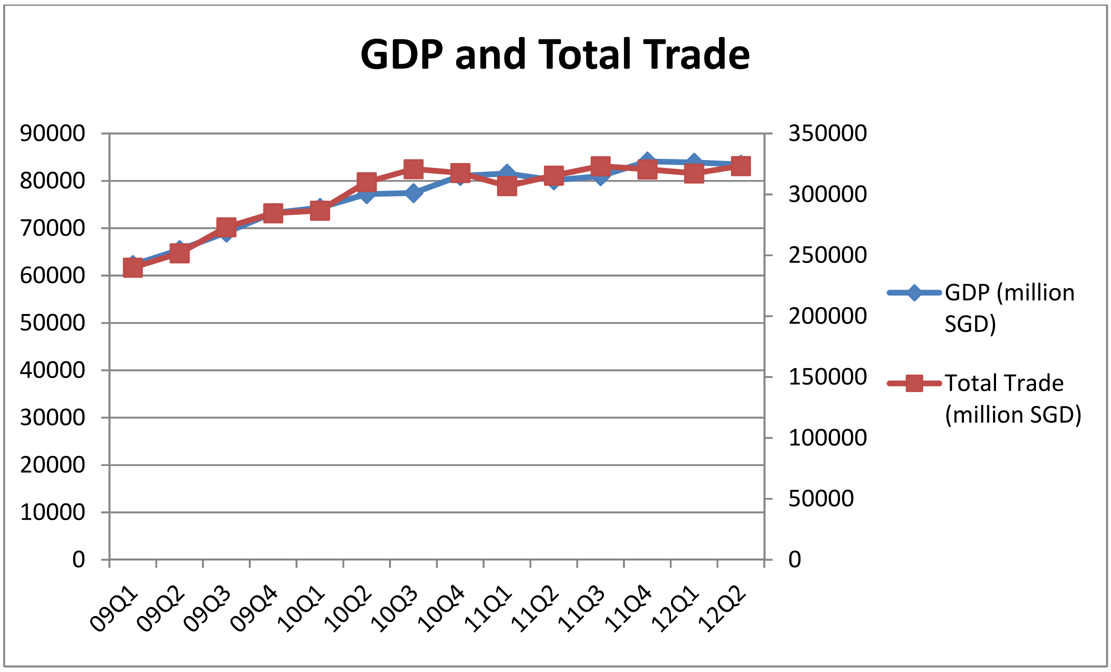

Figure 9 GDP and Total Trade value from 09Q1 to 12Q2

Considering Figure 7, carbon emissions can be divided into three periods according to the steepness of the line, i.e. 09Q1 – 09Q3, 09Q3 – 11Q2, and 11Q2 – 12Q2.

Table 4 Singapore CO_2 Control Performance, 2009-2012

Period	GDP Growth	CO_2 Growth	CO_2 performance
09Q1-09Q3	10.93%	36.24%	No coupling
09Q3-11Q2	16.02%	16.05%	No coupling
11Q2-12Q2	4.11%	-19.43%	Absolute decoupling

Table 4 summaries the growth rates of GDP and air freight CO_2 emissions, showing that a decoupling only takes place when there is a significant reduction in air freight during economic recession. This suggests that Singapore can improve on carbon efficiency and reduce CO_2 emissions during economic development.

5. CONCLUSION

This paper examines the relationship between economic growth and air freight tonnage, and economic growth and CO_2 emissions for Singapore from 2009 to 2012. Two conclusions are drawn from the analysis. First, Singapore's GDP is less sensitive to an economic downturn than air freight, as the transportation mode can be switched from air freight to ocean freight to reduce cost. Second, Singapore still needs to do more in controlling its carbon footprint.

Due to the limitation of data, a temporal relationship is not analyzed. It remains a future research direction to fully test the hypotheses proposed in this paper when more data are available. In addition, the effects of packing efficiency, fill rate and routing schemes on carbon footprint are also interesting to look at. We can also extend the study to ASEAN countries.

Appendix 1

Table 5 Regression results for GDP vs. Tonnage from 2009 Q1 to 2012 Q2

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.656058858
R Square	0.430413225
Adjusted R Square	0.38294766
Standard Error	5497.346068
Observations	14

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	274039464.7	274039464.7	9.067904876	0.010836795
Residual	12	362649765.5	30220813.79		
Total	13	636689230.2			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	30135.41725	15542.09641	1.938954466	0.076382878	-3727.901768	63998.73626	-3727.901768	63998.73626
X Variable 1	0.230786324	0.076640194	3.011296212	0.010836795	0.063801688	0.397770961	0.063801688	0.397770961

Table 6 Regression results for GDP vs. Tonnage from 2009 Q1 to 2011 Q2

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.918701647
R Square	0.844012716
Adjusted R Square	0.824514305
Standard Error	2801.65645
Observations	10

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	339765704	3.4E+08	43.28623174	0.000173099
Residual	8	62794230.93	7849279		
Total	9	402559934.9			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	21453.54991	8062.221177	2.660997	0.028760952	2862.03455	40045.06527	2862.035	40045.07
X Variable 1	0.259644203	0.03946424	6.579227	0.000173099	0.168639503	0.350648903	0.16864	0.350649

Appendix 2

Table 7 Regression results for GDP vs. CO_2 from 2009 Q1 to 2012 Q2

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.653866566
R Square	0.427541486
Adjusted R Square	0.379836609
Standard Error	89229.39017
Observations	14

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	71356138304	71356138304	8.962217695	0.0111971
Residual	12	95542608844	7961884070		
Total	13	1.66899E+11			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	168222.0817	272375.0206	0.617612002	0.548372536	-425232.1071	761676.2704	-425232.1071	761676.2704
X Variable 1	10.58648819	3.536259873	2.993696327	0.0111971	2.88163982	18.29133656	2.88163982	18.29133656

Table 8 Regression results for GDP vs. CO_2 from 2009 Q1 to 2011 Q2

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.943924
R Square	0.890993
Adjusted R Square	0.877368
Standard Error	46326.9
Observations	10

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.4E+11	1.4E+11	65.39007	4.04E-05
Residual	8	1.72E+10	2.15E+09		
Total	9	1.58E+11			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-395524	171894.3	-2.30098	0.050394	-791913	864.3818	-791913	864.3818
X Variable 1	18.67127	2.308968	8.086413	4.04E-05	13.34678	23.99576	13.34678	23.99576

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The Logistics Institute – Asia Pacific
National University of Singapore
21 Heng Mui Keng Terrace, Level 4, Singapore 119613
Tel: (65) 6516 4842 · Fax: (65) 6775 3391
Email: tlihead@nus.edu.sg · URL: www.tliap.nus.edu.sg