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Abstract

This paper studies empirical linkages between cycles and trends in freight transportation activity and real economic activity in Sweden. We find that cycles in freight transportation are highly contemporaneously correlated with cycles in economic variables over both the short run and the medium run. The pattern of long run growth in freight transportation activity coincides with growth in economic variables during long periods, but there are also periods with substantial differences. Furthermore, we observe and explain a large decline in trend growth in tonne-kilometres on road from the mid-nineties and onwards.

JEL Codes: E29, C19, L92

Keywords: freight transportation, business cycles, trend growth, decoupling, efficiency

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1. Introduction

This paper studies linkages between measures of freight transport activity (tonne-kilometres on road, rail, sea and total) and real economic activity (GDP, imports and exports) in Sweden. Short and medium term cyclical fluctuations and long run trend growth rates are analyzed separately. The study uses time series that have been decomposed using wavelet methods, which enable deconstructing "the data in ways that are potentially revealing" (Ramsey 2002, p. 1). It is well understood in economics that the relationship between different economic variables can vary across time horizons (King and Watson 1996, Ramsey and Lampart 1998, Ramsey 2002, Crowley 2007). Forming a better understanding of the relationship between freight transportation activity and key indicators of economic activity at different time horizons is important to, among other things, ongoing policy discussions concerning the efficient use of transportation resources and environmentally sustainable growth in Sweden and elsewhere; See, for example, SOU (2003, 2006, and 2007), Swedish Government (2005a), Ramanathan (2001), EU (2001), Lahiri and Yao (2006) and OECD (2006).

Sweden's real GDP more than tripled between 1960 and 2004. Figure 1 shows that this growth in GDP is coupled with large increases in aggregate freight transportation activity. Although growth in freight transportation was lower than real GDP growth during the seventies and the nineties, the growth rates of the two series appear to follow each other closely during long periods of time.[1]

[1] Looking ahead, SIKA (2005) forecasts that freight transportation activity in Sweden will grow by 21 % until the year 2020. The National Institute for Economic Research forecasts that GDP will increase by 35% from 2004 to 2015 (www.konj.se, August 2007). Furthermore, the EU white paper on transportation policy for 2010 states that (EU 2001, p. 15) "economic growth will almost automatically generate greater needs for mobility, with estimated increases in demand of 38% for goods services" in the EU area.

[FIGURE 1 ABOUT HERE]

The importance of the transportation sector as a whole to society cannot be underestimated. Trade enables, for example, specialization of production and intertemporal reallocation of resources. Nevertheless, the sector is also associated with a number of problems. These problems, which include congestion, accidents and pollution, have been the subject of much interest both by academic researchers and policy analysts. Current discussions on global warming often point to the fact that this sector is one of the main contributors to global warming through its emission of green house gasses. The Swedish Government (2005b), for example, claims that approximately 30 % of all CO_2 emissions in Sweden are caused by the transportation sector. Furthermore, the Intergovernmental Panel on Climate Change states that global green house emissions from the transportation sector increased by 120 % between 1970 and 2004 (IPCC 2007).

The apparent coupling of economic growth to transportation activity and transportation activity to emissions has given rise to a literature that concentrates on decoupling, both in Sweden (SOU 2003, Åhman 2004, Åkerman and Hedberg 2005, and Naturvårdsverket 2006) and internationally (EU 2001, OECD 2006 and Tapio 2005). This literature focuses on ways to quantifying and breaking the observed linkages.

Ramanathan (2001) finds a stable cointegration relationship between transportation activity and real economic activity for India, which can be interpreted as evidence of long run coupling. He also provides evidence of persistent deviations from the estimated long run equilibrium. Lahiri and Yao (2006) discuss transportation activity from a business cycle perspective. They show, using a stage-of-fabrication model with transportation, that freight transportation is closely connected to input inventories. Inventories have, in turn, played an important role in business cycle fluctuations in many countries. See, for example, Abramovitz (1950) and Blinder and Maccini (1991).

The studies mentioned above, as well as many other existing studies, can be interpreted as implying different dynamic relationships between transportation and economic variables across time horizons. Long run growth in transportation is closely connected to increasing production volumes, whilst, for example, the interaction between inventories and transports can cause the pattern of cyclical responses in freight transportation to differ from the pattern of cyclical fluctuations in economic variables. Obtaining a better understanding of linkages across horizons is important since it enables more efficient use of resources through, among other things, better predictions of future developments. What are, for example, the required investments in infrastructure given long term economic growth? In turn, how will these investments affect economic conditions? Better knowledge concerning temporary fluctuations in transports and growth can, furthermore, be used to ensure more efficient use of available infrastructure by, for example, improved congestion charging schemes.

The empirical analysis in this paper is based on growth rates of measures of freight transportation activity and real economic variables. In particular, the paper uses decomposed series reflecting short run (1-4 years), medium run (4-16 years) and long run (16 years and over) developments.[2] The division into three components follows, in spirit, Englund et al. (1992, p. 355) who write that “one often wants to decompose the series into a ‘trend component’, a ‘cyclical component’ and a ‘noise component’”. Wavelet methods have proven useful in analyzing key features of economic time series and are used in this paper to decompose the data.[3] Wavelet analysis stretches across both the time and the frequency domains. This is a

[2] The short run and the medium run capture shocks and the effect of shocks that disappear after, respectively, 1 to 2 years and 4 to 8 years.

[3] See Gençay et al. (2001) and Percival and Walden (2006) for textbook summaries of wavelet methods. The survey papers by Ramsey (2002) and Crowley (2007) on wavelet methods are particularly directed towards economists.

key difference compared to alternative spectral methods, since it allows for the "identification of both events in the time domain and the waxing and waning of cyclical fluctuations in the frequency domain" (Crowley 2007, p. 255-6).

The empirical analysis shows that a large part of the variability in the data is attributable to short run fluctuations, implying that most shocks do not have a strongly persistent effect on the variables under investigation. This also suggests that this component will be highly influential in empirical work based upon directly observable growth rates. Correlation analysis is used to investigate whether freight transportation measures are leading, lagging or coincident with economic variables at the short and medium term. Contemporaneous correlations are found to be high and positive both in the short run and the medium run. At a minimum, this suggests that shocks hitting the economy also have an immediate effect on activity in the freight transportation sector (or vice versa). Correlations remain high for leads and lags in the medium run, but are substantially lower in the short run. A general pattern is that all medium term transportation variables lead medium run GDP as well as imports. This suggests that transportation variables are useful for forecasting medium run economic developments.

The long run freight transportation growth rates tend, as expected, to follow the general growth pattern observed in the indicators of economic activity over long time periods. Common to all transportation modes and measures of economic activity is a high trend growth rate during the sixties and a decline during the seventies. This decline is more pronounced for the transportation activity measures than for the economic variables. A small recovery occurs during the late seventies and the early eighties in all variables except GDP, which remains at the lower levels exhibited in the late seventies. It is more difficult to generalize developments from the nineties onwards. Growth in freight transportation by rail increases from the mid nineties whilst growth in freight transportation by road declines. Trend growth in total freight transportation remains stable even though trend growth in real GDP increases.

Several factors contributing to the decline in road transportation growth that started in the mid nineties are discussed in the paper. One such factor is the increasing share of freight transports using foreign-registered trucks that followed Sweden's entry into the EU. Since emissions, accidents and congestion are, to a large extent, unaffected by whether a particular cargo haulier operating on Swedish roads is registered within the country or not, this leads us to question the usefulness for policy of the official tonne-kilometer measures for freight transport by road. Another contributing factor to the decline is substitution from heavy to light trucks, which are also excluded from measurement.

The paper is organized as follows. Section 2 presents the data that is used in the study, section 3 analyzes long run developments and correlations and Section 4 concludes the paper.

2. Data

Tonne-kilometre data by freight transportation on road, rail, and sea are obtained from the statistics section of the Swedish Institute for Transport and Communications Analysis webpage (www.sika-institute.se). The underlying concepts and methods used in constructing these time series are described in detail in SIKA (2004). The study also includes a total tonne-kilometres measure that is constructed by aggregating over the individual tonne-kilometer series.

Standard real volume indexes for GDP, imports, and exports are obtained from Thomson Financial DataStream.[4] GDP is included in the study since it is the broadest and most commonly cited measure of economic activity. Imports and exports are included since these

[4] GDP: DS Mnemonic SDY99BVPH, Imports; DS Mnemonic SDOIMVOLH, and Exports: DS Mnemonic SDOEXVOLH.

activities are important to the Swedish economy and directly related to goods movement. Several alternative measures of economic activity were considered, but left out of the paper for reasons of brevity. These included industrial production and other GDP spending components.[5]

The length of the sample period (1960-2004) is determined by the availability of consistent time series. In particular, the start-date for both the import- and the export-volume indexes is 1960. The last observation for the corresponding GDP volume index is 2004.

The empirical analysis uses yearly percentage growth-rates. The growth rates for road, rail, sea and total tonne-kilometres are shown in Panel A of Figure 2 and growth rates for the economic indicators are presented in Panel B of that same figure. Descriptive statistics for the full set of growth rates are given in Table 1.

[TABLE 1 ABOUT HERE]

[FIGURE 2 ABOUT HERE]

Growth in total tonne-kilometres averages 1.95 % per year over the full sample. The individual tonne-kilometer measures show that tonne-kilometers on road have grown faster than total tonne-kilometres (4.10 %), whilst tonne-kilometres on both rail and sea have grown slower than the total (1.69 % and 1.00 % respectively). Interestingly, the variability in total freight transportation is lower than the variability in the individual measures, implying substitution between modes of transportation over time.[6] GDP growth averages 2.69 % per year

[5] These results are available from the authors upon request.

[6] Tonne-kilometres on road grew from 6.8 billion tonne-kilometres in 1960 to 37.7 billion tonne-kilometres in 2004. Freight transportation on rail grew from 10.9 billion tonne-kilometres in 1960 to 20.9 billion tonne-kilometres in 2004 and sea transportation activity grew from 24.3 billion tonne-kilometres to 35.2 billion tonne-kilometres. Total freight trans-

between 1961 and 2004, while imports and exports have increased more rapidly at 4.71 % and 5.78 % respectively. The latter growth rates are also more volatile than GDP growth.

3. Freight Transportation Activity and Real Economic Activity

All time series analyzed in this section have been decomposed using a maximum overlap discrete wavelet transform, closely following Chapter 5 in Percival and Walden (2006).[7] Figures 3-6 show the decomposed tonne-kilometer measures jointly with the decomposed indicators of economic activity. Each figure is divided into three panels representing the short run (Panel A), the medium run (Panel B) and the long run (Panel C). The medium run measures fluctuations around the long run trend that have a periodicity of 4-16 years. This definition is chosen with respect to the historical business cycle pattern in Sweden.[8] The short run measures 1-4 year fluctuations, thus capturing shocks and non-persistent cyclical fluctuations.

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portation increased from 42.1 billion tonne-kilometres in 1960 to 93.8 billion tonne-kilometres in 2004. See SIKA (2004) for further details.

[7] The decomposition requires the researcher to specify a particular wavelet function. The analysis in this paper is based on the well-known Haar wavelet specification. Earlier work on wavelet decompositions of discrete time series required exactly 2^j observations (j being an integer). Using a maximum overlap discrete wavelet transformation circumvents this restriction and it also makes the decomposition less sensitive to the exact choice of wavelet function. See Crowley (2007) for additional discussion.

[8] Englund et al. (1992) study business cycles in Sweden over 1861-1988 using spectral techniques. They consider fluctuations in the three to eight year interval. Business cycles in the nineties and beyond have tended to become longer in Sweden and elsewhere, and it is therefore reasonable to extend the length of the medium run cycle. The next possible length in the wavelet analysis is 16 years.

The original growth rates in Figure 2 can be restored at every point in time by summing over the cyclical components and the long run trend component in Figures 3-6.

Tables 2-4 report both simultaneous correlations and correlations based on leads and lags between transportation variables and economic variables following Englund et al. (1992), King and Watson (1996), Lindé (2004) and others. Table 2 is based on the full sample and Tables 3 and 4 are based on the equally sized sub samples 1961-1982 and 1983-2004. The correlation coefficients in Tables 2-4 are indicative of whether short run and medium run cycles in transportation are leading, lagging, or coincident with economic fluctuations. No correlations are computed for the trend growth rates. Such correlations would automatically be high and uninformative due to low variability in these components.

[TABLES 2-4 ABOUT HERE]

[FIGURE 3-6 ABOUT HERE]

3.1 Short Run Fluctuations

All tonne-kilometer measures are volatile in the short run, as can be seen in Panel A of Figures 3-6. The highest volatility is observed for freight transportation by rail, with a maximum annual growth rate of 18 % and minimum growth rate of -16 %. Short run fluctuations in real GDP are substantially smaller than fluctuations in freight transportation, imports and exports. The magnitude of the observed short run fluctuations in both tonne-kilometer measures and economic variables changes over time. The relatively calm sixties is followed by a volatile period starting in the seventies that lasts through the early years of the eighties. The oil price shock in 1973 (OPEC I) has a strong impact on imports and exports and all measures of transportation activity. The devaluations of the Swedish krona in 1976 and 1977 caused large short run fluctuations in the economy and the transportation sector.

After the devaluation following the volatile seventies in 1982, there is an apparent drop in volatility in all freight transportation growth rates. The decrease is especially pronounced for rail and sea transport, but less so for road transport.[9]

Freight transportation activity and economic activity are contemporaneously positively correlated both in the full sample and the two sub samples. The correlations are generally higher in the first sub sample than in the second.

The strongest correlation for freight transportation by road is obtained together with exports. This correlation coefficient is 0.48 or 0.77 depending on the sample period. It is higher in the first sub sample than in the second. The correlation coefficient is 0.64 for the whole sample.

Freight transportation activity by rail is highly correlated with all economic variables, irrespective of sample period. Although the differences are small compared to the other economic variables, the highest correlation coefficients are obtained with exports, both for the full sample and the period 1961 to 1982 (0.71 and 0.83 respectively).

Both sea and total tonne-kilometres are more highly correlated with imports than with either exports or GDP for the full sample and the first sub sample. Total tonne-kilometres are more highly correlated with GDP than with exports and imports in the second sub sample.

[9] The decrease in volatility from the mid eighties is not surprising to an economist. It is well-documented in the macroeconomic literature that volatility decreased around this time in many economic variables, see Blanchard and Simon (2001) and Bernanke (2004). This fall in volatility occurs simultaneously in many countries and the phenomenon is sometimes referred to as *the great moderation.* Commonly cited explanations for this moderation include structural changes (especially in inventory management), improved monetary policies, and good luck (in practice, usually interpreted to mean fewer and less severe oil price shocks).

Adding a lag structure by either lagging the economic variable or the freight transportation measure one period reduces the strength of the correlations and the correlation coefficients become negative in some cases. Lagging imports one period, for example, reduces the correlation with freight transportation by sea from 0.71 to -0.20.

3.2 Medium Run Fluctuations

Key features of the Swedish business cycle are captured by GDP growth in the medium run. One example is the recession preceding the depreciation of the krona that followed the followed the abandonment of the fixed exchange rate in November 1992. This depreciation gave rise to an upturn in economic activity that lasted throughout the rest of the decade, although at a reduced rate during the last few years of this period. The devaluations in 1981 and 1982 had a pronounced effect on tonne-kilometres on road and total tonne-kilometres in the medium run. Interestingly, these devaluations mainly affect the short term component of the economic variables. Both imports and exports exhibit a greater variation than real GDP. The growth rates in tonne-kilometres by road and sea closely track the developments of imports and exports from the mid eighties.

The contemporaneous correlations are indicative that measures of transportation and economic variables are coincident and moving in the same direction. Positive correlations are obtained in 34 out of 36 cases across measures and samples. It tends to be more correlated with imports than with any of the other economic variables. A main different to the analysis of the short run is that the correlation coefficients based on leads and lags tend to be larger. Altogether the correlation coefficients suggest that, freight transportation leads medium run fluctuations in GDP and imports.

3.3 Trend Growth

Panel C of Figures 3-6 show that the trend growth patterns for the various modes of transportation change substantially over time. The trend growth rates in transportation appear to be related to the trend growth rates in the economic variables over long time periods, such as the sixties. There are, however, also periods when the growth rates diverge, such as the late seventies. GDP growth stabilizes at a historically low level around this time while, for example, growth in tonne-kilometres on sea and total tonne-kilometres slowly begin to increase. Another period of divergence occurs following the mid nineties. GDP growth is strong during this period while total freight transportation only grows at a moderate pace. Overall, there appears to be no simple relationship between transportation activity and real economic activity in the long run.[10]

Freight Transports by Road

Trend growth in freight transportation by road was strong throughout the sixties, on average 10 %. The trend growth in real GDP was on average 4.5 % per year during this decade. This period of strong economic growth was coupled with large investments in road infrastructure in Sweden and it is reasonable to believe that such investments further contributed to the growth in road transportation. The trend growth rate in road transportation declined during the seventies, coinciding with the economic downturn in Sweden following the large increase in oil prices in 1973. It picked up some speed again in the eighties and peaked in 1994 with an annual trend growth rate of 3.5 %. It has since been steadily declining – falling to almost 0 % in 2004. During this period of decline, trend GDP growth has increased each year. This observed decoupling is related to an increased presence of foreign trucks on Swedish roads fol-

[10] The study of India by Ramanathan (2001) finds evidence of cointegration between tonne-kilometre measures and measures of economic activity. The long-run trends shown in Panel C of Figures 3-6 do not support this form of cointegration in Sweden. This finding could be changed if additional variables, such as relative prices, were added to the analysis.

lowing the country’s entry into the EU in 1995 (SIKA 2001).[11] Another explanatory factor is substitution from heavy to light trucks over the same period, as indicated by statistics on newly registered trucks and data on kilometers covered by heavy and light trucks.[12]

The explanatory factors discussed above have a negative effect on official tonne-kilometre measures, which are governed by EU regulation. More specifically EU Council Regulation (EC) No. 1172/98 regulating statistical returns in respect to the carriage of goods by road states that “[e]ach Member State shall compile Community statistics on the carriage of goods by road by means of goods road transport vehicles which are registered in that Member State, and on the journeys made by such vehicles”. The regulation also states that “[e]ach Member State may exclude … road transport vehicles whose load capacity or maxi-

[11] EU wide regulations aiming at increasing competition in the EU transportation market came into effect around the time of Sweden’s entry into the EU. For example, paragraph 1 of Article 1 in Council Regulation (EEC) No 3118/93 states that “[a]ny road haulage carrier for hire or reward who is a holder of the Community authorization provided for in Regulation (EEC) No 881/92 shall be entitled, under the conditions laid down in this Regulation, to operate on a temporary basis national road haulage services for hire and reward in another Member State, hereinafter referred to respectively as 'cabotage' and as the 'host Member State', without having a registered office or other establishment therein.”

[12] Data on newly registered trucks are available from Statistics Sweden’s webpage (www.scb.se). No data on tonne-kilometres produced by light trucks are available. However, existing statistics on kilometres covered by light and heavy trucks reveal that while kilometres covered by heavy trucks increased by 17.9 % between 1995 and 2004, kilometres covered by light trucks has increased by 49.2 % over the same period (www.sika-institute.se). Furthermore, no statistics on the number of foreign trucks in Sweden have been produced since 1990; See SIKA (2001) for further discussion.

mum permissible laden weight is lower than a certain limit". This limit is set to 3.5 tonne in Sweden and other countries (SIKA 2004).

Freight Transport by Rail

The trend growth in freight transports by rail is more volatile than the trends in the other transportation variables. It was high in the sixties and declined in the early seventies. Growth became negative in 1975 and it remained negative until 1980. Trend growth is positive and increasing during the early eighties. It peaked in 1986 with an annual growth rate of 2.6 %. Average growth in the eighties is about one percentage point higher than in the seventies. It is, however, 2.5 percentage points lower than the average for the sixties. Growth slowed down in the last few years of the eighties and became negative yet again in 1993. The trend has slowly increased since 1997 and reached 2.1 % in 2004.

Freight Transports by Sea

Freight transportation by sea grew steadily between 1961 and 1968, averaging 5 %. It declined to 4 % in 1969 and became negative three years later, coinciding with the general decline in economic activity in Sweden. While annual GDP growth stabilizes at around 2 % per year in the second half of the seventies, sea transportation continues to decline and does not reach its minimum level until 1977 at -3.5 %. Trend growth remains negative for another eight years until the mid eighties. It has since been stable at around 1.5 % per year.[13]

Total Freight Transports

The trend in the total tonne-kilometre measure follows the general pattern of the individual transportation modes. Growth is high during the sixties (5.6 % on average) but declines rapidly during the early seventies. It is negative between 1975 and 1981 before it recovers in

[13] Tonne-kilometre on sea measures freight transports on Swedish territorial waters. Swedish exports or imports transported on international waters are not included in the measure.

1982. The trend growth stabilizes at 1.5 % after 1986. This level is approximately maintained until 1999. A small decline is then observed and trend growth is close to 1.2 % in 2004. This fall coincides with an increase in GDP growth from 2.6 % to 3.1 %. It is obviously related to the fall in freight transportation by road. Tonne-kilometres on road accounted for more than 40 % of total tonne-kilometres in 2004.

4. Conclusions

This paper investigates the relationship between freight transportation activity and real economic activity in Sweden from 1961 to 2004. Particular attention is paid to developments of growth rates in the short term, the medium term and the long term. The analysis is facilitated by the use of wavelet methods, which are have been found useful for decomposing economic time series.

The analysis shows that a large part of the observed variability in both freight transportation activity and economic activity is attributable to short run developments. Such fluctuations in freight transportation are simultaneously positively correlated with corresponding changes in economic activity. The short run correlation coefficients are substantially lower for leads and lags of the variables under investigation.

The medium run fluctuations are smaller than the short run fluctuations. The medium run components of freight transportation and the medium run indicators of real economic activity are, similar to what was found for the short run, highly contemporaneously correlated. A main difference to the short run is that the correlations remain high when leads and lags are considered. A general finding for the medium run is that freight transportation leads both GDP and imports.

The patterns of the trend growth rates are similar for different measures of freight transportation activity and economic activity over long time periods, even though there are differences in growth levels. Growth was, for example, strong in the sixties for all measures of freight transportation and all measures of economic activity. The annual trend growth in tonne kilometers by road was above ten percent for several years. The economic turmoil following the oil price shocks in the seventies caused growth to fall. Most measures of freight transportation activity fell more than the economic variables considered in this paper. The transportation variables recovered somewhat during the eighties. This period is also characterized by low and stable economic growth.

Long run developments in the nineties are more difficult to generalize. Trend GDP growth increased from the early nineties and so did growth in imports and exports. This followed Sweden’s adoption of a floating exchange rate in 1992 and the subsequent depreciation of the value of the krona. Trend growth in road traffic falls from the mid nineties. Contributing factors to this decline involve increased transportation using foreign registered hauliers and substitution from heavy to light trucks, which are both excluded from measurement. Trend growth in rail traffic increases from the mid nineties, whereas trend growth in freight transportation by sea remains stable. Growth in total transportation is low and the growth rate declines throughout the last years under study. This decline is clearly linked to the fall in freight transportation by road.

The empirical findings in this paper altogether suggest that the relationships between freight transportation measures and real economic variables differ across time horizons. This knowledge can lead to improved policies concerning freight transportation by providing better answers to several questions facing the policy-maker. What policy measures are, for example, required to attain a more efficient transportation system in the long run that also contributes to strong long term economic growth? Can existing infrastructure be used more efficiently today to remove temporary bottlenecks problems during economic boom periods ?

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Table 1. Full Sample Descriptive Statistics

	Road	Rail	Sea	Total	GDP	Imports	Exports
Mean $(\overline{X})$	4.10	1.69	1.00	1.95	2.69	4.71	5.78
Standard deviation (σ)	5.25	6.55	5.73	4.87	1.99	6.06	5.20

Notes

1. $N = 44$ annual growth rates (1961-2004).
2. $\overline{X} = (1/N)\sum X_i$ and $\sigma^2 = \sum (X_i - \overline{X})^2 / (N-1)$

Table 2. Stylized facts about short and medium term cycles over the full 1961-2004 sample

		Correlation with GDP			Correlation with Imports			Correlation with Exports		
		t-1	*t*	*t*+1	*t*-1	*t*	*t*+1	*t*-1	*t*	*t*+1
Short Run	Road	-0.16	0.41	0.18	-0.27	0.38	0.14	0.05	<u>0.64</u>	-0.14
	Rail	-0.18	0.62	0.19	-0.29	0.63	0.03	0.22	<u>0.71</u>	-0.29
	Sea	0.08	0.54	0.02	-0.20	<u>0.71</u>	-0.04	0.05	0.33	-0.12
	Total	-0.08	0.65	0.14	-0.29	<u>0.72</u>	0.04	0.10	0.62	-0.20
Medium Run	Road	0.29	0.64	0.82	0.66	<u>0.90</u>	0.84	0.82	0.75	0.44
	Rail	0.10	0.44	0.72	0.32	0.65	0.79	0.83	<u>0.85</u>	0.64
	Sea	-0.35	0.09	0.54	0.15	0.53	0.77	0.57	0.82	<u>0.85</u>
	Total	-0.13	0.30	0.68	0.36	0.71	0.85	0.72	<u>0.86</u>	0.77

Notes

1. $correl(X,Y) = \sum\left(X-\overline{X}\right)\left(Y-\overline{Y}\right) \Big/ \sqrt{\sum\left(X-\overline{X}\right)^2 \sum\left(Y-\overline{Y}\right)^2}$

2. The highest correlation for each mode of transportation and component is underlined

Table 3. Stylized facts about short and medium term cycles over 1961-1982

		Correlation with GDP			Correlation with Imports			Correlation with Exports		
		t-1	*t*	*t*+1	*t*-1	*t*	*t*+1	*t*-1	*t*	*t*+1
Short Run	Road	-0.18	0.43	0.18	-0.45	0.56	0.05	0.05	<u>0.77</u>	-0.27
	Rail	-0.22	0.67	0.28	-0.33	0.72	0.06	0.19	<u>0.83</u>	0.22
	Sea	0.00	0.62	0.07	-0.26	<u>0.81</u>	-0.02	-0.04	0.40	-0.10
	Total	-0.13	0.70	0.19	-0.36	<u>0.84</u>	0.03	0.05	0.69	-0.19
Medium Run	Road	-0.04	0.27	0.56	0.32	0.60	0.76	0.70	<u>0.86</u>	0.84
	Rail	0.31	0.52	0.69	0.42	0.72	0.83	<u>0.90</u>	0.86	0.61
	Sea	-0.56	-0.21	0.26	0.35	0.42	0.44	0.30	0.61	<u>0.80</u>
	Total	-0.44	-0.10	0.34	0.36	0.51	0.57	0.43	0.70	<u>0.84</u>

Notes

1. $correl(X,Y) = \sum\left(X-\bar{X}\right)\left(Y-\bar{Y}\right) \Big/ \sqrt{\sum\left(X-\bar{X}\right)^2 \sum\left(Y-\bar{Y}\right)^2}$

2. The highest correlation for each mode of transportation and component is underlined

Table 4. Stylized facts about short and medium term cycles over 1983-2004

		Correlation with GDP			Correlation with Imports			Correlation with Exports		
		t-1	*t*	*t*+1	*t*-1	*t*	*t*+1	*t*-1	*t*	*t*+1
Short Run	Road	-0.14	0.41	0.17	-0.01	0.13	0.30	0.05	<u>0.48</u>	0.01
	Rail	-0.01	<u>0.52</u>	-0.08	-0.23	0.42	-0.15	0.38	0.47	-0.36
	Sea	<u>0.44</u>	0.36	-0.18	0.05	<u>0.44</u>	-0.15	0.35	0.21	-0.27
	Total	0.07	<u>0.58</u>	0.00	-0.09	0.40	0.07	0.28	0.55	-0.23
Medium Run	Road	0.35	0.71	0.87	0.71	<u>0.95</u>	0.85	0.90	0.76	0.36
	Rail	0.01	0.43	0.80	0.32	0.69	<u>0.89</u>	0.80	0.87	0.67
	Sea	-0.29	0.21	0.68	0.09	0.61	0.94	0.72	<u>0.95</u>	0.89
	Total	-0.01	0.47	0.85	0.38	0.82	<u>0.99</u>	0.88	0.96	0.74

Notes

1. $correl(X,Y) = \sum\left(X-\overline{X}\right)\left(Y-\overline{Y}\right) \Big/ \sqrt{\sum\left(X-\overline{X}\right)^2 \sum\left(Y-\overline{Y}\right)^2}$

2. The highest correlation for each mode of transportation and component is underlined

Figure 1. Indexes of Real GDP and Total Tonne-kilometres 1960-2004 (1960=100)

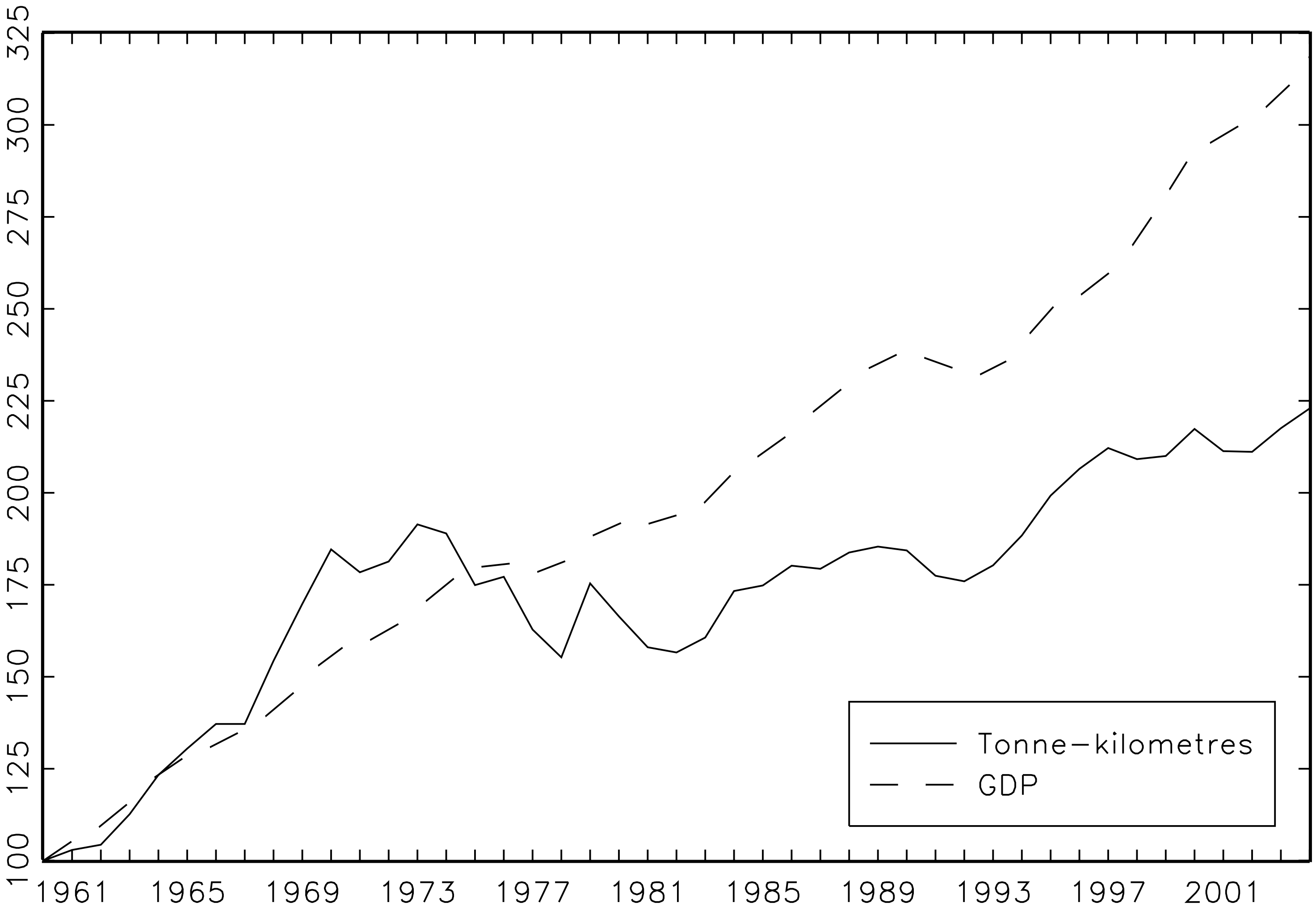
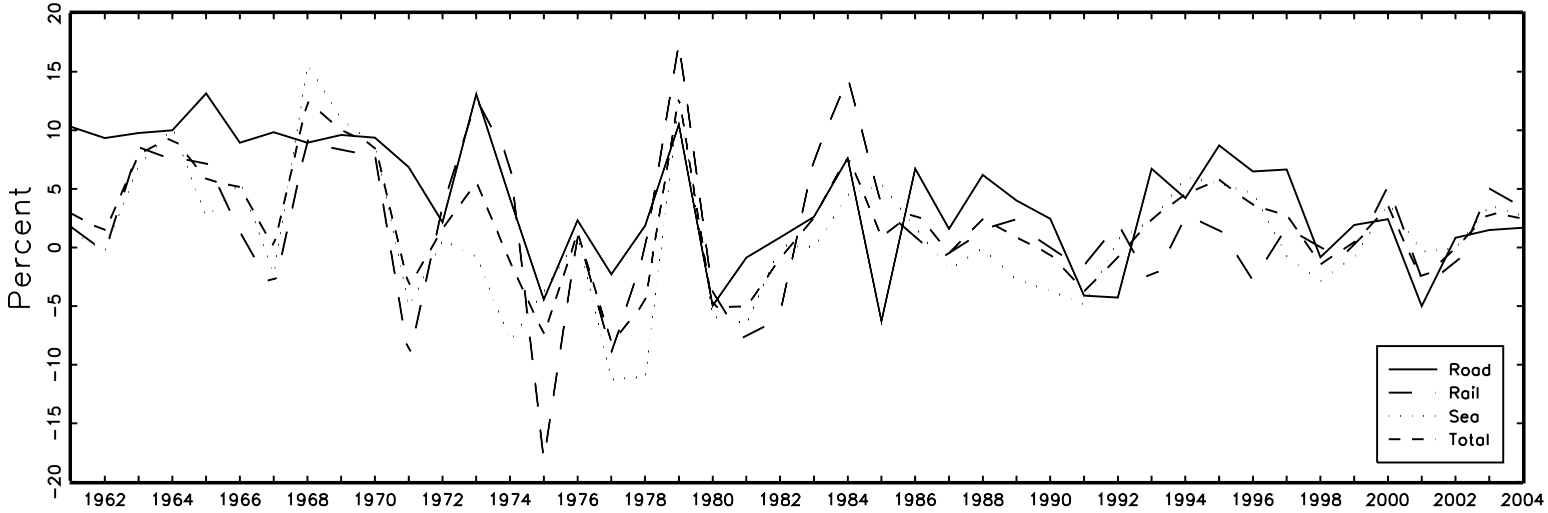


Figure 2. Time Series Growth Rates

Panel A: Tonne–Kilometre Growth Rates



Panel B: GDP, Imports, Exports Growth Rates

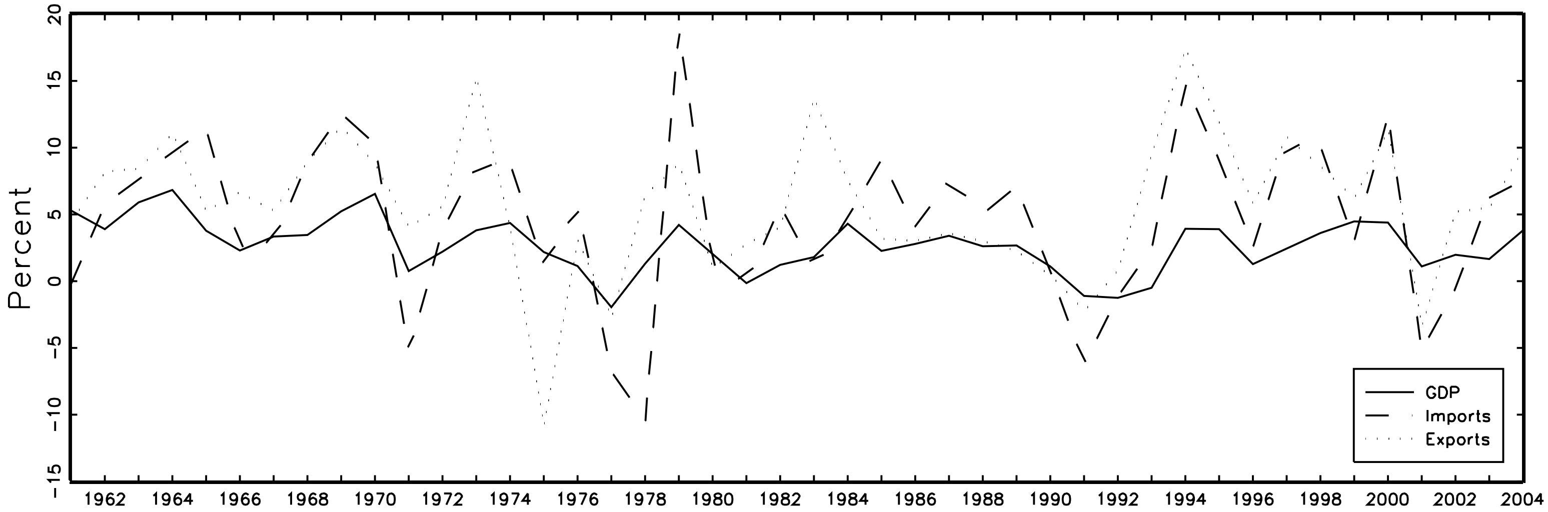


Figure 3. Tonne-kilometres on Road

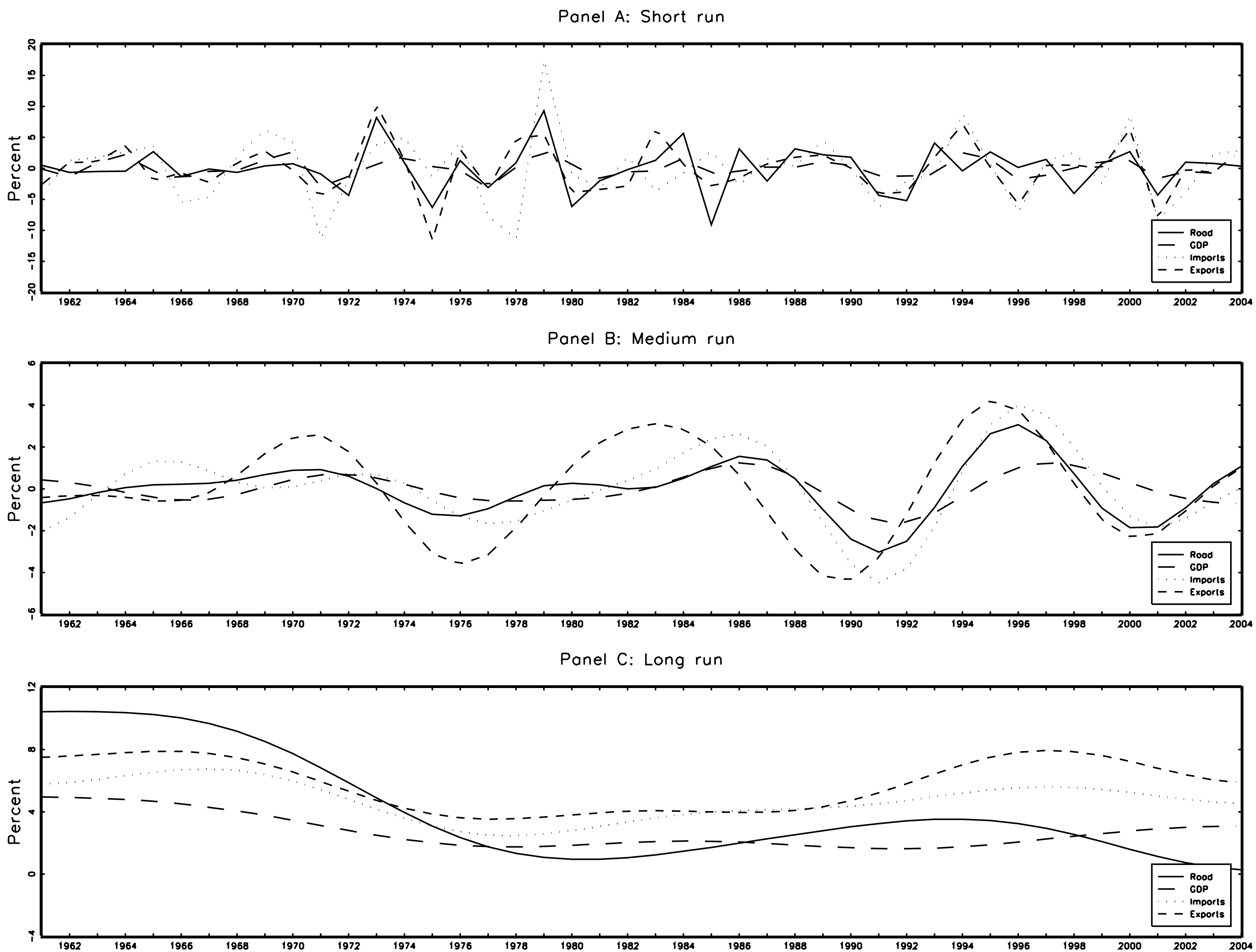


Figure 4. Tonne-kilometres on Rail

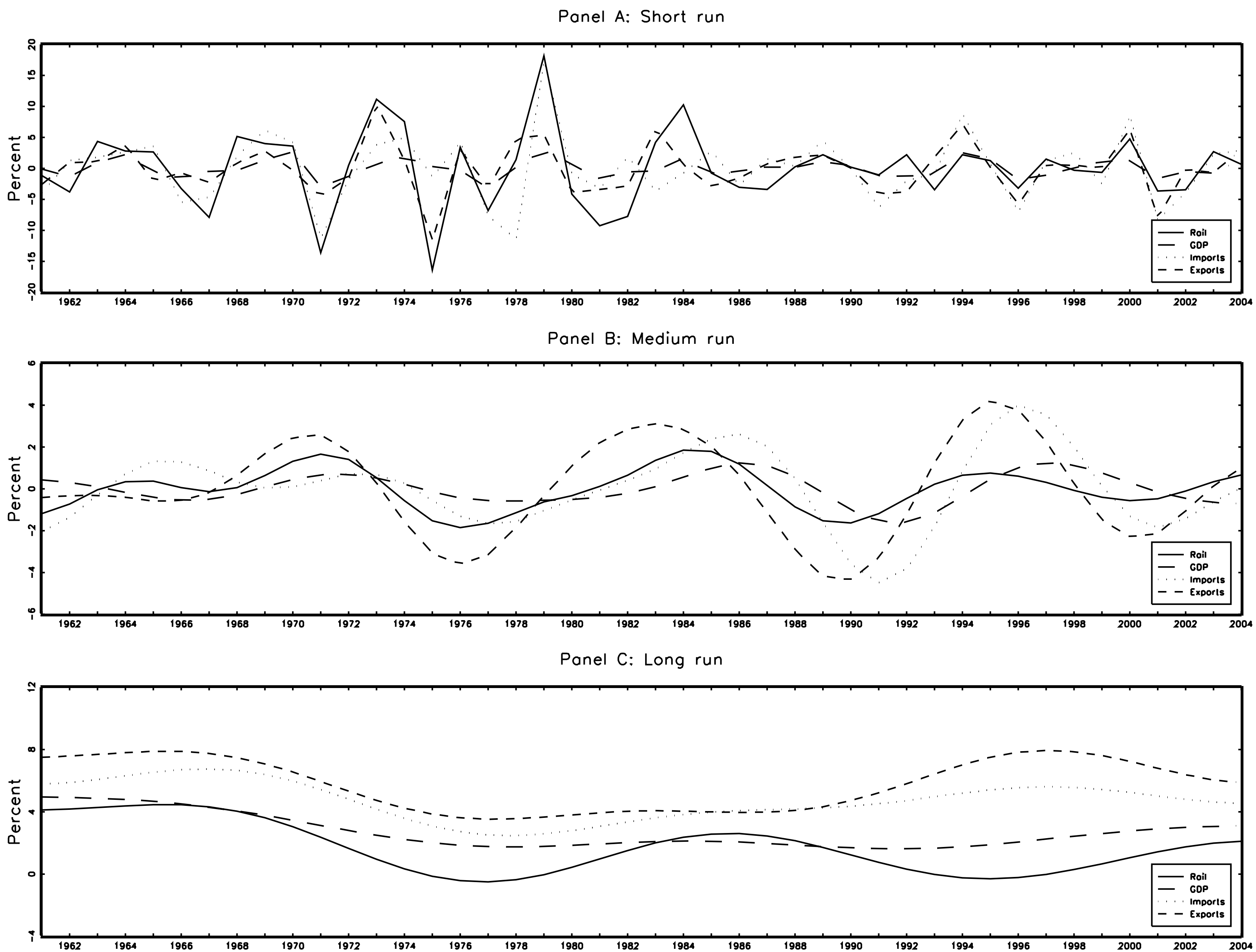


Figure 5. Tonne-kilometres on Sea

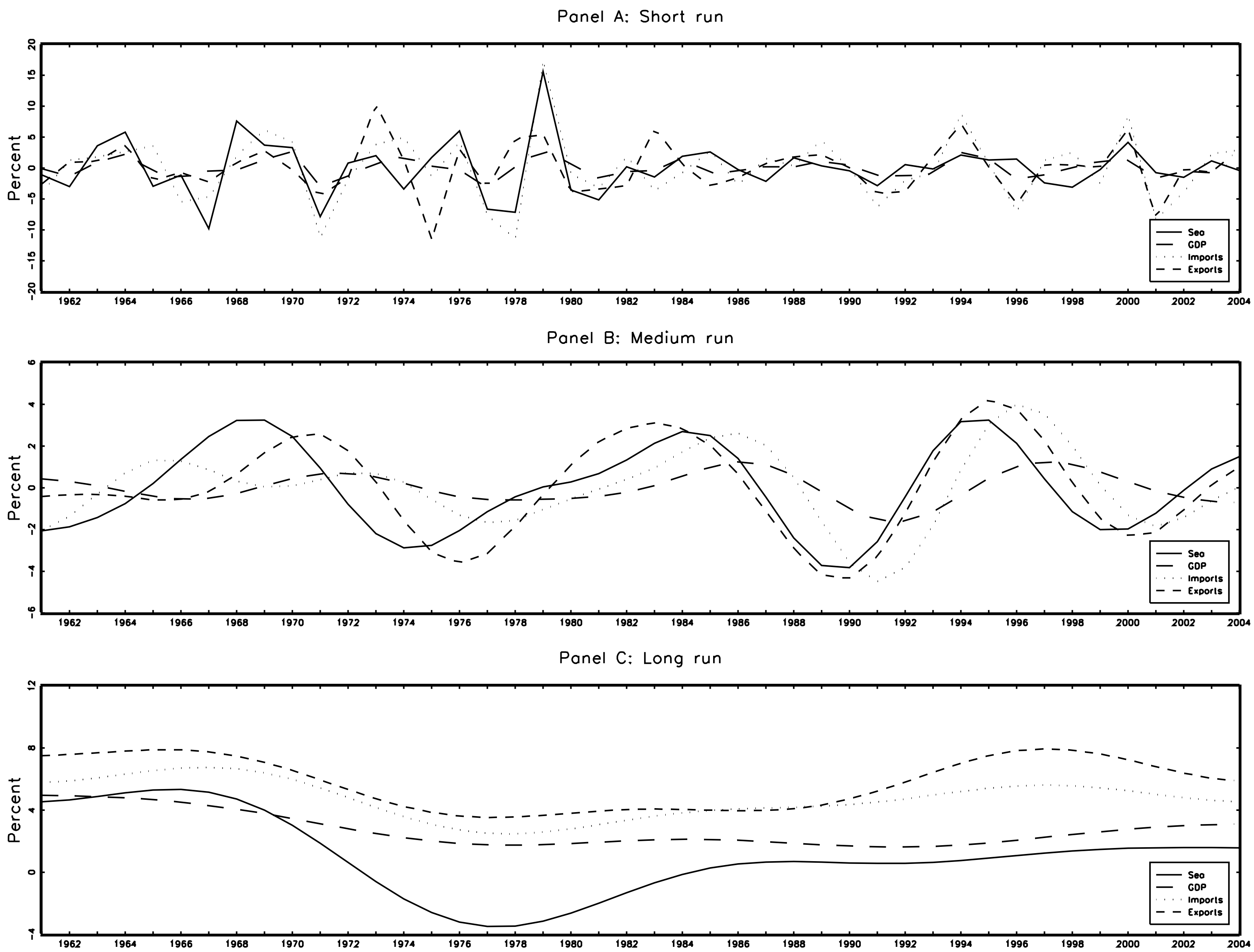
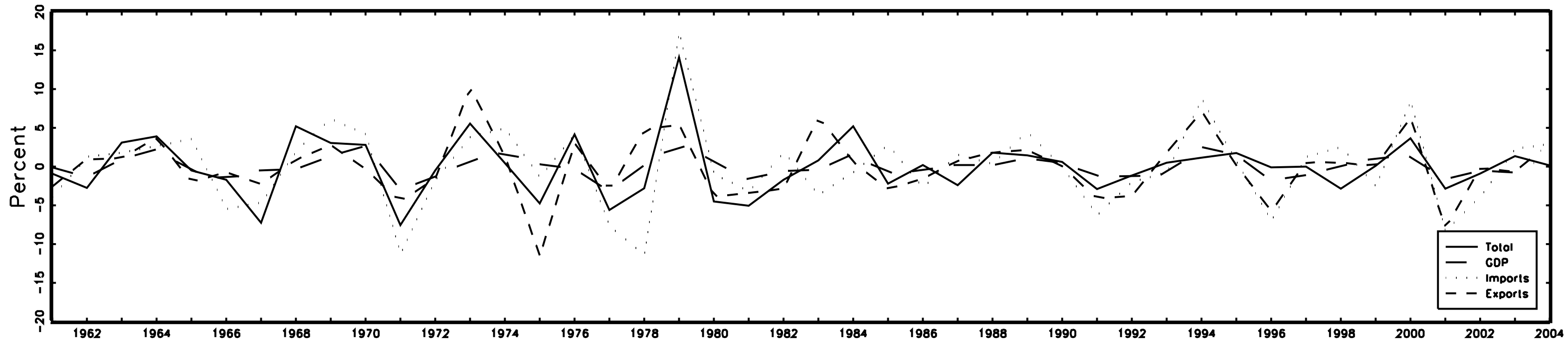
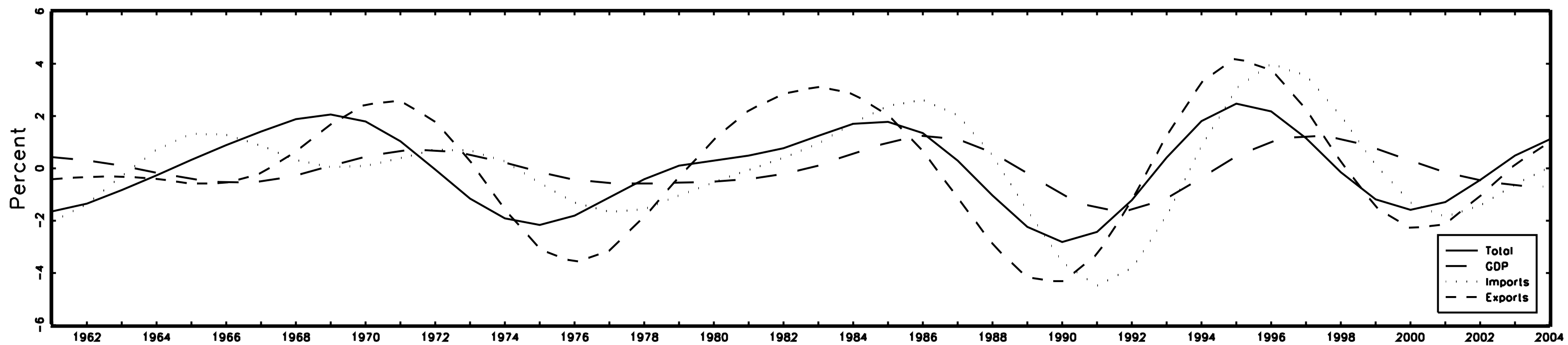


Figure 6. Total Tonne-kilometres

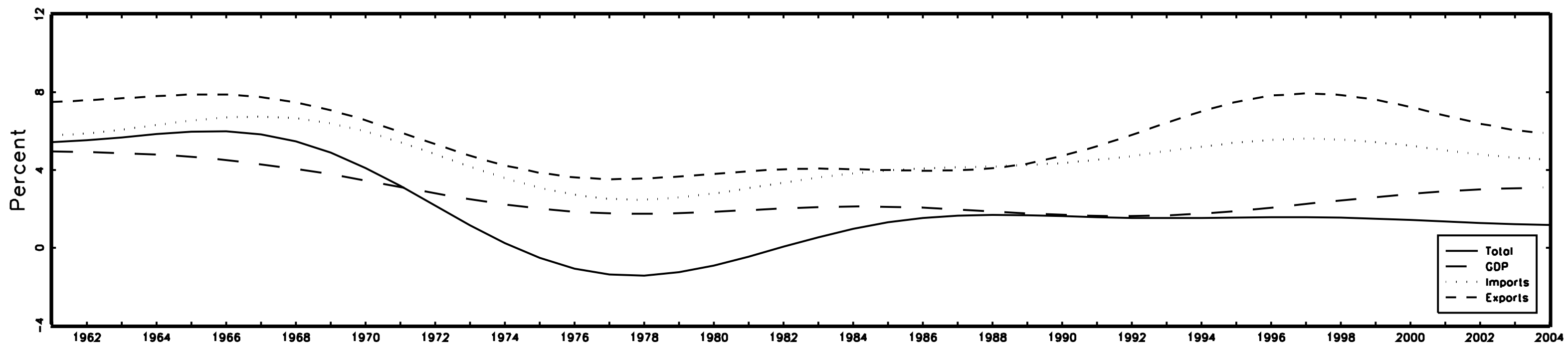
Panel A: Short run



Panel B: Medium run



Panel C: Long run



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