The Relationship between Economic Activity and Telecommunications Service Expenditure

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Abstract:

In this paper, we investigate the co-movements of the real GDP cycle and the telecommunications service expenditure cycle over 1980 through 2000 in Korea. We used several appropriate statistical tools to characterize and to compare the co-movements between the two aforementioned variables. The statistics presented in this paper are common, easy to interpret and capture important visual, descriptive information and the dynamics of data that would be lost if one focused only on the unconditional correlation coefficients of de-trended data.

This paper examines four possible characteristics for the co-movements of real GDP and telecommunications service expenditure in Korea. The first is that in low frequency, the cyclical movements in telecommunications service expenditure are very similar to the cyclical movements in real GDP. The second is that in the high frequency, the estimated stationary cyclical telecommunications service expenditure is not closely related to the estimated stationary cyclical real GDP. Third, according to co-spectra analysis, the strong relationships between the variables are found in the mid-term frequency and as such this empirical finding has important implications for telecommunications policy and telecommunications service implementation strategies. Finally, in the short-term period, our empirical

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results support telecommunications network theories such as path dependence properties, lock-in, positive feedback externality, and network externality.

Keywords: Difference filtering; State Space Model; Kalman Filtering; H-P Filtering; Co-spectra Analysis Path Dependence, Network Externality
JEL Classification: C23; E1.

I. Introduction

This paper is to examine the relationship between economic activities and telecommunications service expenditure fluctuations. Telecommunications service expenditure in advanced countries including Korea increased after 1980, and showed signs of rapid growth rates. However, the studies on the relationship between economic activity and telecommunications service expenditure are seldom found in the existing literature.

Common trends and common cycles appear in the macroeconomic studies as several empirical investigations. On the one hand, the literature on the modeling of macroeconomic data as either a trend stationary or a difference stationary process has received considerable attention since Nelson and Plosser (1982). In particular, Fleissig and Strauss (2001), Strauss (2000), Funk and Strauss (2000) have important implications for macroeconomic policy and modeling. On the other hand, some economists have long been puzzled by the real observations that macroeconomic data display recurrent, large fluctuations in GDP, industrial productions, and prices over relatively short periods of time. Some formal investigations have been initiated by Kydland and Prescott (1982, 1990), Clark (1987, 1989), Watson (1994), and Canova (1998)[1].

There are at least three interrelated directions, which are important and which collectively imply that our study issue is consistent with previous research objectives. First of all, direction is based on the concept of co-integration, which allows us to describe the existence of equilibrium, or stationary relationship among data. Secondly, study investigates the question of how large business cycle fluctuations are and how many business cycles are represented during various sample periods. Finally, some papers analyze the co-movement among aggregate data using different sets of statistics to characterize the relationships between variables. As Baxter and King (1999) have emphasized, almost all contemporary studies of the business cycle within these fields face two basic issues: First, how can the cyclical component of a given time series data be isolated? Secondly, how can simple correlation among variables over the sample periods be interpreted?

The idea of the paper is to develop a systematic manner in three attempts. First, we report the relationship between real GDP and telecommunications service expenditure fluctuations using a number of different de-trending methods. Second, we identify whether there exists a close correlation between the aforementioned two variables. Thirdly, we provide dynamic evidence and coherence between two variables and imply some telecommunications industry policy and market strategies, which may guide future research developments. The concepts of path dependence, lock-in, installed based customers, and network externalities play eminent roles of modeling in telecommunications economics literature (David,

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[1] Alternatively, Stock and Watson (1989) adopt the framework of the state space form and Kalman filter in which to construct an optimal estimate of an unobserved component.

2000, Shapiro and Varian, 1999)[2]. Since Katz and Shapiro (1986) studied the dynamics of network industry evolution with network externality, there have shown how network externality in the telecommunications industry can influence fundamental effects on the industry evolution at the level of theoretical pure theory. There are, however, few empirical evidences for those concepts on empirical levels.

Any empirical investigation of these kinds of connection study between country level data and industry level data involves the complicate and delicate issue of detrending. Within the empirical business cycle literature, there are several pre-filtering procedures by which the results may have been distorted. In this paper, we examine whether telecommunications service expenditure fluctuation can explain real GDP fluctuation. To analyze the relationship between two variables, we use three different filtering methods: First Difference Filtering, Kalman Filtering with state space model (Unobserved Component Method), and Hodrick-Prescott Filtering (H-P Filtering). As following Hoderick and Prescott (1997), we want to investigate the data from a number of different perspectives. Finally, our analysis investigates the dynamic information on the relationship between two variables by using co-spectra analysis in the frequency domain. For our study, we used the ITU data set and another data set from the Bank of Korea over the 1980-2000 time periods.

In contrast to most previous research, our analysis is based on the following methodologies. First, we try to examine the relationship between real GDP and telecommunications service expenditure by using formal econometric tools. Second, we study the dynamic relationship between the two aforementioned variables based on co-spectra analysis to predict the relationship for the future. Finally, to overcome the sensitive results from each different filtering, we design our empirical analysis adopting three generally used methods.

This paper contains three types of results. The first is that in low frequency, the cyclical movements in telecommunications service expenditure are very similar to the cyclical movements in real GDP. The second is that in the short run, the estimated stationary cyclical telecommunications service expenditure is not closely related to the estimated stationary cyclical real GDP. Finally, according to co-spectra analysis the strongest relationship between our two variables is found in the mid-term frequency and this empirical finding has important implications for telecommunications policy and telecommunications service introduction strategies.

The outline of this paper is as follows. First, we will explore analysis methodologies in Section **II**. We stress in particular, the important papers by Hodrick and Prescott (1997), Pakko (2000), and Kim and Nelson (1999). The data and empirical results are described in Section **III**. Section **IV** presents a brief study conclusion and implications for our study.

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2 See Laffont and Tirole (2000) for an extensive review of the competition in telecommunications under network externality.

II. Analysis Methodologies[3]

Significant literature has emerged since the Hodrick and Prescott's (1980) seminal work on the behavior of macroeconomic variables over the various business cycles. The co-movements among economic variables motivating recent specifications of the business cycle models may have been distorted by pre-filtering procedures. Moreover, it is now clear that different statistical representations for the trend embedded different economic concepts of business cycle fluctuations and of choosing one de-trending method over another implies selecting one particular economic object over another. See Canova (1998).

We apply the first difference filtering, Kalman filtering with state space, and Hoderick and Prescott filtering to analyze the relationship properties of the two variables in our data set. This section, therefore, reviews the procedures we use to extract trends from the observable time series.

1. First Difference Method

The basic assumptions of a first order differencing procedure are that the trend component is random work with no drift, the cyclical component is stationary. The two components also are uncorrelated each other. In addition, it is assumed that n_t has a unit root, which is exclusively due to the secular components of the data. Therefore, y_t is represented by:

$$y_t = n_t + x_t + e_t \tag{1}$$

If we assume the trend is followed by previous real data, the cyclical part will be the first difference between present and the previous year. Thus,

$$n_t = y_{t-1} \tag{2}$$

$$x_t = y_t - y_{t-1} \tag{3}$$

2. State Space Model with Kalman Filtering (Kim et al. 1999)[4]

A typical application of the unobserved economic time series model can be decomposed into two components: trend and cycle. The key identifying assumptions of this procedure are that the trend component follows a random walk and that the cyclical component is a stationary finite order AR process. If we simply express these points, the measurement equation is given by:

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[3] For more details, refer to original papers.

[4] To extend the general liner model introduced in this section to state space models with Markov switching, see Kim and Yoo (1995) as a successful empirical application for deriving New Coincident Index.

$$y_t = n_t + x_t \tag{4}$$

The transition equations also are given by:

$$n_t = g_{t-1} + n_{t-1} + v_t, \quad v_t \sim i.i.d.N(0, \sigma_v^2) \tag{5}$$

$$g_t = g_{t-1} + w_t, \quad w_t \sim i.i.d.N(0, \sigma_w^2) \tag{6}$$

$$x_t = \phi_1 x_{t-1} + \phi_2 x_{t-2} + e_t, \quad e_t \sim i.i.d.N(0, \sigma_e^2) \tag{7}$$

These parameters are typically estimated using prediction error decomposition of the likelihood and a smoothing algorithm, which revises recursive estimates[5]. Given the estimates of the parameters with zero mean and a diagonal covariance matrix, recursive estimates of the state vectors are obtained with the Kalman Filter[6].

3. H-P Filtering (Hodrick et al. 1997)

The H-P filtering optimally extracts a trend that is stochastic but that moves smoothly over time and is uncorrelated with the cyclical component. The selection mechanism that economic theory imposes on the data via the H-P filter can be justified using the statistical literature on curve fitting. Therefore, the assumption that the trend is smooth is imposed by assuming that the sum of squares of the second differences of x_t is small thus,

$$y_t = n_t + x_t \tag{8}$$

The basic idea behind H-P Filtering is that the smoothness of the $\{n_t\}$ path, which results from the sum of the squares of its second difference.

$$\min_{\{x_t\}_{t=-1}^{T}} \{\sum_{t=1}^{T} x_t^2 + \lambda \sum_{t=1}^{T} [(n_t - n_{t-1}) - (n_{t-1} - n_{t-2})]^2\} \tag{9}$$

These ideas lead to the dynamic programming problem for determining growth components. The parameter λ_t also is defined as a positive number, which penalizes variability in the trend component

[5] For more comprehensive surveys and technical investigations in this area, see Hamilton (1994 a, 1994 b).
[6] Kalman filtering method can be better approximated with more observations to estimate initial parameters in the system, thus leaving fewer for analysis.

series. In our study, we set λ_t equal to 100[7].

4. Relationship Analysis in Frequency Domain (Pakko, 2000)

Our major objective in this paper is to present additional and necessary information about the dynamic relationship between the real GDP and telecommunications service expenditure in Korea by investigating the relationship in the frequency domain. The co-spectra of the two variables for sample periods are estimated to decompose the correlation into frequency components. The purpose of this decomposition is to investigate whether the differences in real GDP and telecommunications service expenditure correlations across sample periods reflect shifts in the relative importance of the various frequencies embedded within the correlation or whether they reflect more fundamental changes in the entire spectral relationship.

In this paper we accommodate the advantages of co-spectra analysis in frequency domain in the following ways. First, we can uncover important information about the dynamic relationship between economic activities and telecommunications service expenditure under the frequency domain. The most important reason is the benefit of applying spectral methods to our analysis of the co-movement among different economic time series. This method allows us to decompose statistics into constituent frequency components proving a richer representation of dynamic interactions to consider. Finally, we can predict two variable co-movements in the long run period.

The Co-spectra analysis derives from the spectral representation theorem, which states that any real valued, covariance stationary process can be represented as the weighted sum of orthogonal periodic components, namely:

$$y_t = \int_{-\pi}^{\pi} [\alpha(\varpi)\cos(\varpi t) + \beta(\varpi)\sin(\varpi t)]d\varpi \qquad (10)$$

Next, we formulate population Spectrum of a vector of a time series Fourier sum like this:

$$s(\varpi) = \frac{1}{2\pi}\sum_{k=-\infty}^{\infty}\Gamma_k^{-i\varpi k} \qquad (11)$$

where Γ_k is k-th other auto-covariance matrix of the vector time series. The auto-covariance matrix will recover Fourier Integral.

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7 Baxter and King (1999) point out two problems in using H-P filtering: (i) unusual behavior of cyclical components near the end of the sample. (ii) The choice of the smoothing parameter for data sampled at other than the quarterly frequency.

$$\Gamma_k = \int_{-\pi}^{\pi} e^{i\omega k} s(\omega) d\omega \tag{12}$$

where initial Γ_0 is defined by this:

$$\Gamma_0 = \int_{-\pi}^{\pi} s(\omega) d\omega \tag{13}$$

Finally we estimate spectra and co-spectra of a vector of time series through real data like this:

$$\hat{s}(\omega) = \frac{1}{2\pi} \sum_{k=-(T-1)}^{(T-1)} w(k) \hat{\Gamma}_k e^{i\omega k} \tag{14}$$

$$w(k) = \{ \begin{matrix} [1+\cos(\pi k/h]/2 & for \quad |k| \leq h \\ 0 & otherwise \end{matrix} \tag{15}$$

For a relevant kernal method, we use Blackman-Tukey and determine h as this:

$$h = 2\sqrt{T} \tag{16}$$

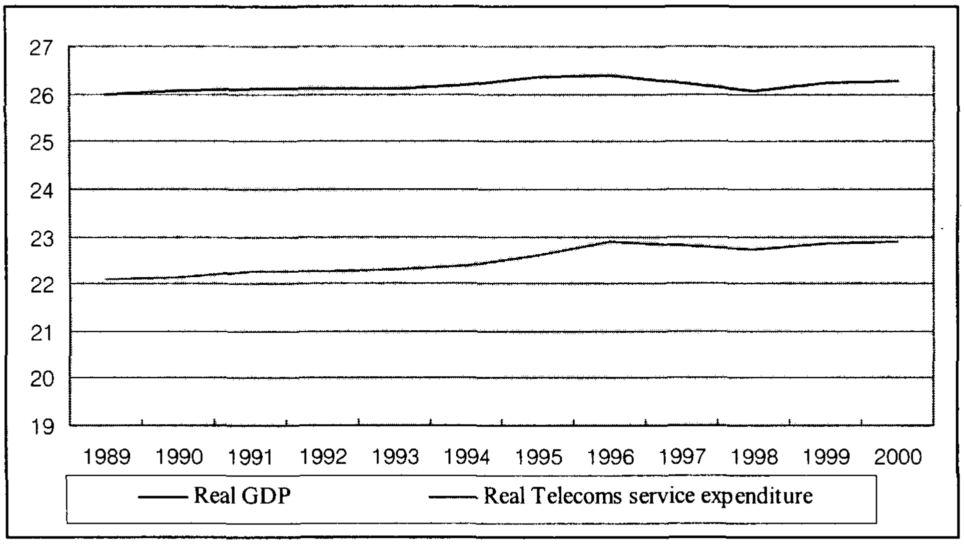
where T indicates sample size in our data set.

We follow the above empirical approaches to analyzing the relationship between economic activity and telecommunications service expenditure based on availability of data.

III. The Cyclical Behavior between Real GDP and Telecommunications Service Expenditure in Korea

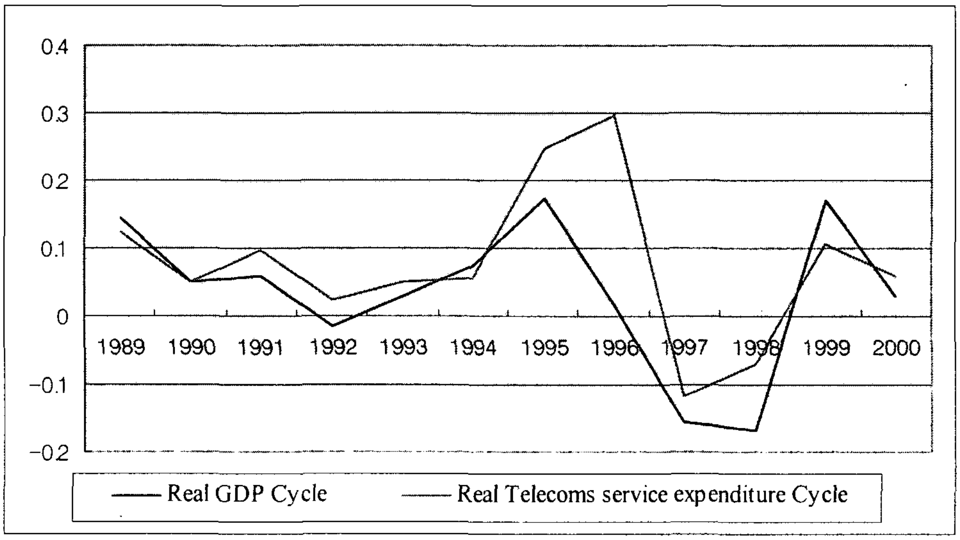
In this section, the previous empirical tools are now applied to the data. The data used are from the ITU data set and download directly from Bank of Korea. The annual real per capita GDP and real telecommunications service expenditure are taken from the year of 1980 through 2000. All variables are expressed in logs.

As shown in (Figure 1), real GDP and Telecommunications service expenditure trended fairly steadily upward during our sample period. The visual pairwise correlations are obviously fairly high, so it may be difficult to disentangle the relative co-movement of the two variable cyclical behaviors.



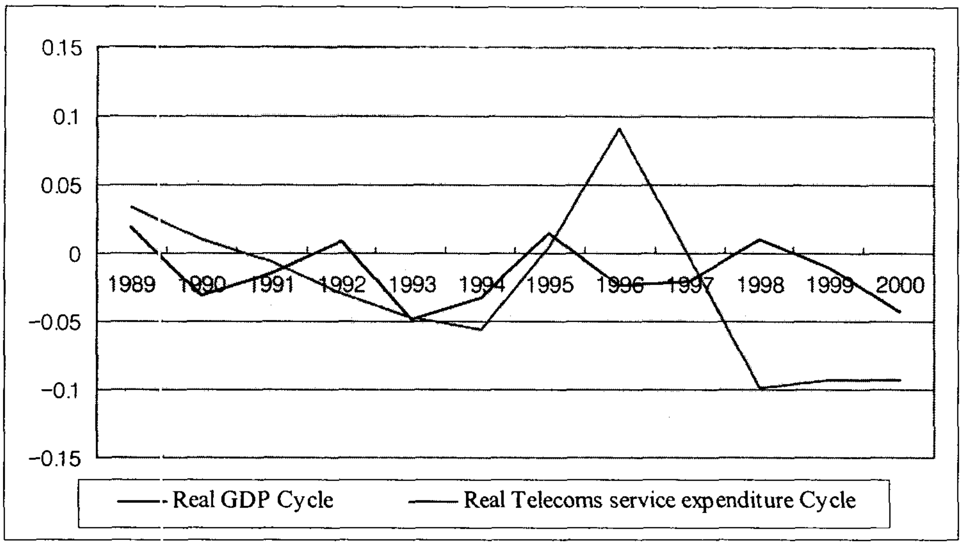
(Figure 1) The Co-movements of real GDP and real telecommunications service expenditure

We initially estimate the data using first difference filtering to investigate the relationship between real GDP and telecommunications service expenditures. The results in (Figure 2) provide some visual evidence concerning the time series properties of our two economic variable co-movements.



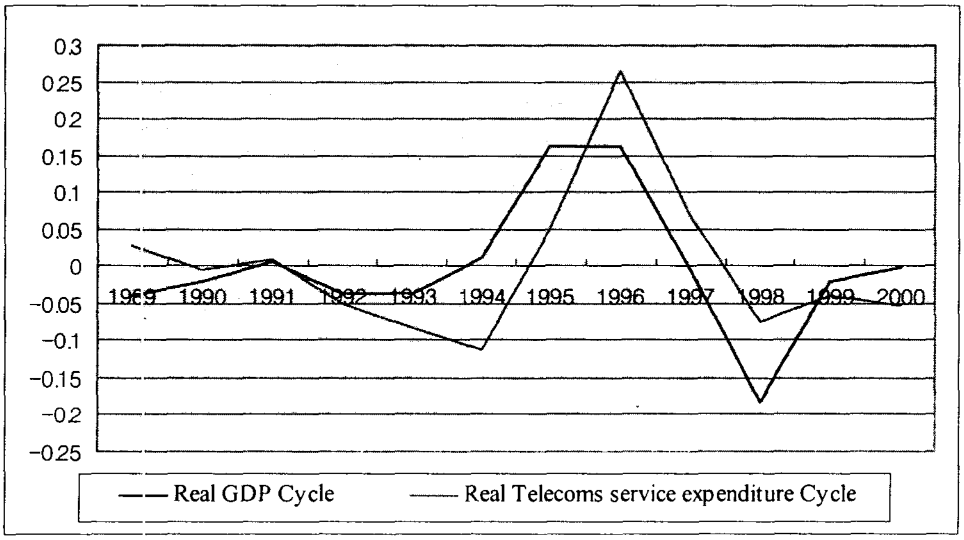
(Figure 2) Real GDP business cycle and telecommunications expenditure business cycle with first difference filtering

Next, we use the State Space Model with Kalman Filtering for the cyclical relationship between two variables and present the results in (Figure 3)[8].



(Figure 3) Real GDP business cycle and telecommunications business cycle with State Space Model with Kalman filtering

Finally, we use H-P filtering for the cyclical relationship between two variables and present the results in (Figure 4).



(Figure 4) Real GDP business cycle and telecommunications business cycle with H-P filtering

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8 In estimating the State Space Model with Kalman Filtering, we set 1980 to 1989 as initial starting value to get parameter vectors.

First difference filtering, Kalman filtering, and H-P filtering results shown in (Figure 2) through (Figure 4) demonstrate that first, there is some sensitivity among filtering methods. Second, by compared to the real GDP cycle, our country experienced high altitude of telecommunications service expenditure cycle for our sample periods. Thirdly, we can see the similar patterns of three different filtering methods with different cycle durations

For final further stage of study, we show the basic statistic results on the real GDP cycle and telecommunications service expenditure cycle in (Table 1)

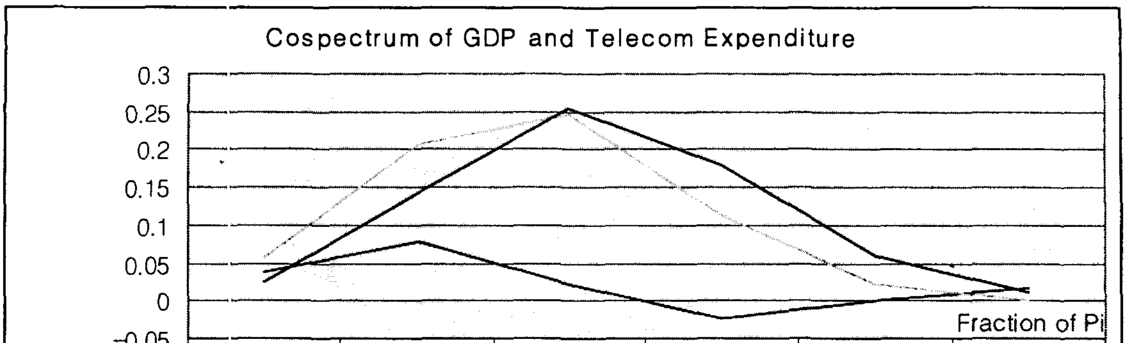
(Table 1) Basic statistics for the real GDP cycle and the telecommunications service Expenditure cycle

	First Difference	Kalman Filtering	H-P Filtering
Average of GDP Cycle Part	0.0345	-0.00142	0.00
Average of Telecom Cycle Part	0.0769	-0.0238	0.00
Maximum of GDP Cycle Part	0.1747	0.0019	0.1637
Maximum of Telecom Cycle Part	0.2968	0.0908	0.2652
Minimum of GDP Cycle Part	-0.1668	-0.0048	-0.1821
Minimum of Telecom Cycle Part	-0.1185	-0.0989	-0.1129
Coefficient of correlation	0.7058	0.13805	0.6786

(Table 1) presents seven dates for three different filtering methods. As expected, there are positive correlations between real GDP fluctuations and telecommunications service expenditure fluctuations regardless of which filtering methods we used. However, the differences are largest between Kalman Filtering and first difference filtering.

Finally, this paper examines coherence or co-spectra analysis for analyzing deep co-movements between two variables and comparing the three filtering methods[9]. We present the results in (Figure 5).

[9] There is conceptual difference between coherence and co-spectra. For more details, refer to Pakko (2000)



	0.08	0.25	0.42	0.58	0.75	0.92
Kalman	0.037661	0.078619	0.022052	-0.024343	-0.000067	0.017914
H-P	0.057806	0.206392	0.24595	0.113355	0.023293	0.001285
Diff	0.024497	0.143487	0.254082	0.179749	0.059791	0.012401

(Figure 5) Co-spectra analysis applying first difference, State Space model with Kalman filtering and H-P filtering

(Figure 5) shows the co-spectra of real GDP and telecommunications service expenditure for the sample periods. (Figure 5) is easy to interpret and capture important information about the dynamics of the data that would be lost if one focused only on the unconditional correlation coefficient of de-trended data. The benefit of Co-spectra analysis also allows us to decompose the simple statistics like those in (Table 1) into constituent frequency components.

The analysis of empirical Co-spectra in (Figure 5) indicates some important points. First, the co-movement between real GDP and telecommunications service expenditure is positive in the long and mid-run, but shows virtually no relationship in the short-run. If we carefully describe the results of co-spectra analysis, we can find the same general features and the particular differences among the filtering methods. Similarly very high frequencies contribute relatively little to the overall covariance between real GDP and telecommunications service expenditures under three different filtering methods. Generally taking the range of business cycle frequencies to encompass periodicities of between 0.08π and 0.33π, the three filtering methods show positive cyclical correlations and first difference filtering boots the importance of high-frequency moments in the log-run period under our study. However, the different facts are that co-spectra of first difference and H-P filtering shows the positive covariance in mid-range but that of Kalman filtering shows the negative covariance between the two variables.

Second, our result of Co-spectra analysis is similar to previous results (i.e. Pakko 2000). Within the range of frequencies, the first difference filtering generates the co-spectrum pictures that have the same patterns as the H-P filtering.

Finally, we can infer implications for telecommunications economic theory. As seen in (Figure 5), co-spectra analysis gives us a dynamic relationship between economic activities and telecommunication service activities. These results suggest that telecommunications carriers or policy makers are greatly concerned about successful telecommunications service implementation plans for mid-run periods. For only short-run periods, our results support telecommunications economic theories such as lock-in, positive feedback externality, and network externality.

IV. Conclusion

The basic goal of this paper was to examine the cyclic relationship between economic activities and telecommunications service expenditure under recent econometric methods. The results indicate that first, our results support a stable long-run co-movement relationship between real economic activity and telecommunications service expenditure, even though there are some differences among filtering methods The data demonstrates that there is a positive correlation between the two cyclical variables. Secondly, for the co-spectra analysis, we find a strong long-run co-movement between the two cyclical variables but do not find any relationship between the two cyclical variables in short-run period. Third, since the amplitude of co-spectra analysis is high in the mid-range period, we conclude that the real economic activity to telecommunications service expenditure link is less conclusive from our empirical study. We, therefore, predict little current or short run telecommunications service expenditure fluctuations resulting from real current economic activity fluctuations. Furthermore, as expected, the results indicate that there will be a steady increase in telecommunications service expenditure even in our current economy recession. Finally, our empirical evidence supports lock-in and positive network externality hypothesis in telecommunications network economics. In other words, telecommunications service expenditure will follow its own time dependent paths even with exogenous shocks in the short–run period.

To conclude, our study implies the following two major implications for related works. With a large data set, there is a potential advantage that the longer period data may reduce several erroneous results. For the filtering selection problem, on the other hand, researcher should be cautious and not impose strong properties of the data based on solely on one filtering method.

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