A dynamic factor model of the coincident indicators for the US transportation sector

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Abstract

This paper studies the business cycle features of the transportation sector using dynamic factor models. The transportation reference cycles peak ahead of the economic cycles, but lag by a few months at troughs. The asymmetric relationship between these two suggests the usefulness of transportation in monitoring business cycles.

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1. INTRODUCTION

Transportation, being an important service-providing sector, represents a significant part of the U.S. economy. More importantly, transportation plays a vital role in facilitating economic activity between sectors and across regions. Ghosh and Wolf (1997), in examining the importance of geographical and sectoral shocks in the U.S. business cycles, find that transport is one of sectors highly correlated with intra-state and intra-sector shocks, and is thus crucial in the propagation of business cycles. Interestingly, a number of transportation indicators were included as part of the twenty-one cyclical indicators in the original NBER lists by Mitchell and Burns (1938) and Moore (1961, pp. 184-261). Further efforts to study the role of transportation in monitoring modern business cycles were hindered largely due to the discontinuation of many transportation indicators such as freight carloadings in the 1950s and the 1960s. For more information on the history of cyclical indicators, see the NBER Macrohistory database available online (Feenberg and Miron, 1997).

Lahiri and Yao (2004) have explored the macroeconomic forecasting potential of a monthly experimental index measuring the aggregate output of the transportation sector developed in Lahiri *et al.* (2003). This transportation services index (TSI), now being produced by U.S. Department of Transportation, utilizes eight series on freight and passenger movements from airlines, rail, waterborne, trucking, transit and pipelines (NAICS codes 481-486) covering around 90% of total for-hire transportation during 1980-2000. TSI is a chained Fisher-ideal index, and is methodologically similar to the Industrial Production (IP) index, which is one of the four coincident indicators for the aggregate economy.[1] Following the conventional economic indicator analysis (Zarnowitz, 1992), we can use TSI together with other coincident indicators from transportation to study the business cycles characteristics of this sector, and its relationship to the aggregate economy. This paper applies dynamic factor models with regime switching

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[1] Gordon (1992) and Bosworth (2001) have provided valuable insights into the different methodologies and data that BEA and BLS use to construct alternative annual transportation output series. A comparison suggests that these annual output measures reflect the long-term trends of TSI, and that the latter is superior in reflecting the cyclical movements in the transportation sector.

(Kim and Nelson, 1998) and without regime switching (Stock and Watson, 1991) to estimate the composite coincident index (CCI) for the transportation sector.

2. THE MODEL AND ESTIMATES

Given a set of coincident indicators Y_{it}, their growth rates can be explained by an unobserved common factor ΔC_t, interpreted as growth in CCI, and some idiosyncratic dynamics. This defines the measurement equation for each component:

$$\Delta Y_{it} = \gamma_i \Delta C_t + e_{it}, \tag{1}$$

where ΔY_{it} is logged first difference in Y_{it}. In the state-space representation, ΔC_t itself is to be estimated. In the transition equations, both the index ΔC_t and e_{it} are processes with AR representations driven by noise terms w_t and ε_{it} respectively:

$$\Phi(L)\ (\Delta C_t - \mu_{st} - \delta) = w_t, \tag{2}$$

$$\Psi(L)\ e_{it} = \varepsilon_{it}. \tag{3}$$

These two noise terms are assumed to be independent of each other. The transitions of different regimes (μ_{st}), incorporated in (2), are governed by a Markov process:

$$\mu_{st} = \mu_0 + \mu_1 S_t,\ S_t = \{0, 1\},\ \mu_1 > 0, \tag{4}$$

$$Prob\ (S_t = 1 \mid S_{t-1} = 1) = p,\ Prob\ (S_t = 0 \mid S_{t-1} = 0) = q. \tag{5}$$

Equations (1) ~ (3) define the dynamic factor model while (4) ~ (5) add a nonlinear regime switching feature to it. Following the NBER tradition and Layton and Moore (1989), we use four conventional coincident indicators to define the current state of U.S. transportation sector. They are: TSI (Y_{1t}) as defined earlier, real aggregate payrolls of transportation workers (Y_{2t}), real personal consumption expenditure on transportation services (Y_{3t}), and total employment (Y_{4t}) in this sector. These indicators, plotted in Figure 1, reflect information on output, income, sales, and labor usage in the transportation sector.

For the sake of comparison, we first constructed a coincident index for the transportation sector using the model-free NBER approach, see Conference Board (2001).[2] Using the index of concordance proposed by Harding and Pagan (2002), we

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[2] This nonparametric approach includes four steps: 1) month-to-month changes (x_t) are computed for each component (X_t) using the conventional formula; 2) the month-to-month changes are adjusted to equalize the volatility of each component using the standardization factors; 3) the level of the index is computed using

found that the specific cycles of each series are highly synchronized (all values were in excess of 0.60) with the transportation reference cycle based on the NBER index. To implement the Kim-Nelson model, we used priors from the estimated Stock-Watson model. Priors for regime switching parameters were obtained from information provided by the NBER index. Both models were estimated using computer routines described in Kim and Nelson (1998). Unlike the Stock-Watson (1989) model specification for the aggregate economy, personal consumption expenditure and employment in transportation appear to be somewhat lagging to the current state of transportation.

The final specification and parameter estimates from Stock-Watson and Kim-Nelson models are reported in Table 1. The two sets of estimates are close except that the sum of the AR coefficients for the state variable in the Stock-Watson model is significantly higher, implying more state dependence in the resulting index. This difference is complemented by a much larger role that employment plays in the Kim-Nelson model. The latter model also distinguishes between two clear-cut regimes of positive and negative growth rates. The estimated transportation CCIs from these two models are plotted against the NBER index in Figure 2. Compared to the Kim-Nelson index, the Stock-Watson index agrees more closely with the NBER index throughout the period. Despite differences in their model formulations and in minor details, their cyclical movements appear to be very similar to one another and synchronized well with the NBER-defined recessions for the economy (the shaded areas).

3. RELATION WITH BUSINESS CYCLES

NBER dating algorithm described in Bry and Boschan (1971) is employed to identify the turning points for four coincident indicators and the NBER index. The NBER procedure to define recessions for U.S. economy involves visually identifying clusters of turning points of all series and minimizing the distance between the turning points in each cluster (Layton and Moore, 1989). Following these standard steps, we define the chronology of cycles in the U.S. transportation sector since January 1979 that includes four major recessions: 1979:03 ~ 1980:08, 1981:01 ~ 1983:02, 1990:05 ~ 1991:06, and 2000:11 ~

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the symmetric percent change formula; and 4) the index is re-based to be 100 in 1996 to make a formal NBER index.

2001:12. These periods are compared against the NBER-defined recessions of the aggregate economy in Table 2. Overall, there is a one-to-one correspondence between cycles of the transportation sector and those of the overall economy. However, the relationship between transportation and the economy is asymmetric at peaks and troughs.[3] Specifically, the transportation sector peaked ahead of the economy by almost 6 months on the average, while at troughs it lagged by two months. In other words, recessions in the transportation sector lasted longer that the economy-wide recessions by almost 8 months. Thus, the cycles of this sector can potentially be used to confirm the NBER dating of U.S. recessions.

The above analysis is based on the nonparametric procedure practiced by the NBER Dating Committee. Alternatively, reference cycles can be defined from the probability of recessions implied by the regime-switching model of Kim and Nelson (1998). Figure 3 depicts the posterior probability that transportation sector is in a recession as inferred from the Kim-Nelson model estimation. The darker shaded areas represent the NBER-defined recessions for the U.S. economy, while the lightly shaded areas represent recessions in the U.S. transportation sector as defined in Table 2. If we define the transportation recessions parametrically by taking the first month that the probability begins to rise (drop) as the trough (peak), the resultant chronology would be very similar to shaded areas representing transportation recessions defined earlier. The probabilities in Figure 3 show that, corresponding to each of the four economy-wide recessions defined by NBER, there is a recession in the transportation sector. The Kim-Nelson recession probabilities also indicate that the transportation recessions are consistently longer in duration than the economy-wide recessions. Figure 3 suggests that the latest recession in the U.S. transportation sector ended in December 2001, which is just one month after the recently announced NBER trough of the economic recession that began in March 2001. Interestingly, the finding on the longer duration of transportation recessions is very similar to that in Moore (1961, pp. 48-51), who used only railway freight data for his conclusion.

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[3] Interestingly, a similar asymmetry also exists between inventory and business cycles, see Zarnowitz (1992, p. 336) and Humphreys *et al.* (2001).

4. CONCLUDING REMARKS

This paper reports certain business cycle features of the U.S. transportation sector using economic indicator analysis. Four coincident indicators are selected to measure labor inputs, production, income and spending in this sector. Then composite indexes of these coincident indicators are created using both the NBER non-parametric method and dynamic factor models. The resulting indexes are seen to be very similar. We find a close correspondence between the recessions in the transportation sector and those in the aggregate economy. However, duration of the transportation recessions is longer than that of economy-wide recessions by almost 8 months. Further research is needed to explain the asymmetric lead/lag relationship between the two reference cycles at peaks and troughs.

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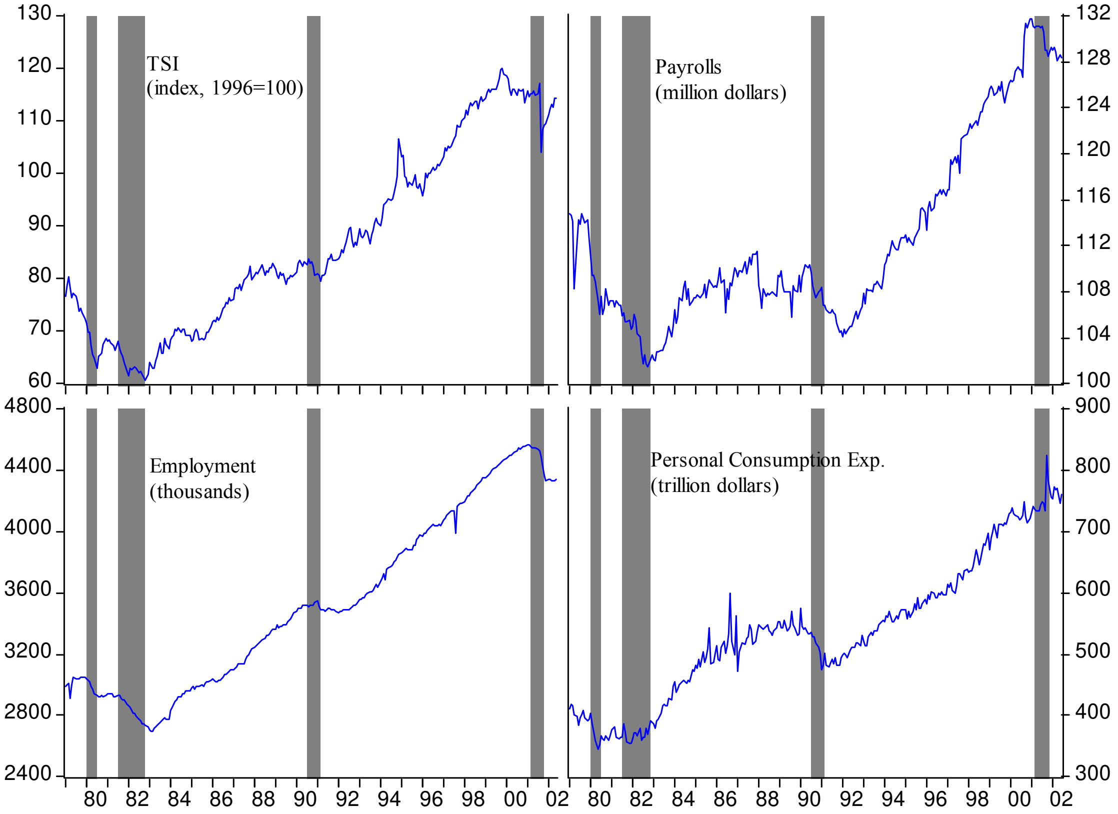
Figure 1

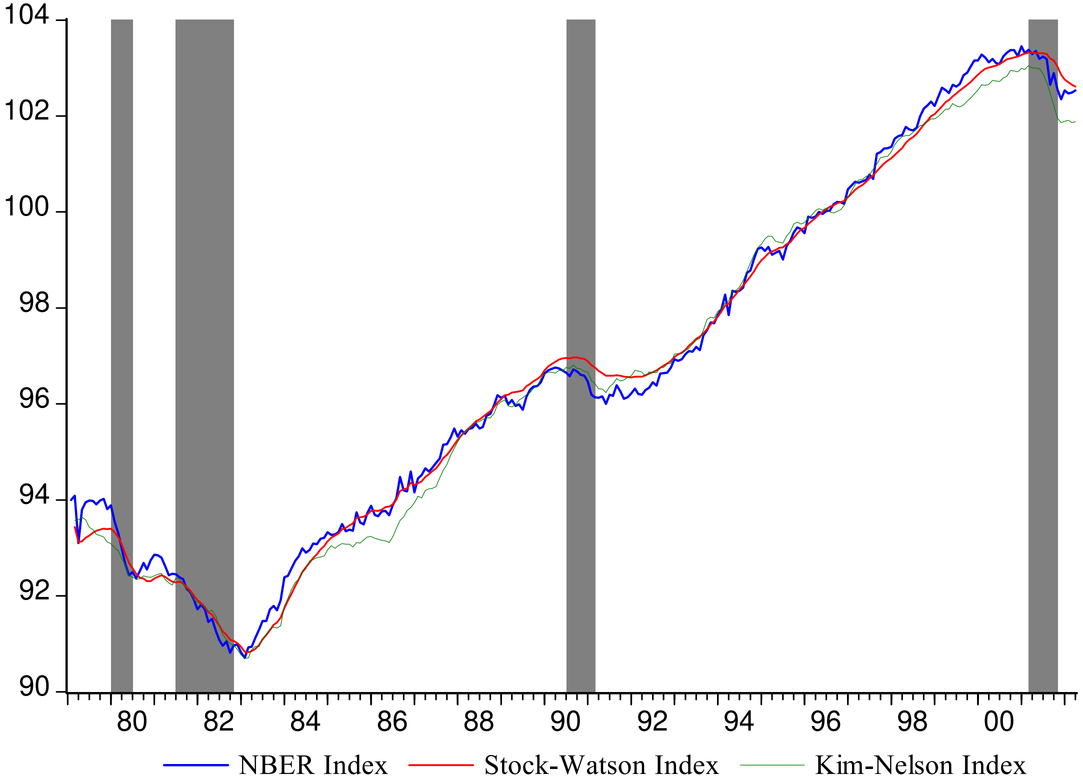
Coincident Indicators for the U.S. Transportation Sector



*Shaded areas represent NBER-defined recessions for the U.S. economy

Figure 2

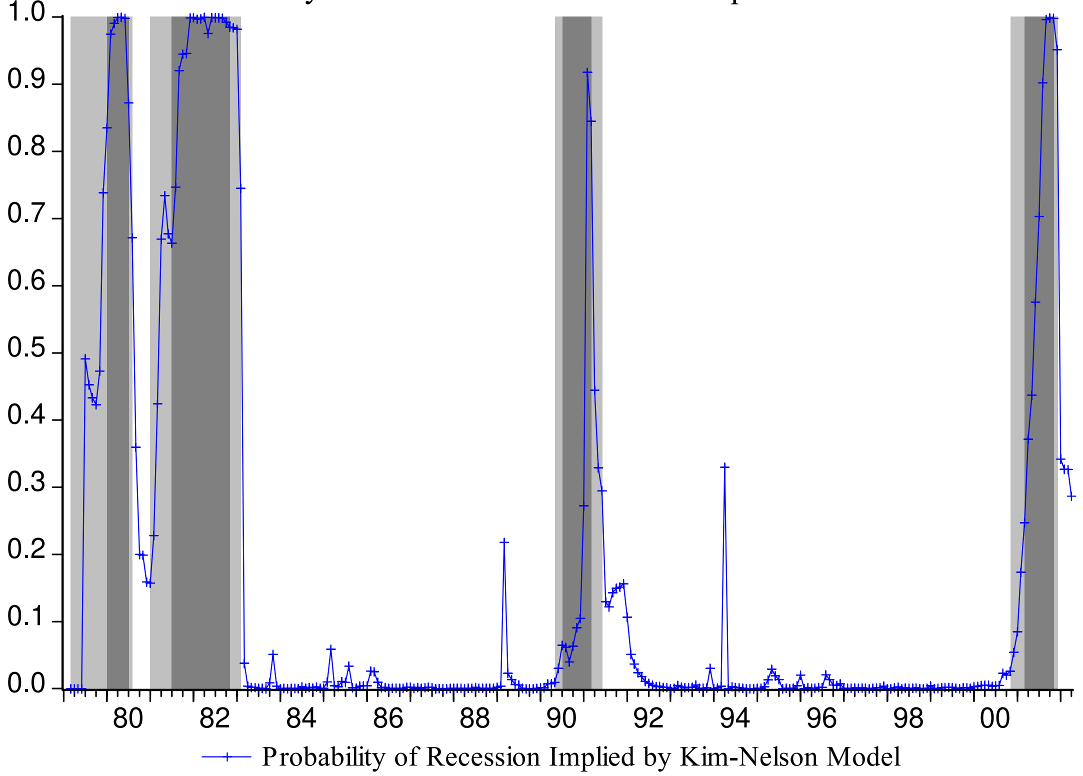
Coincident Indexes of the U.S. Transportation Sector



*Shaded areas represent NBER-defined recessions for the U.S. economy

Figure 3

Probability of Recession in the U.S. Transportation Sector



* Darker shaded areas represent NBER-defined recessions for the U.S. economy; lightly shaded areas represent recessions of the U.S. transportation sector.

Table 1 Estimates of the Transportation Coincident Index Models

Variables	Parameters	Stock-Watson Model		Kim-Nelson Model			
				Prior	Posterior		
		Estimate	s.e.		Mean	s.e.	Median
ΔC_t	Φ_1	0.775	0.167	0.775	0.127	0.119	0.114
(State Variable)	Φ_2	0.107	0.162	0.107	0.121	0.085	0.124
ΔY_{1t}	γ_1	0.171	0.057	0.1	0.136	0.028	0.136
(Output)	φ_{11}	-0.519	0.067	-0.2	-0.637	0.057	-0.638
	φ_{12}	-0.067	0.017	0	-0.401	0.057	-0.401
	σ_1^2	5.181	0.480	2	0.652	0.057	0.648
ΔY_{2t}	γ_2	0.148	0.048	0.1	0.173	0.042	0.172
(Payrolls)	φ_{21}	-0.162	0.077	-0.1	-0.216	0.061	-0.216
	σ_2^2	2.107	0.210	2	0.782	0.071	0.778
ΔY_{3t}	γ_3	1.485	0.631	1.5	0.059	0.060	0.059
(Personal	γ_{31}	-1.364	0.626	-1.4	-0.041	0.059	-0.039
Consumption	φ_{31}	-0.149	0.122	-0.1	-0.388	0.060	-0.388
Exp.)	σ_3^2	2.443	1.831	2	0.849	0.076	0.844
ΔY_{4t}	γ_4	0.110	0.021	0.1	0.548	0.081	0.557
(Employment)	φ_{41}	-0.006	0.357	-0.1	-0.025	0.084	-0.026
	σ_4^2	0.072	0.015	2	0.125	0.081	0.120
	P_{00}			0.967	0.926	0.066	0.945
	P_{11}			0.986	0.985	0.012	0.988
	μ_0			-0.869	-1.822	0.554	-1.727
	μ_1			0.745	2.208	0.580	2.110
	δ			-	0.356	0.038	0.359
	$\mu_0 + \mu_1$			-	0.385	0.132	0.385

Table 2 Comparisons of Two Reference Cycles

Transportation Business Cycles			Leads (-) and Lags (+), in months, of Transportation Business Cycles relative to NBER Business Cycles		
P	T	Duration	P	T	Duration
03/79	08/80	17	-10	+1	6
01/81	2/83	25	-6	+3	16
05/90	06/91	13	-2	+3	8
11/00	12/01	13	-4	+1	8
Mean		18	-6	+2	10
Median		17	-3	+3	8
Std Dev.		6	3	1	5