OECD Journal: Journal of Business Cycle Measurement and Analysis
Volume 2012/1

Should transportation output be included as part of the coincident indicators system?

by
Kajal Lahiri* and Wenxiong Yao

With the increasing importance of the service-providing sectors, information from these sectors has become essential to the understanding of contemporary business cycles. This paper explores the usefulness of the transportation services output index (TSI) as an additional coincident indicator in determining the peaks and troughs of US economy. The index represents a service sector that plays a central role in facilitating economic activities between sectors and across regions, and can be useful in monitoring the current state of the economy. We evaluate the marginal contribution of the TSI in identifying cyclical turning points in the context of four currently used NBER indicators. The TSI is found to have advantages over the composite index of coincident indicators in identifying turning points, and has been of critical importance in recent recessions.

JEL classification: E32, C10

Keywords: Transportation Services Index (TSI), business cycles, coincident indicators

* Corresponding author: Department of Economics, University at Albany-SUNY, Albany, NY 12222, klahiri@albany.edu. This paper received the Isaac Kerstenetzky Award (Honorable mention, Best paper in the World category) at the 29th CIRET Conference, Santiago, Chile 2008. We thank Anirvan Banerji, Antony Davies, Ullrich Heilemann, Gernot Nerb, Ataman Ozyildirim, Herman Stekler, Victor Zarnowitz, two anonymous referees and Editor-in-Chief Michael Graff for helpful comments. Yongchen Zhao provided able research assistance. The research reported in this paper was supported by grants from the Bureau of Transportation Statistics, US Department of Transportation. The contents of this paper however reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein.

1. Introduction

Modern economies have become increasingly more service-intensive in the post-war period. For instance, over 1953-2009 in the US, the share of goods in the GDP has declined from 54% to 33% compared to an increase in the share of services from 34% to 58%. Yet among the four coincident indicators that the National Bureau of Economic Research (NBER) uses to date business cycle turning points, none specifically represents the service-providing sectors (Layton and Moore, 1989). Indicators used by dating committees in Europe and elsewhere are largely the same.

Transportation-related sectors covering goods, services and structures had been of great interest to the early NBER scholars. Dixon (1924) studied the pervasive influence of transportation on all aspects of an economy, and even proposed that regulation of the railways be a part of stabilisation policies. More interestingly, a number of transportation indicators appeared prominently among the twenty-one cyclical indicators in the original NBER list proposed by Mitchell and Burns (1938) and Moore (1950).[1] Burns and Mitchell (1946, p. 373) and Hultgren (1948, 1955) found that cyclical movements in railways coincided with the prosperities and depressions of the economy at large. Moore (1961, Volume I, pp. 48-50), based on updated data through 1958, found that railway freight carloadings, while still being coincident at troughs, showed longer leads at peaks after the 1937-1938 recession. This observation, which Moore attributed to the declining trend of rail traffic, marked the failure of railway freight movements as a roughly coincident indicator of the aggregate economy. Further efforts to study the role of transportation in monitoring modern business cycles were hindered largely due to the discontinuation of many of the monthly transportation indicators in the 1950s.[2] Today, with increasing global competition, inventories and sales have become more integrated, and consequently transportation has become critical for efficient business operations.[3] However, this part of the service economy is largely ignored in business cycle studies.

Transportation represents a significant part of the US economy. Using different definitions of the scope of the transportation industry would yield different measures of its importance, varying anywhere from 3.09% (Transportation GDP) to 16.50% (Transportation-driven GDP), see Han and Fang (2000). 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 geographic and sector shocks in the US business cycles, find that transport (and/or motor vehicles) is one of the few sectors that is highly correlated with intra-state and intra-sector shocks, and is crucial in the propagation of business cycles. Thus, a measure of transportation activities can potentially be very useful in monitoring the current state of general economic activity.

In a project sponsored by US Bureau of Transportation Statistics (BTS), we have developed a monthly experimental index to measure the aggregate output of the transportation sector. This transportation services output index (TSI) utilises eight series on freight and passenger movements by 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, see Lahiri *et al.* (2004a, 2006) for details.[4] Lahiri and Yao (2004b) also find that the strong cyclical movements observed in the TSI appear to be well synchronised with the NBER-defined recessions and growth slowdowns of the US economy. TSI can give early signals to the onset of economic recessions while being contemporaneous to economic recoveries. Thus given its key role, TSI can be an additional coincident indicator in dating business cycle turning points in a timely fashion.[5]

The paper is organised into three sections. After the Introduction, Section 2 reviews the historical NBER chronology of US cycles since 1973 with the inclusion of transportation. Section 3, which contains the main methodological contribution of the paper, constructs various composite coincident indexes (CCI) with different combination of the four currently used coincident indicators and TSI. Three alternative methods are employed for this purpose: NBER non-parametric method, dynamic factor model (Stock and Watson 1989), and dynamic factor model with Markov regime switching (Kim and Nelson 1998). For each of these models, we use appropriate scoring methods to evaluate the relative performance of the five indicators in dating economic turning points. The last section summarises the main conclusions of the paper.

2. TSI and current four coincident indicators

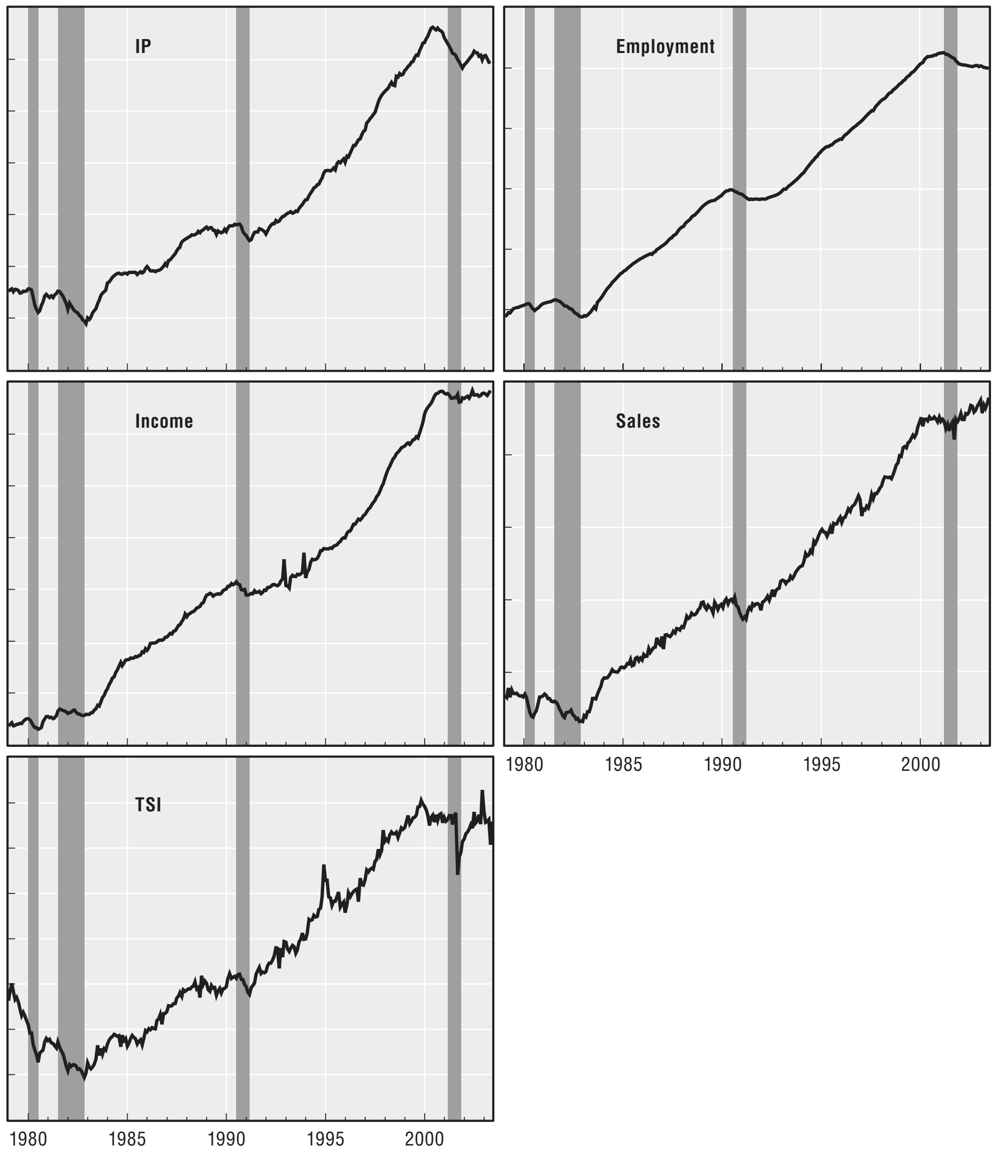
2.1. History of NBER coincident indicators

In 1938, Wesley Mitchell and Arthur Burns selected a set of twenty-one indicators from among several hundred time series under the NBER project. After the World War II, Geoffrey Moore took over the job and published a new list of indicators in 1950. They are classified into three groups: leading (8), roughly coincident (8) and lagging (5) indicators, according to six selection criteria, see Lahiri and Moore (1991). These indicators, like industrial production and inventory investment, typically cover those sectors and processes that are sensitive to market conditions (Zarnowitz, 1975; 1977; 1992). The coincident indicators are used to define the current state of the economy. Among the four currently used coincident indicators, all employees of nonfarm industries (EMP) and personal income less transfer payments (INC) are comprehensive indicators with broad coverage. The other two, industrial production (IP) and, manufacturing and trade sales (Sales) measure the performance of individual sectors, namely manufacturing and trade sectors.[6] Thus, none of the current four indicators represents the service sectors of the economy. The newly constructed TSI can be the fifth coincident indicator representing a service sector that has a pervasive connection with different sectors and regions of the economy. The seasonally adjusted data of these five indicators are depicted in Figure 1.[7] They all seem to be well synchronised with NBER recessions (shaded areas). But cycles in TSI, as with IP, are very deep and clear with two extra turns capturing the stand-alone slowdowns in 1984 and 1995. This suggests that transportation output is sensitive to changes in market conditions, and thus can serve as a quality indicator such as IP.

2.2. Spider charts for historical business and growth cycles

We examine the historic record of these five coincident indicators using the spider charts for six recessions and two cyclical slowdowns since 1973.[8] TSI is available from January 1979, but its value can be examined during the recession of 1973-75 using its largest component, the trucking tonnage index. To compare the timing of each indicator

Figure 1. **Proposed TSI and four current coincident indicators of US economy**



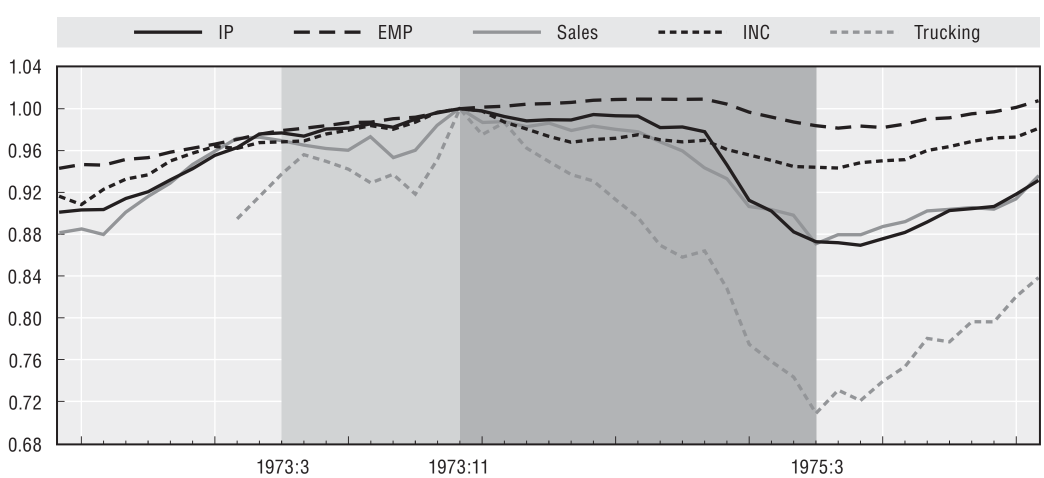
relative to NBER's chronology, the NBER dating algorithm described in Bry and Boschan (1971), namely the BB algorithm, is employed to identify the turning points via peak and trough dating. The NBER procedure for determining the reference cycle requires visually identifying clusters of turning points of all series and minimising the distance between the turning points in each cluster (Boehm and Moore, 1984).[9] In reality, many discretional considerations are involved. For instance, considerations in dating peaks could be different from those in dating troughs. This is because turning points in four current coincident indicators are more diverse at peaks than at troughs, which actually makes the decisions on peaks more difficult to make. Historically, NBER-defined peaks of the US economy coincided with the peaks of at least one of two broad indicators, EMP or INC, regardless of the other two. There was consensus among the four coincident indicators at all troughs except for the 2000 recession.

We have prepared eight spider charts, one for each of the six recessions and two growth slowdowns. They are plotted in Figures 2a through 2h, where the darker shaded areas represent NBER recessions and lightly shaded areas represent NBER-defined growth slowdowns preceding or following full-fledged recessions. See Zarnowitz (1992, Chapter 7) and Zarnowitz and Ozyildirim (2002) for discussions on growth cycles, and Gordon (1980), Zarnowitz (1992, Chapter 3), McNees (1992) and Temin (1998) for excellent commentaries on the chronology of American business cycles in historical perspective.

2.2.1. Recession of 1973:11-1975:3

The 1973-75 recession produced an unprecedented dip in economic activity in the post-war period. Many studies have discussed the characteristics and causes of this recession. There is no doubt that the cause of this cycle was the quadrupling of oil price by the Organization of the Petroleum Exporting Countries (OPEC). This oil shock was clearly evident at the time and has been the object of countless studies since then (Temin, 1998). McNees (1992) and Lahiri and Wang (1994) argued that after 1967, inflation continued to intensify and the economy was struck by an oil embargo and large increases in energy costs following the outbreak of the Yom Kippur War on 6 October 1973. However, many commentators at the time and later argued that the Federal Reserve System (Fed) was excessively aggressive in its attempt to limit the resulting inflation (Gordon, 1980; Zarnowitz, 1992). The federal funds rate was maintained above 10% from April through October of 1973, the month before the start of the recession. This was recognised as a slowdown beginning in March 1973 followed by a recession beginning November 1973. As Figure 2a shows, a substantial decline had occurred in Sales in February through August of 1973 while only the deceleration of growth rates was reflected in IP, EMP, and INC. Following the monetary tightening, IP, Sales, and INC began a severe and long-lasting decline in November, which was defined as the peak of the economy-wide recession. EMP responded sluggishly with an 11-month lag following this peak.

Figure 2a. **Spider chart during recession of 1973:11 to 1975:3**



According to Romer and Romer (1994), the Fed was quick to discern the onset of recession around February 1974, but was slow to realise its severity. It was not until the October 14, 1974 Federal Open Market Committee (FOMC) meeting that the Fed acknowledged that there would be an extended decline in real activity. Beginning in September however, the FOMC began to ease their policy significantly resulting in a dramatic decline of the federal funds rate. The summary of actions by the Board of Governors of the Federal Reserve System in September through November explicitly states the use of the discount rate and open market operation to combat recession. These anti-recessionary policies continued into the first quarter of 1975, which was dated as the end of the recession. At the trough, Sales and INC reached consensus in March 1975 while EMP and IP began their recoveries one or two months later.

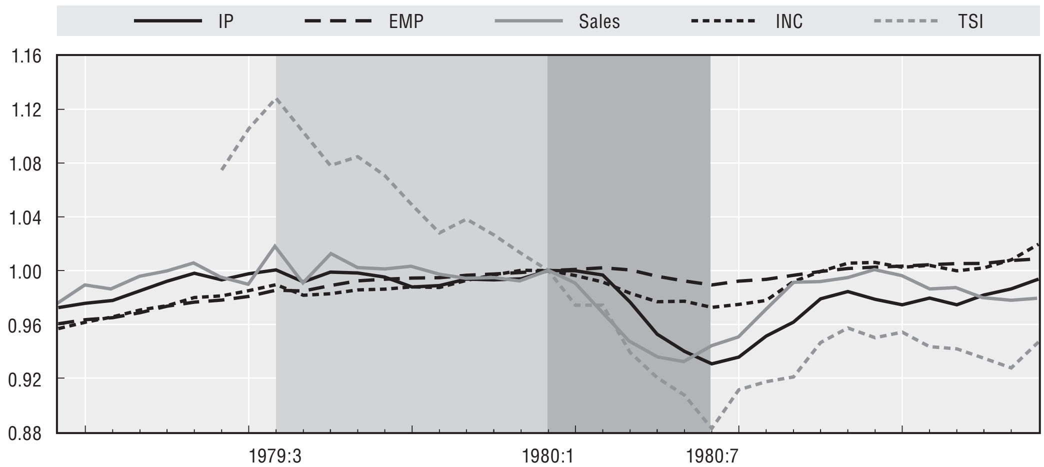
The 1973-1975 recession can be divided into two fairly distinctive phases: November 1973 to September 1974 and October 1974 to March 1975. During the first phase, EMP actually continued to grow and IP only declined slightly (McNees, 1992; Lahiri and Wang, 1994). Thus, this period was identified not as a genuine recession. It was only during the second phase of the recession that real economic activity actually decreased sharply. This distinction coincides with the timing of monetary policies.

Trucking tonnage has become available since January 1973 and thus can be used as a proxy for TSI. Like Sales in this period, trucking activity also experienced a temporary real decline in April 1973 following the monetary tightening, which corresponded to the slowdown preceding that recession. Then a much more severe decline occurred in the trucking industry exactly during the month when IP, Sales and INC began their decline in November 1973. The decline in trucking activity was much deeper than any of the others during this recession, and its turning points are exactly concurrent with the economic peak and trough. From the peak to the trough, trucking tonnage decreased by 30%. Part of the reason is that the recession was a result of the oil shocks, which actually affected the trucking industry from both the supply and demand sides. Like two other sector measures (IP, Sales), trucking tonnage is also very sensitive to monetary policy and market changes. However the cyclical behaviour of trucking tonnage is more correlated with Sales, the realisation of which involves delivery.

2.2.2. Recession of 1980:1-1980:7

The first recession in early 1980s is by far the smallest downturn classified as a cycle. It is a precursor of the larger cycle in 1981. Although no separate cause for it is noted in the literature, it is possibly a result of the oil shock. There was a sudden dramatic surge in the spot price of oil in 1979 when the revolution in Iran disrupted the world oil market, which raised the price from USD 14.85 to USD 32.50 per barrel by January 1980. Driven by high energy costs, the annual inflation rate rose to 18% during 1979 and 1980. To combat this high inflation, the Fed kept the federal funds rate constantly above 10% with large increases in March and April of 1979. From August 1979 to January 1980, the Fed raised the rate again from 9% to 19%, a record-breaking high. Following these increases, both IP and Sales (see Figure 2b) began their real declines in March 1979, corresponding to the growth slowdown defined by the NBER. This shock was reflected in EMP and INC with only somewhat slight decline and decelerations until the beginning of recession in January 1980. The peak of the recession coincided with that of INC while EMP peaked two months later. The labour market had already stagnated in late 1970s and early 1980s, and hence EMP did not aid in identifying the peak of this cycle. According to Romer and Romer (1994), at every meeting of the FOMC from July 1979 through the summer of 1980, the Fed believed that a recession was either under way or was imminent. Concern about inflation and money growth however, prevented policy-makers from moving to lower interest rates

Figure 2b. **Spider chart during recession of 1980:1 to 1980:7**



until the spring of 1980. Then from the third quarter of 1980, the combination of weak money growth and unfavourable news about real GDP pushed the FOMC to lower the federal funds rate sharply, which actually brought all four coincident indicators to the end of this cycle around July 1980.

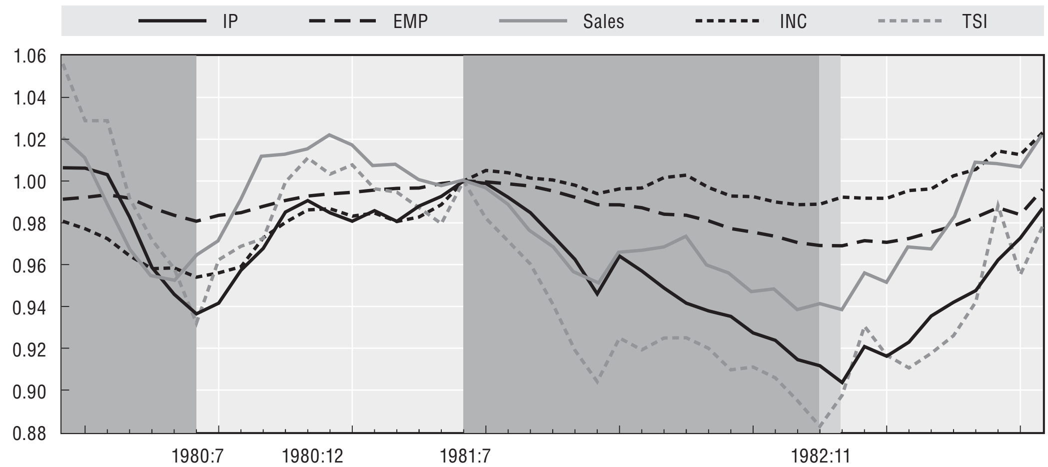
TSI is available during the recession of 1980:1 to 1980:7. Like trucking tonnage in the previous recession, cycles in TSI (see Figure 2) are always very sharp and clear. TSI is also very sensitive to policy and market condition changes, even more so than IP and Sales. In response to oil price shocks and hyperinflation, TSI began to decline in March 1979 at the same time as IP and Sales, and continued until the end of the recession with a clear downtrend. While recoveries of both IP and Sales from the slowdown were interrupted by the monetary tightening in early 1980, nothing had affected the continuing downturn of TSI. Therefore, this indicator gave the sharpest signal for the start of the slowdown and recovery from the recession in this episode.

2.2.3. Recession of 1981:7-1982:11

The recession starting in July 1981 is attributed to additional reasons besides the oil crisis, in part due to Paul Volcker, who was appointed as the Chairman of the Fed by President Carter. Monetary policy in early 1980s was a departure from Fed policy during the 1970s and was fiercely contractionary as an effort to reduce the double-digit inflation. The average federal funds rate in 1980 through July 1981 was 15.5%. Figure 2c reveals that Sales and TSI started to exhibit real declines from December 1980, and continued until the end of recession in November 1982. IP and INC only dropped slightly around December 1980, subsequently recovering from April that year until January 1981, and then falling again into recession. The peak of the recession was defined based on peaks in IP and INC, while EMP peaked one month later. TSI, IP, and Sales recorded surges in their corresponding economic activities in January 1982, corresponding to Fed's action of lowering the federal funds rate.

Following the recession, major declines in interest rates occurred in the fourth quarter of 1981, and in the third and fourth quarters of 1982. The declines in late 1981 were a response both to weak money growth and to the recession. Partly due to Fed stimuli, all coincident indicators finally reached their bottom and began to recover around

Figure 2c. **Spider chart during recession of 1981:7 to 1982:11**



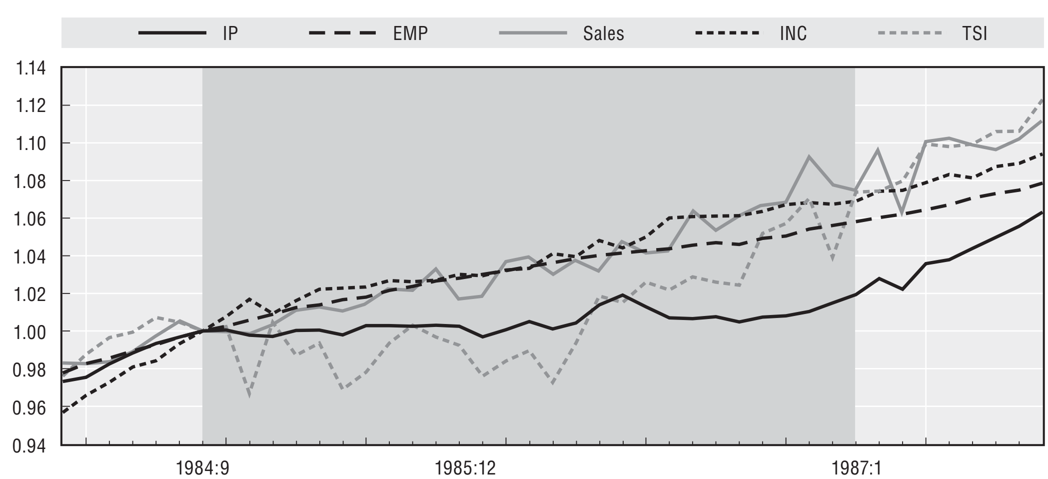
November 1982. The trough of the recession was coincident with that of INC and Sales (also TSI) while EMP and IP recovered a month later.

2.2.4. Slowdown of 1984:9-1987:1

From the recession of 1982 to that of 1990, there was actually one stand-alone slowdown that lasted for 2.5 years. Since growth cycles are less well known as compared to classical business cycles, there has been not much work studying them.[10] We value them simply because recessions are usually preceded by slowdowns, which may or may not develop into recessions due to a number of reasons including concerns and discretionary policies of the Federal Reserve. But due to the sensitive nature of cyclical indicators, many usually detect signs of slowdown right from the beginning.

The slowdown beginning in 1984 was more prominent in IP and TSI than in the rest of the coincident indicators, as depicted in Figure 2d. IP, as the measure of manufacturing output, had stagnated through the period from September 1984 to January 1987 while TSI, the measure of transportation output, began to slow down two months earlier and ended

Figure 2d. **Spider chart during slowdown of 1984:9 to 1987:1**

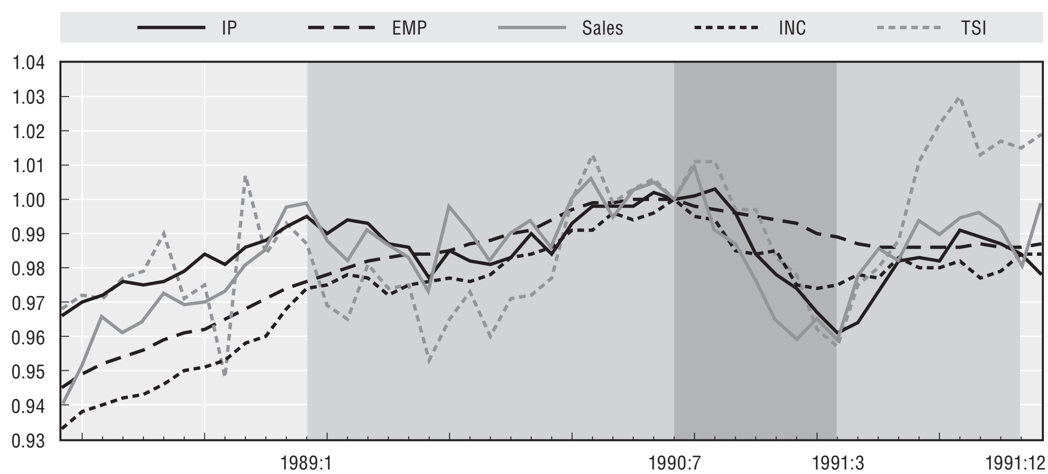


its stagnation in December 1985, about 13 months prior to IP. The cycle in the latter is also clearer with larger amplitude. FOMC actually raised the federal funds rate a few times from early 1983 through the third and fourth quarter of 1984. Slowdowns in IP and TSI could be responses to this monetary tightening.

2.2.5. Recession of 1990:7-1991:3

The 1990 recession was due to a fall in consumption even though economists have debated whether the fall was exogenous (Temin, 1998; Blanchard, 1993; Hall, 1993; Hansen and Prescott, 1993). It is true that real consumption had declined in the fourth quarter of 1990 and the first quarter of 1991, but signs of a slowdown had appeared long before in 1989. McNees (1992) argues that this recession was the natural result when a "soft landing" was not achieved after a long lasting boom. In Figure 2e, it can be seen that IP and Sales started to decline from January 1989, began a recovery in July of that year, and were finally hit by consumption shocks in the third quarter of 1990. TSI had a similar experience, but it peaked three months earlier than both IP and Sales at the start of slowdown. It also had been recovering since July 1989 until the economic recession began. For the other two indicators, a mild slowdown occurred to INC in early 1989 while nothing significantly affected EMP until the beginning of the recession.

Figure 2e. **Spider chart during recession of 1990:7 to 1991:3**



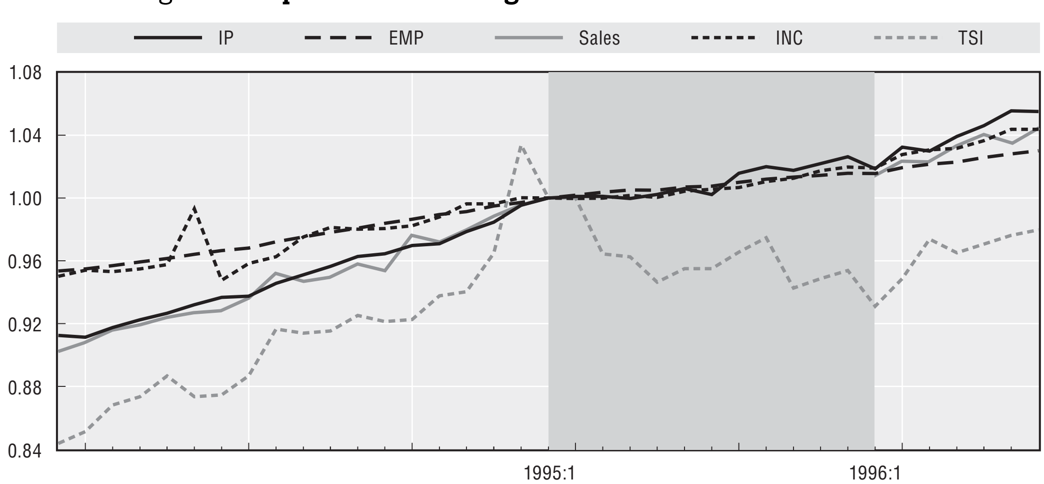
According to Romer and Romer (1994), immediately after what is now known as the peak of the recession (July 1990), the FOMC expected sustained but subdued growth in economic activity for the next several quarters. However, the Fed was fairly slow to realise that a recession was actually under way during the third quarter of 1990 and so was slow to take effective measures. Not until November 1990 did the FOMC decide for some immediate easing of severe conditions. The federal funds rate was lowered in early 1989 and additional reductions were not made until November 1990. In the four months following the Fed's move, IP, Sales and TSI all reached their trough and started moving upward. This was also defined as the trough of the economy. INC peaked slightly earlier than the economic trough while EMP was totally out of sync, recovering 10 months after the overall trough.

Immediately following the recession, the economy did not experience a strong recovery like those in 1980s or earlier. Instead, all the series except TSI underwent slowdowns until December 1991 or even later. Therefore, the recession of 1990 and the one we will discuss next were both preceded and followed by fairly long slowdowns. This new characteristic of recessions can be described as double-dip. The first phase corresponds to a slowdown and the second corresponds to a real recession. This newly observed feature has made TSI even more useful in dating peaks and troughs in a timely fashion because the onset of the slowdowns and the start of economic recovery are all well captured by TSI (Lahiri and Yao, 2004b). A similar characteristic is also found in IP and Sales. Recall one of the reasons for the so-called "great moderation" in the United States: as service-providing sectors have become increasingly more important and the supply chain management, and monetary policies more fine-tuned, the US economy has witnessed more stability since the mid-1980s. Various factors have made recessions shorter and less severe. But as we see, the reduced part of a typical recession has possibly been counted as part of the growth slowdowns, which can only be reflected in these highly sensitive sector measures such as IP, Sales and TSI, rather than the broad measures. As Figures 2f and 2g reveal, although the durations of recessions have been short, the durations of recessions and their neighboring growth cycles have not. Thus, in the future, we may have to rely on sector indicators to identify turning points, particularly at the troughs.

2.2.6. Slowdown of 1995:1-1996:1

Between the recession of 1990 and that of 2001 is a long-lasting boom. In the middle, there is also a stand-alone slowdown that did not culminate into a full-fledged recession. In Figure 2f, we see that IP, Sales and INC exhibited signs of deceleration over the period of 1995:1 to 1996:1. Declines in IP and INC were lesser than that in Sales. However, transportation experienced a severe sector-wide slump during 1994:12 to 1996:1 with a drop of 11% – about its average decline during recessions and worse than the 1990 recession (6%). Thus, TSI also gave a signal for an economy-wide slowdown. This decline followed a series of small increments in the federal funds rate since November 1993. Consequently, declines in TSI, IP and Sales could have been responses to this monetary tightening.

Figure 2f. **Spider chart during slowdown of 1995:1 to 1996:1**

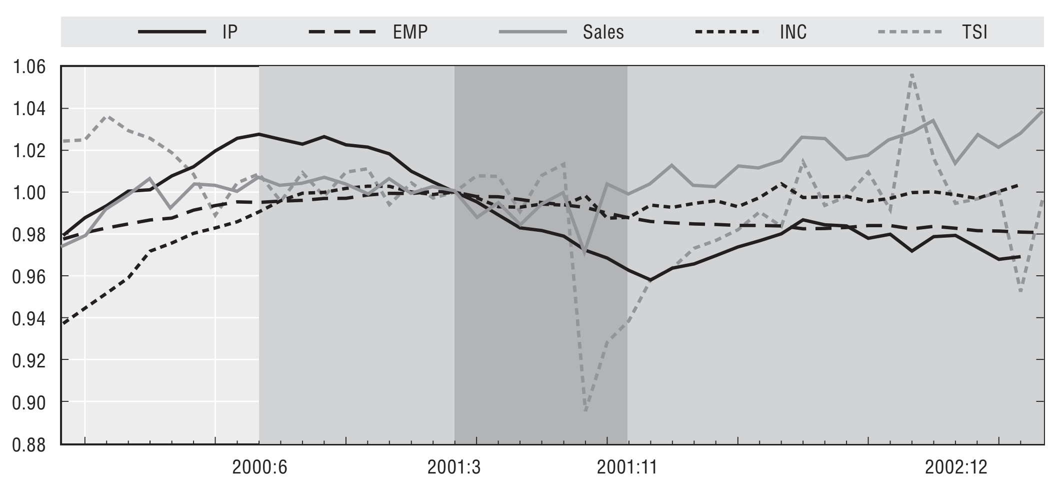


2.2.7. Recession of 2001:3-2001:11

In the 1990s, the US economy experienced the longest expansion in its history. Cautious of possible "irrational exuberance", the FOMC raised the federal funds rate beginning in June 1999. This was the first credit tightening in more than two years. The rise continued until November that year when TSI began to decline. The effects on IP and Sales were a little bit slower. IP began its real decline in June 2000, while Sales showed signs of stagnation from January through December 2000 – its peak occurring in January 2000. Declines in IP, TSI and Sales corresponded to the economic slowdown beginning in June 2000. Like in the previous recession, TSI also exhibited a double-dip recession. The first phase was in the period 1999:11 to 2000:4 when this sector began recovering, and the second was from 2000:11 to 2001:9, which still gave an early signal for the economic peak four months ahead. If we combine the two phases, TSI would have issued a signal for the recession with a lead-time of 11 months.

The peak of this cycle was defined as that of EMP, while INC peaked three months earlier. Since then the federal funds rate was lowered below 2%. A special event during this recession was the September 11 terrorist attacks (9/11) which had a profound effect on TSI (dropped by 12%) but only marginal effects on Sales and other series (see Figure 2g). This marked September 2001 as the trough for TSI.[11] However the trough of this overall cycle was defined at somewhere between those of Sales, INC and IP, but closer to INC. Like in the recession of 1990, EMP did not recover till the third quarter of 2003, about two years after the general economic turnaround.

Figure 2g. **Spider chart during recession of 2001:3 to 2001:11**

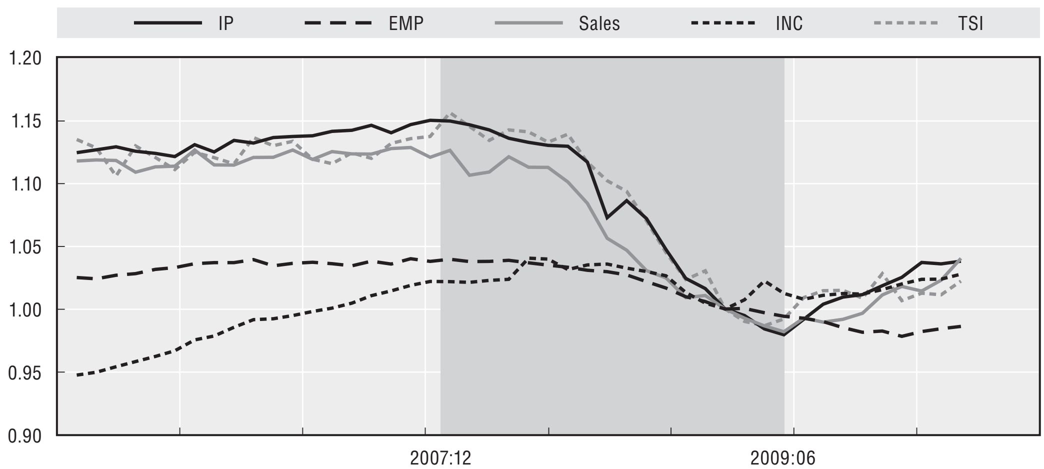


2.2.8. Recession of 2007:12-2009:6

The bankruptcy of Lehman Brothers in September 2008 precipitated what in retrospect, is likely to be judged to be the most virulent global recession ever. Whereas the causes of the current recession are being debated, it is widely believed that the housing downturn which started in 2006, is a primary cause of the broader economic malaise. The fall of housing prices from its peak levels cut deeply into home building and home purchases. This also caused a sharp rise in mortgage foreclosures for which institutions that had exposure to mortgage securities took great losses to the tune of over

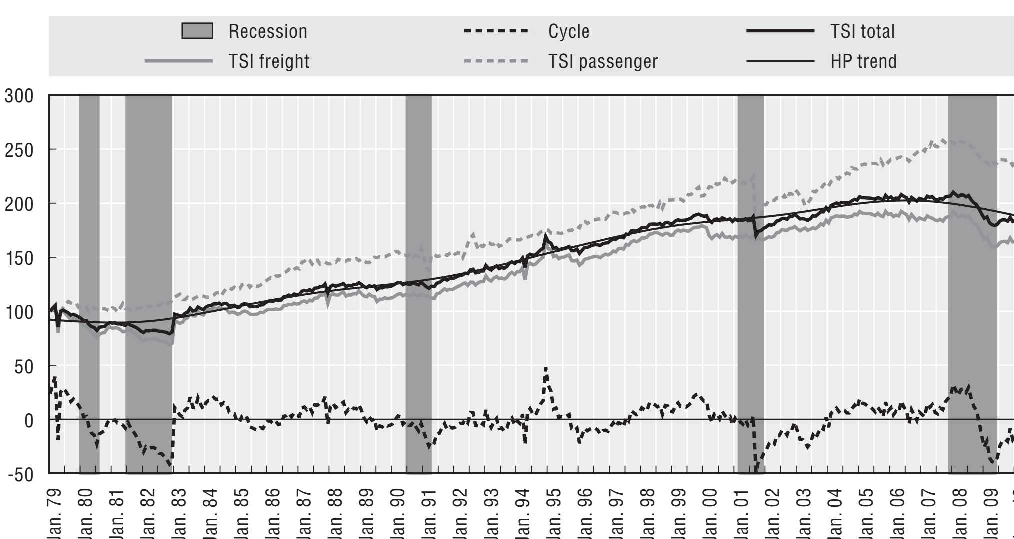
USD 400 billon. In July 2008, oil prices peaked at USD 147 a barrel and a gallon of gasoline was more than USD 4 across most of the US In addition, US monetary policy contributed to the recession by excessive money creation. Figure 2h reveals that, compared to EMP and INC, sector indices like IP, Sales and TSI again issued very clear signals for a peak around December 2007.

Figure 2h. **Spider chart during recession of 2007:12 to 2009:06**



The same indicators together with INC suggested a trough of the cycle around June 2009 – thus the current recession would have lasted over 16 months. In Figure 3, we have plotted TSI and its freight and passenger components from 1979:1 until 2010:3. The deviation of TSI from its HP trend is also depicted. We clearly see that during the last recession that began in December 2007, TSI has been almost coincident with the peak and the trough. The role of TSI as a faithful coincident indicator both at the peak and the trough is again established.

Figure 3. **TSI total, its components and growth cycle, Jan. 1979-March 2010**



The above episodic analysis of eight recessions and slowdowns in the US suggests that during every recession and growth slowdown, TSI, IP and Sales have been very sensitive to economic and policy shocks. All recessions since 1973 have been preceded by a fairly long slowdowns.[12] Cycles in these three individual indicators correspond to both slowdowns and recessions. Sometimes these cycles made distinctions between growth slowdowns and recessions with a two-phase cycle; otherwise, they had a complete cycle right from the onset of slowdown. During recessions of 1990 and 2001, TSI had displayed a double-dip feature, where its first phase gave clear signals for a slowdown while the second high corresponded to the next phase of the economic recession. During the latest peak of 2007 recession, TSI again signalled the onset of the recession as did IP and Sales. During this recession, the signals from personal income and employment were less clear. Thus, we can conclude that TSI always gives early and clear signals for economic recessions.

The timing of these five coincident indicators relative to the NBER chronology is reported in Table 1. At the troughs of last few recessions, recovery of EMP appears very weak, lagging behind the other measures of the overall economy, which is partly due to improved productivity since the mid-1980s. This eliminates EMP as a useful indicator in identifying economic troughs. The missing role of labour data can be made up by the TSI, whose recoveries could have always started at the same time as economic recoveries had the event of 9/11 not occurred. Nevertheless, TSI's dating power for US economic troughs is better than that of any of the four currently used coincident indicators. At peaks, TSI tends to always peak earlier, by seven months on the average. Unlike IP or Sales, which may lead, lag or coincide with economic peaks, TSI consistently leads the onset of economic recessions. Given that the NBER committee places special importance on the two broad indicators (EMP and/or INC) to identify the peak of US economy, TSI as a sector indicator can be very useful in correctly dating peaks when combined with these two broad indicators. Moreover, transportation output represents an important service sector that relates to various stages of fabrication. Adding TSI as additional coincident indicator can broaden the representation of the current NBER dating system and add additional discriminatory power.

Table 1. **Timing of five coincident indicators relative to NBER chronology**

NBER-defined recessions	IP		EMP		Sales		INC		Median of these four		TSI	
	P	T	P	T	P	T	P	T	P	T	P	T
Nov. 73-March 75	0	2	8	0	0	0	0	0	0	0	0	0
Jan. 80-July 80	–10	0	2	0	–10	–1	0	0	–5	0	–10	0
July 81-Nov. 82	0	0	0	0	–6	0	1	–1	0	0	–7	0
July 90-March 91	2	0	–1	10	1	0	0	–2	0.5	4	–4	0
March 01-Nov. 01	–6	1	0	8	–9	–2	–4	–1	–5	0	–16	–2
Mean	–2.7	0.4	1.7	2.6	–4.1	–0.6	–0.3	–0.9	–1.7	0.5	–7.4	–0.4
Median	–2.0	0.0	0.0	0.0	–3.0	0.0	0.0	–1.0	–1.0	0.0	–7.0	0.0
St Dev	4.1	0.8	3.1	4.4	4.3	0.8	1.7	0.9	2.3	1.6	6.1	0.9
All 4 indicators	w/o TSI		w/ TSI									
Mean	–1.4	0.4	–2.6	0.2								
Median	–1.3	–0.3	–2.4	–0.2								
St Dev	3.3	1.7	3.9	1.6								
Extra turns											5/84	10/85
											12/94	1/96

3. CCIs with TSI

The NBER methodology of business cycles, inherited from Burns and Mitchell (1946), has two key features: comovement and regime switch (Diebold and Rudebusch, 1996). Extracting the comovement among coincident indicators leads to the creation of CCI. We consider three different methods to construct CCI: a non-parametric method of the NBER (Conference Board, 2001) and two parametric methods based on a single-index dynamic factor model (Stock and Watson, 1989), and a similar dynamic factor model with regime switching (Kim and Nelson, 1998). We name the CCI obtained from these three methods NBER index, SW index and KN index respectively.

3.1. NBER index

The NBER index is created by assigning fixed standardisation factors as weights to the growth rate of each component and taking the average. Four steps are involved.

1. Month-to-month changes for each component of an indicator X_{it} (i = 1, 2, 3, .., k; t = 1, 2, 3, .., T) are computed using the symmetric percentage change formula:

   $\delta X_{it} = 200 * (X_{it} - X_{it-1})/(X_{it} + X_{it-1})$.
2. The month-to-month changes are adjusted to equalise the volatility of each component using the standardisation factors. The standardisation factor for each component (r_i) is the inverse of standard deviation of the indicator over sample period, then normalised to sum = 1, *i.e.*, $r_i = w_i^{-1}/\Sigma_j\,(w_j^{-1})$ and $m_{it} = r_i * \delta X_{it}$.
3. The level of the index is computed using the symmetric per cent change formula: first, the change of the composite index, s_t, is the average of adjusted month-to-month changes across all individual components for each t (*i.e.*, $s_t = \bar{m}_t$ where $\bar{m}_t = (1/k)\Sigma_i\, m_{it}$); second, to get back to the level of the index, the first month's value is $I_1 = (200 + s_1)/(200 - s_1)$ and $I_t = I_{t-1} * (200 + s_t)/(200 - s_t)$ *for t = 2, 3, ..,* T.
4. The index is re-based to be 100 in 1996.

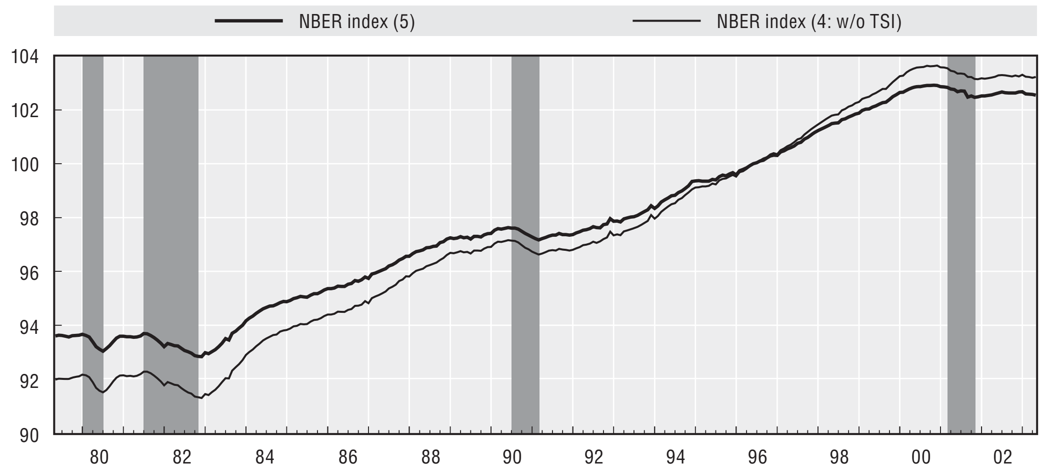
By using the inverse of the standard deviation as a weight, the contribution of the change in each series to the final index is well-balanced. The factors for constructing an NBER index from all five indicators are reported in Table 2. Besides this index, denoted as NBER index (5), four alternative indexes are achieved by excluding, individually, one indicator from the composite at a time. This results in a total of six NBER indexes. Among them, NBER index (4: w/o TSI) is constructed from four currently used coincident indicators, thus should be identical to the CCI currently maintained by the Conference Board. To keep a clear distinction between indexes, we only plot this index against NBER index (5) in Figure 4. Their cyclical movements are largely identical with only subtle

Table 2. **Standardisation factors for NBER Index**

Components of CCI	Standardisation factors
IP	0.159
EMP	0.532
INC	0.155
Sales	0.101
TSI	0.054

Note: The factors are defined as the inverse of standard deviations.

Figure 4. **NBER indices with and without TSI**



differences in their slopes. Note that the two indexes cross at 1996; since both have base 1996 = 100, it means that the composite NBER index with TSI is located uniformly a few points higher than the original NBER index (without TSI), but has the same cyclical characteristics.

To compare the performance of these six indexes to nowcast business cycles, their turning points are identified using the BB algorithm. The timing of these turning points relative to the NBER chronology is then reported in Table 3. Historically, all CCIs have the same turning points as the NBER chronology except that NBER index (4: w/o EMP) that shows a peak ten months earlier than that in NBER chronology for the 1980 recession. For the business cycle peak of March 2001, three indexes peaked in November 2000, two in December 2000 and one in October 2000, but none in March 2001. They also suggest a trough around November 2001 as defined by the NBER committee. All the indexes also signalled a new peak around December 2002.

We also computed Pearson's bellwether index of concordance based on a contingency table to measure the concurrence of turning points of each of these six NBER indices with NBER chronology:

$$\hat{I} = \frac{1}{T}\{\sum_{t=1}^{T} S_{xt}S_{yt} + \sum_{t=1}^{T}(1-S_{xt})(1-S_{yt})\} \tag{1}$$

where the state variables (0 for recession and 1 for recovery) are defined for two binary series *x* (a particular NBER composite index) and *y* (the NBER chronology) using the BB algorithm. Thus, $S_{yt} = 1$ if period *t* is a recovery period according to the NBER chronology (0 if recession), and $S_{xt} = 1$ if a particular NBER composite index in the same period *t* also belongs to a recovery period (0 if recession). The concordance index in equation (1) ranges between 0~1, see Harding and Pagan (2002). These values are reported in the last row of Table 3. Taking the NBER index (5) as the benchmark, the difference between $\hat{I}$ for other NBER indexes and $\hat{I} = 0.979$ for NBER index (5) shows the marginal contribution of the omitted variables to the composite five indicators CCI. Interestingly, INC and Sales have small negative contributions in correctly dating peaks and troughs of US economy, and thus the dating performance would improve without them. EMP has the largest contribution among the group of coincident indicators. However, partly because of the

Table 3. **Timing of NBER indexes (CCI) relative to NBER chronology**

NBER-defined recessions	Five coincident indicators excluding											
	None[1]		TSI		IP		EMP		Sales		INC	
	P	T	P	T	P	T	P	T	P	T	P	T
Jan. 80-July 80	0	0	0	0	0	0	–10	0	0	0	0	0
July 81-Nov. 82	0	1	0	1	0	0	0	1	0	0	0	1
July 90-March 91	–1	0	–1	0	–1	0	1	0	–1	0	–1	0
March 01-Nov. 01	–4	0	–3	–1	–3	–2	–5	–2	–4	0	–4	1
Detected new peak	Jan. 03		Jan. 03		Dec. 02		Dec. 02		Dec. 02		Jan. 03	
Mean	–1.3	0.3	–1.0	0.0	–1.0	–0.5	–3.5	–0.3	–1.3	0.0	–1.3	0.5
Median	–0.5	0.0	–0.5	0.0	–0.5	0.0	–2.5	0.0	–0.5	0.0	–0.5	0.5
St Dev	1.9	0.5	1.4	0.8	1.4	1.0	5.1	1.3	1.9	0.0	1.9	0.6
Concordance w/NBER chronology	0.979		0.979		0.979		0.935		0.986		0.983	

1. CCI from five coincident indicators.

relatively few turning points in our sample, and also because the index value with the four original indicators is already very close to one (0.979), the marginal contribution of TSI cannot be properly discerned by looking at the concordance index in this case.

3.2. Stock-Watson index

An alternative to the NBER index is the use of modern time-series techniques to develop dynamic factor models with regime switching (Kim-Nelson) or without regime switching (Stock-Watson). The resulting single indexes would represent the underlying state of its constituent time series. Thus dating turning points could be based on the probabilities of the recessionary regime implied by the regime switching models.

Defining Y_{it} as the logarithm of the coincident indicators X_{it}, their individual growth rates are posited to 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:

$$\Delta Y_{it} = \gamma_i \Delta C_t + e_{it}, \tag{2}$$

where ΔY is the simple first difference (*i.e.*, $Y_{it} - Y_{it-1}$) of the indicator Y_{it} times 100. 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.

$$\Phi(L)\,(\Delta C_t - \mu_{st} - \delta) = w_t, \tag{3}$$

$$\psi(L)\,e_{it} = \varepsilon_{it}, \tag{4}$$

where L denotes the lag operator, δ is an intercept parameter, $\Phi(L)$ is a scalar lag polynomial, and $\psi(L)$ is a lag polynomial matrix. The two noise terms w_t and ε_{it} are assumed to be independent of each other. The equations (2)~(4) with regime specific means $\mu_{st} = 0$ define the Stock-Watson model; the state variable that we estimate from the model is the SW index. Our model specification is identical to original Stock-Watson model where three lags of state variables are used for the employment variable to account for its lagging nature, while no lag is used for newly added TSI. Like the NBER index, we estimate six SW indexes using different combinations of five coincident indicators. The estimation results are reported in Table 4, where the index estimated from all five indicators can be

Table 4. **Estimates of SW model with five coincident indicators**

SW models		Five coincident (IP, EM, IN, SA and TS) indicators excluding											
		None		TSI		IP		INC		Sales		EMP	
Parameters		coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.
	ϕ_1	0.43	(0.09)	0.45	(0.10)	0.74	(0.29)	0.35	(0.09)	0.50	(0.11)	0.37	(0.09)
	ϕ_2	0.22	(0.09)	0.23	(0.09)	0.00	(0.26)	0.24	(0.08)	0.18	(0.10)	0.27	(0.08)
IP	γ_1	0.65	(0.06)	0.60	(0.06)	–	–	0.71	(0.06)	0.60	(0.06)	0.68	(0.06)
	φ_{11}	–0.21	(0.09)	–0.19	(0.09)	–	–	–0.18	(0.12)	–0.23	(0.09)	–0.07	(0.11)
	φ_{12}	–0.01	(0.01)	–0.01	(0.01)	–	–	–0.01	(0.01)	–0.01	(0.01)	0.00	(0.00)
	σ_1^2	0.32	(0.05)	0.37	(0.05)	–	–	0.29	(0.06)	0.36	(0.06)	0.33	(0.06)
INC	γ_2	0.28	(0.04)	0.27	(0.03)	0.24	(0.05)	–	–	0.27	(0.03)	0.28	(0.03)
	φ_{21}	–0.03	(0.05)	–0.04	(0.05)	–0.08	(0.06)	–	–	–0.04	(0.05)	–0.03	(0.05)
	φ_{22}	0.03	(0.05)	0.02	(0.04)	0.01	(0.05)	–	–	0.02	(0.04)	0.04	(0.04)
	σ_2^2	0.28	(0.03)	0.27	(0.03)	0.23	(0.03)	–	–	0.27	(0.03)	0.28	(0.03)
Sales	γ_3	0.34	(0.04)	0.31	(0.04)	0.25	(0.06)	0.37	(0.05)	–	–	0.37	(0.05)
	φ_{31}	–0.40	(0.06)	–0.40	(0.06)	–0.43	(0.07)	–0.39	(0.06)	–	–	–0.41	(0.06)
	φ_{32}	–0.04	(0.01)	–0.04	(0.01)	–0.05	(0.01)	–0.04	(0.01)	–	–	–0.04	(0.01)
	σ_3^2	0.66	(0.06)	0.70	(0.06)	0.68	(0.07)	0.64	(0.06)	–	–	0.64	(0.06)
EMP	γ_4	0.42	(0.04)	0.45	(0.04)	0.38	(0.05)	0.39	(0.04)	0.45	(0.05)	–	–
	γ_{41}	0.07	(0.05)	0.04	(0.05)	–0.07	(0.10)	0.13	(0.04)	0.02	(0.05)	–	–
	γ_{42}	0.00	(0.07)	–0.01	(0.04)	0.07	(0.06)	–0.02	(0.04)	–0.02	(0.04)	–	–
	γ_{43}	0.15	(0.04)	0.15	(0.04)	0.20	(0.04)	0.17	(0.04)	0.14	(0.04)	–	–
	φ_{41}	0.28	(0.05)	0.27	(0.05)	0.21	(0.10)	0.29	(0.05)	0.27	(0.05)	–	–
	φ_{42}	0.44	(0.07)	0.46	(0.07)	0.33	(0.11)	0.45	(0.06)	0.49	(0.07)	–	–
	σ_4^2	0.19	(0.03)	0.16	(0.03)	0.20	(0.03)	0.20	(0.03)	0.16	(0.03)	–	–
TSI	γ_5	0.28	(0.04)	–	–	0.18	(0.05)	0.29	(0.04)	0.23	(0.04)	0.28	(0.04)
	φ_{51}	–0.36	(0.06)	–	–	–0.36	(0.06)	–0.40	(0.06)	–0.38	(0.06)	–0.41	(0.06)
	φ_{52}	–0.03	(0.01)	–	–	–0.03	(0.01)	–0.04	(0.01)	–0.04	(0.01)	–0.04	(0.01)
	σ_5^2	0.61	(0.06)	–	–	0.64	(0.07)	0.62	(0.05)	0.64	(0.06)	0.60	(0.06)
Log L		312.12		223.25		269.94		289.26		223.02		337.57	

considered as an unrestricted model while others are restricted models. Thus, likelihood ratio tests can be employed to test the validity of these restrictions for removing one indicator at a time. All the restrictions that the coefficients of removed variable are zero are rejected at the 5% level.[13] In Table 4, coefficient estimates are very similar across different models. The estimated SW index with five indicators and that with four coincident indicators are plotted in Figure 5. They are almost identical to each other and their turning points are also very close.

3.3. Kim-Nelson index

Adding regime switching to the Stock-Watson model forms the Kim-Nelson model.[14] The transitions of different regimes (μ_{st}), incorporated into (3), are governed by a Markov process:

$$\mu_{st} = \mu_0 + \mu_1 S_t,\ S_t = \{0, 1\},\ \mu_1 > 0, \tag{5}$$

$$Prob\ (S_t = 1 \mid S_{t-1} = 1) = p,\ Prob\ (S_t = 0 \mid S_{t-1} = 0) = q, \tag{6}$$

This model can be estimated using Gibbs-sampling. To implement the Kim-Nelson model, we used priors from the estimated Stock-Watson model. Priors for regime switching parameters were obtained from sample information of the NBER index. The final specification and parameter estimates from Kim-Nelson models are reported in Table 5.

Figure 5. **SW indices with and without TSI**

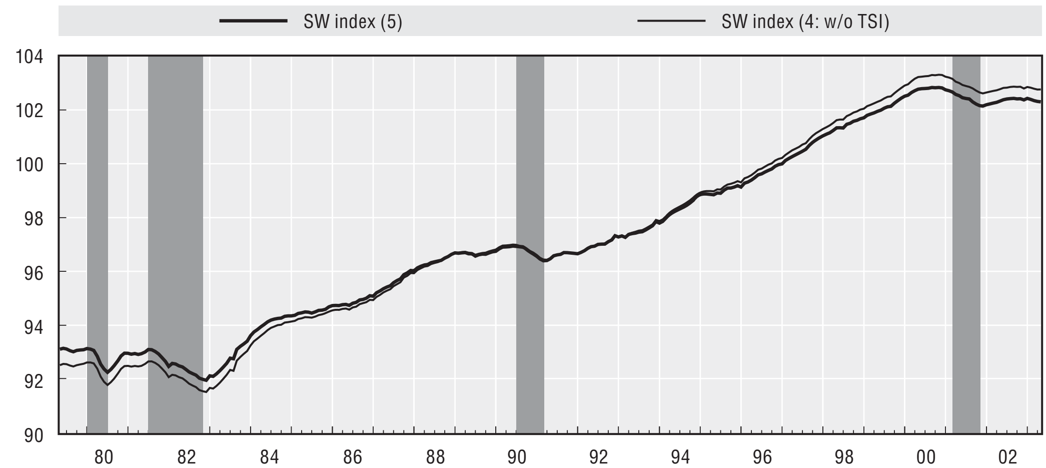
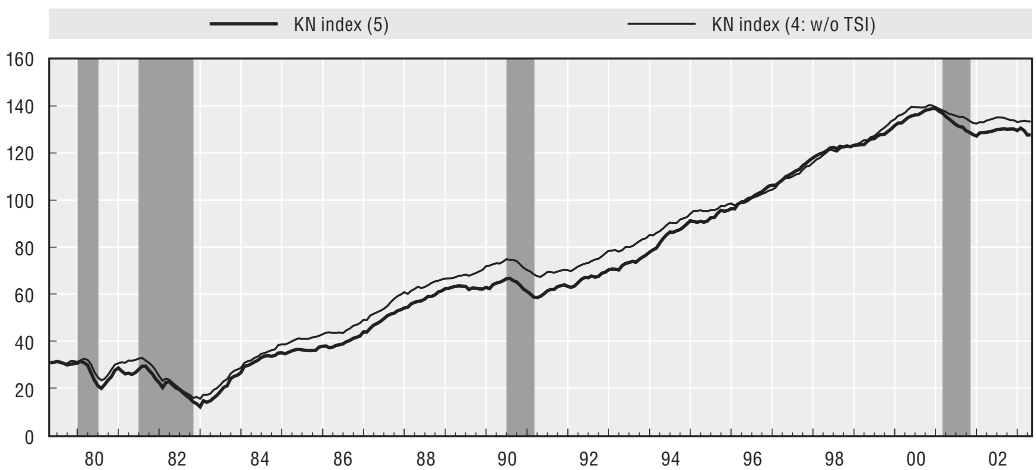


Table 5. **Estimates of KN model with five coincident indicators**

KN model		Five coincident (IP, EM, IN, SA and TS) indicators excluding											
		None		TSI		IP		INC		Sales		EMP	
Parameters		coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.	coef	s.e.
	ϕ_1	0.33	(0.15)	0.46	(0.19)	0.31	(0.27)	0.26	(0.13)	0.50	(0.19)	0.37	(0.18)
	ϕ_2	0.12	(0.08)	0.10	(0.09)	0.03	(0.09)	0.12	(0.08)	0.07	(0.09)	0.12	(0.10)
IP	γ_1	0.58	(0.06)	0.56	(0.06)	–	–	0.60	(0.06)	0.54	(0.06)	0.61	(0.08)
	φ_{11}	–0.09	(0.09)	–0.09	(0.09)	–	–	–0.07	(0.09)	–0.11	(0.08)	–0.05	(0.09)
	φ_{12}	0.02	(0.08)	0.05	(0.08)	–	–	0.03	(0.08)	0.06	(0.08)	0.01	(0.08)
	σ_1^2	0.32	(0.06)	0.37	(0.07)	–	–	0.29	(0.06)	0.39	(0.07)	0.32	(0.08)
INC	γ_2	0.26	(0.04)	0.26	(0.04)	0.26	(0.05)	–	–	0.25	(0.04)	0.26	(0.04)
	φ_{21}	–0.37	(0.06)	–0.38	(0.06)	–0.35	(0.07)	–	–	–0.37	(0.06)	–0.36	(0.06)
	φ_{22}	–0.08	(0.06)	–0.08	(0.06)	–0.05	(0.06)	–	–	–0.08	(0.06)	–0.07	(0.06)
	σ_2^2	0.79	(0.07)	0.78	(0.07)	0.78	(0.07)	–	–	0.78	(0.07)	0.80	(0.07)
Sales	γ_3	0.31	(0.04)	0.28	(0.04)	0.29	(0.06)	0.31	(0.04)	–	–	0.33	(0.05)
	φ_{31}	–0.36	(0.06)	–0.36	(0.07)	–0.36	(0.07)	–0.35	(0.07)	–	–	–0.36	(0.07)
	φ_{32}	–0.13	(0.06)	–0.12	(0.06)	–0.11	(0.07)	–0.12	(0.06)	–	–	–0.13	(0.06)
	σ_3^2	0.66	(0.06)	0.68	(0.06)	0.67	(0.07)	0.65	(0.06)	–	–	0.64	(0.06)
EMP	γ_4	0.26	(0.04)	0.38	(0.05)	0.34	(0.07)	0.33	(0.04)	0.39	(0.05)	–	–
	γ_{41}	0.07	(0.04)	0.05	(0.05)	0.05	(0.06)	0.08	(0.04)	0.03	(0.05)	–	–
	γ_{42}	0.09	(0.04)	0.09	(0.05)	0.10	(0.05)	0.09	(0.04)	0.10	(0.05)	–	–
	γ_{43}	0.11	(0.04)	0.12	(0.04)	0.12	(0.04)	0.11	(0.04)	0.10	(0.04)	–	–
	φ_{41}	–0.38	(0.06)	0.05	(0.08)	0.10	(0.10)	0.11	(0.07)	0.05	(0.08)	–	–
	φ_{42}	–0.08	(0.06)	0.30	(0.08)	0.30	(0.09)	0.36	(0.06)	0.30	(0.08)	–	–
	σ_4^2	0.72	(0.07)	0.34	(0.04)	0.37	(0.06)	0.37	(0.04)	0.34	(0.04)	–	–
TSI	γ_5	0.26	(0.04)	–	–	0.24	(0.06)	0.26	(0.04)	0.22	(0.04)	0.28	(0.04)
	φ_{51}	–0.38	(0.06)	–	–	–0.35	(0.07)	–0.38	(0.06)	–0.36	(0.06)	–0.40	(0.06)
	φ_{52}	–0.08	(0.06)	–	–	–0.06	(0.07)	–0.09	(0.06)	–0.08	(0.06)	–0.09	(0.06)
	σ_5^2	0.72	(0.07)	–	–	0.74	(0.08)	0.71	(0.06)	0.76	(0.07)	0.71	(0.06)
	μ_0	–1.82	(0.80)	–1.15	(0.97)	–1.44	(0.87)	–1.95	(0.73)	–1.30	(1.04)	–1.37	(0.98)
	μ_1	2.17	(0.83)	1.53	(1.05)	1.95	(0.94)	2.30	(0.78)	1.64	(1.10)	1.81	(1.00)
	P_{00}	0.83	(0.15)	0.83	(0.21)	0.88	(0.14)	0.82	(0.14)	0.83	(0.19)	0.80	(0.20)
	P_{11}	0.96	(0.07)	0.88	(0.21)	0.93	(0.16)	0.94	(0.16)	0.93	(0.15)	0.89	(0.19)
	δ	0.51	(0.06)	0.61	(0.10)	0.55	(0.21)	0.44	(0.05)	0.62	(0.11)	0.41	(0.05)
	$\mu_0 + \mu_1$	0.35	(0.25)	0.38	(0.53)	0.50	(0.51)	0.35	(0.18)	0.34	(0.45)	0.43	(0.66)
QPS		0.09		0.17		0.15		0.10		0.14		0.14	

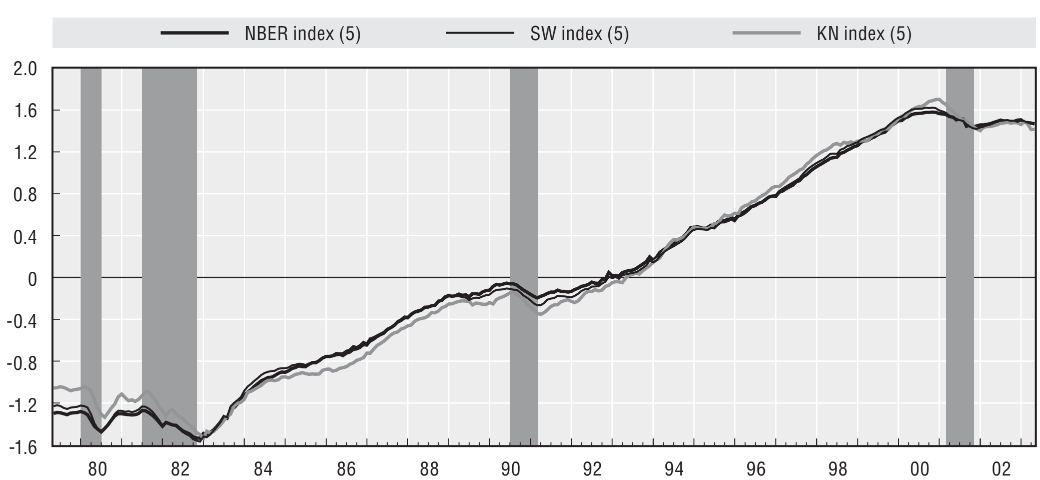
From the table, all the models distinguish between two clear-cut regimes of positive and negative growth rates. The coefficient estimates are also very similar across different model specifications. The estimated two of the six KN indexes are plotted in Figure 6. Both indexes capture the double-dip feature shared by the three sector measures (IP, Sales and TSI), as well as mild slowdowns in 1985 and 1995. All the indexes suggest that the economic peak for the 2000 recession occurred at the end of 2000, but they largely disagree on the date of the trough.

Figure 6. **KN indices with and without TSI**



The coefficient estimates of Stock-Watson and Kim-Nelson models with the same covariate specifications 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 the much larger role that employment plays in the Kim-Nelson model. Both these two types of indexes estimated from all five indicators are plotted against the NBER index in Figure 7. Compared to Kim-Nelson, the Stock-Watson index agrees more closely with the NBER index

Figure 7. **Three CCIs based on five coincident indicators**

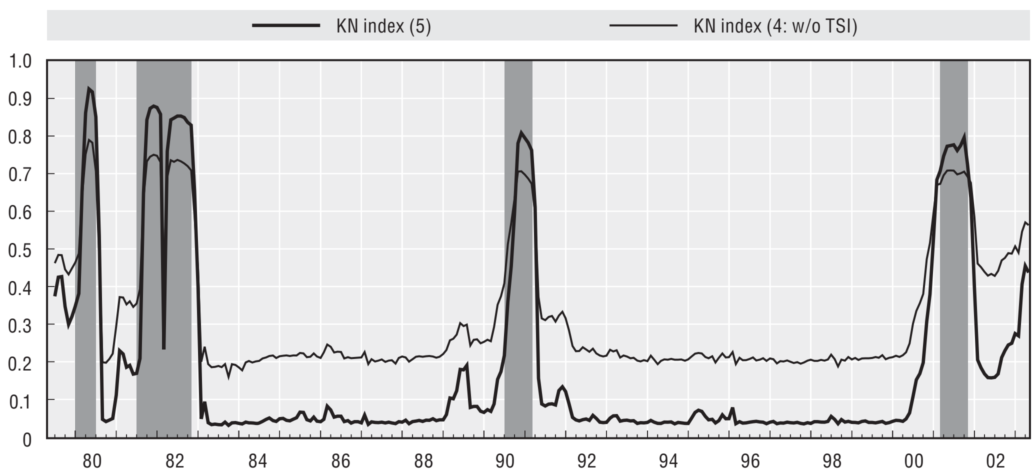


Note: The scale for three indexes has been normalised.

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 are synchronised well with the NBER-defined recessions for the economy (the shaded areas). These results are similar to those in Kim and Nelson's original paper.

As a by-product, the Kim-Nelson model generates the posterior probability that the economy is in recession, as plotted in Figure 8. These probabilities, inferred from the model, feature a real-time and nonparametric dating algorithm. In facilitating the dating, we draw the 0.5 probability line in the figure. The first month going above (below) 0.5 probability line is defined as a peak (trough). The resulting chronology would be very similar to that from using the non-parametric NBER index. The recession probabilities in Figure 8 also suggests that the 2000 recession started a little bit earlier and ended a little bit later as compared to the NBER chronology of March 2001 and November 2001.

Figure 8. **Recession probabilities implied from Kim-Nelson models**



To compare the performances of each KN index to different combinations among the five coincident indicators, we also calculate the Quadratic Probability Score (QPS) (Brier, 1950) based on probabilities implied from each model. Let P_t be the probability that economy is in recession estimated from the model, R_t be the NBER-defined chronology (1 if recession, 0 otherwise), the QPS is given by:

$$QPS = \frac{1}{T}\sum_{t=1}^{T} 2(P_t - R_t)^2, \tag{7}$$

which ranges from 0 to 2, with a score of 0 corresponding to perfect accuracy. This is the unique proper scoring rule that is a function only of the discrepancy between realisations and assessed probabilities (see Diebold and Rudebusch, 1989). We calculate the QPS for the sample period from January 1979 to December 2002 and they are reported in the last row of Table 5. All six KN indexes have QPS lower than 0.2, which suggests that they have good performance in identifying peaks and troughs relative to the NBER chronology. Among them, KN index (5) has the highest accuracy with the lowest QPS with a value of 0.09, and the index excluding TSI has the lowest accuracy with the highest QPS with a value of 0.17. This is corroborated in Figure 8 as well where we see very clearly that the recession probabilities with TSI discriminates between a recession and a recovery much better that do those without TSI. This is because the KN index without TSI generates higher recession probabilities during expansions and smaller probabilities during recessions as compared to the KN index with TSI.

4. Conclusions

In this paper we examined the usefulness of the transportation services index (TSI) as an additional coincident indicator to determine the peaks and troughs of business cycles in the US economy. Transportation represents a service sector that plays an undisputed role in propagating sector or geographic shocks into the overall economy. Adding the TSI into a coincident indicators system can help a dating committee to account for several important changes that have taken place in the economy since mid-1980s such as reduced volatility in real GDP, decreased importance of industrial production, increased share of the services sector, and the failure of the employment indicator to co-move with other coincident indicators. We evaluated the marginal contribution of the TSI to the NBER business cycle dating chronology by using individual indicators as well as composite indexes. The historical consistency between TSI and NBER chronology at troughs outperforms any of the currently used coincident indicators. At peaks, TSI tends to peak seven months ahead on average. Thus, TSI, when combined with one of the two broad business cycle measures, would significantly save the time and confusion in correctly dating peaks in a timely fashion.

Following the single factor dynamic factor model for coincident indicators with regime switching, we constructed six different composite coincident indices using different combinations of these five indicators. For each such combination, we evaluated the marginal contribution of each individual indicator to the system. TSI was found to have a very significant marginal contribution in reducing the QPS score compared to the original four-indicator NBER mix. Given that the NBER and other dating committees place special importance on the two broad indicators (EMP and INC) to identify peaks, TSI as a sector indicator can be useful when used in conjunction with these two board measures. Moreover, transportation represents an important service sector that interconnects various stages of fabrication in any modern economy. Thus, including TSI as an additional coincident indicator can broaden the representation of the current business cycle dating system and add additional discriminatory power.

Notes

1. The transportation indicators included by Mitchell and Burns are passenger car production, total railroad operating income, truck production and ton-miles of freight hauled by railways. The revised NBER list, by Geoffrey Moore in 1950, included railway freight carloadings as one of eight coincident indicators.
2. For more information on the history of cyclical indicators, see the NBER Macrohistory database available online (Feenberg and Miron, 1997). See also Klus *et al.* (2005).
3. Irvine and Schuh (2005) find that 40% of the reduced volatility in GDP is attributed to improved inventory investment and another 30% to reduced correlation between sectors due to more integrated supply chain management. Both factors are closely related with transportation.
4. 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.

5. Since 10 March 2004 TSI has been released and updated on a monthly basis by the Bureau of Transportation Statistics, US DOT, and all reports are now available at *www.bts.gov/xml/tsi/src/index.xml*.
6. In the November 1968 issue of Business Conditions Digest (BCD), US Bureau of Economic Analysis began to produce composite indexes, where the CCI was based on five coincident indicators. In the December 1975 issue of BCD, one of them, (inverse) unemployment rate was dropped and four remained in use till today.
7. The seasonally adjusted TSI is based on its seasonally adjusted component series using Census' X12-ARIMA with adjustments for both trading day and holiday effects. The seasonally adjusted series of other four indicators are readily available.
8. In spider charts, the values of all depicted series are normalised to be one for the month defined as the peak or trough. The spider charts in our paper are defined for peaks, while the NBER Dating Committee presents charts for both peaks and troughs.
9. From specific cycles of each indicator to the final NBER chronology, very limited information has been provided by the NBER dating committee on its procedure. While dating the business cycle chronology for the Australian economy, Boehm and Moore (1984) have provided the clearest description of the NBER procedures.
10. A recent exception is Zarnowitz and Ozyildirim (2006).
11. But without this event, TSI would have reached its trough in November 2001 as well. Using a Census X12-ARIMA procedure, removal of this outlier results in a trend-cycle component of the original TSI that shows a trough in November 2001.
12. The only exception is the recession of 1981. The possibility of a prior slowdown was possibly preempted by the additional short and mild recession of 1980, as we see from Figure 2c.
13. Critical values for $\chi^2(4)$ (four coefficients are specified for IP, SALES, INC and TSI in the model) and $\chi^2(7)$ (EMP, three lags are specified in the equation [2]) are 9.5 and 14.1 respectively at the 5% level of significance.
14. Both models were estimated using computer routines described in Kim and Nelson (1998).

References

Blanchard, O. (1993), "What Caused the Last Recession? Consumption and the Recession of 1990-1991", *AEA Papers and Proceedings*, 83, (2), 270-274.

Boehm, E. and M.H. Moore (1984), "New Economics Indicators for Australia, 1949-84", *Australian Economic Review*, 17, (4), 34-56.

Bosworth, B. (2001), *Output and Productivity in the Transportation Sector: An Overview*, The Brookings Institution.

Brier, G.W. (1950), "Verification of Forecasts Expressed in Terms of Probability", *Monthly Weather Review*, 75, 1-3.

Bry, G. and C. Boschan (1971), "Cyclical Analysis of Time Series: Selected Procedures and Computer Programs", *NBER Technical Paper 20*.

Burns, A.F. and W.C. Mitchell (1946), *Measuring Business Cycles*, New York: National Bureau of Economic Research.

Conference Board (2001), "Calculating the Composite Indexes", *www.conference-board.org*, revised 01/2001.

Diebold, F.X. and G.D. Rudebusch (1996), "Measuring Business Cycles: A Modern Perspective", in *Business Cycles, Durations, Dynamics, and Forecasting*, New Jersey: Princeton University Press, 117-143.

Diebold, F.X. and G.D. Rudebusch (1989), "Scoring the Leading Indicators", *Journal of Business*, 62, 369-391.

Dixon, F.H. (1924), "Transportation and Business Cycle", in Edie, L.D. (ed.), *The Stabilization of Business*, New York: The Macmillan Company, 113-163.

Feenberg, D. and J. Miron (1997), "Improving the Accessibility of the NBER's Historical Data", *Journal of Business and Economic Statistics*, 15, (3), July, 293-299.

Ghosh, A.R. and H.C. Wolf (1997), "Geographical and Sectoral Shocks in the US Business Cycle", *NBER Working Paper #6180*, September.

Gordon, R.J. (1992), "Productivity in the Transportation Sector" in Griliches, Z. (ed.), *Output Measurement in the Service Sectors*, 371-428.

Gordon, R.J. (1980), "Postwar Macroeconomics: The Evolution of Events and Ideas", in Feldstein, M. (ed.), *The American Economy in Transition*, University of Chicago Press, 101-182.

Hall, R.E. (1993), "Macro Theory and the Recession of 1990-1991", *AEA Papers and Proceedings*, 83, (2), 275-279.

Han, X. and B. Fang (2000), "Four Measures of Transportation's Economic Importance", *Journal of Transportation and Statistics*, 3 (1), 15-30.

Harding, D. and A. Pagan (2002), "Dissecting the Cycle: A Methodological Investigation", *Journal of Monetary Economics*, 49, 365-381.

Hansen, G.D. and E.C. Prescott (1993), "Did Technology Shocks Cause the 1990-1991 Recession?", *AEA Papers and Proceedings*, 83, (2), May, 280-286.

Hultgren, T. (1948), *American Transportation in Prosperity and Depression*, New York: National Bureau of Economic Research. See also Hultgren, T. (1948), *The Allocation of Railroad Freight Cars,* Chicago: NBER and University of Chicago.

Hultgren, T. (1955), "Forecasts of Railway Traffic", in National Bureau of Economic Research, *Short-Term Economic Forecasting, Studies in Income and Wealth*, Vol. 17, Princeton: NBER and Princeton University Press, 1955.

Irvine, F.O. and S. Schuh (2005), "Inventory Investment and Output Volatility", *International of Production Economics*, 93-94, (8), 75-86.

Kim, C.J. and C.R. Nelson (1999), "Has the US Economy Become More Stable? A Bayesian Approach Based on a Markov-Switching Model of Business Cycle", *The Review of Economics and Statistics*, 81, 1-10.

Kim, C.J. and C.R. Nelson (1998), "Business Cycle Turning Points, A New Coincident Index, and Tests of Duration Dependence Based on A Dynamic Factor Model with Regime Switching", *The Review of Economics and Statistics*, 80, (2), 188-201.

Klus, A., J.S. Landon-Lane and E.N. White (2005), "How Could Everyone Have Been so Wrong? Forecasting the Great Depression with the Railroads", *Explorations in Economic History*, 42, (1), 27-55.

Lahiri, K. and G.H. Moore (1991), "Introduction", in Lahiri, K. and G.H. Moore (eds.) *Leading Economic Indicators: New Approaches and Forecasting Records*, Cambridge, UK: Cambridge University Press, 1-11.

Lahiri, K. and J. Wang (1994), "Predicting Cyclical Turning Points with Leading Index in a Markov Switching Model", *Journal of Forecasting*, 13, 245-263.

Lahiri, K. *et al.* (2004a), "Monthly Output Index for the US Transportation Sector", *Journal of Transportation and Statistics*, 5 (⅔), 1-27.

Lahiri, K. and W. Yao (2006), "Economic Indicators for the US Transportation Sector", *Transportation Research, Part A: Policy and Practice*, 40, 872-887.

Lahiri, K. and W. Yao (2004b), "The Predictive Power of an Experimental Transportation Output Index", *Applied Economics Letters*, 11 (3), 149-152.

Lahiri, K., W. Yao and P. Young (2003), "Business Cycle Analysis for the US Transportation Sector", paper presented at the conference "Business Cycles: Theory, History, Indicators, and Forecasting" in Honor of Victor Zarnowitz, organised by CIRET and RWI, Essen, Germany.

Layton, A. and G.H. Moore (1989), "Leading Indicators for the Service Sector,"*Journal of Business and Economic Statistics*, 7, (3), July, 379-386.

McConnell, M.M. and G. Perez-Quiros (2000), "Output Fluctuations in the United States: What has Changed Since the Early 1980's?", *American Economic Review*, 90, 1464-1476.

McNees, S.K. (1992), "The 1990-1991 Recession in Historical Perspective", *New England Economic Review*, January/February, 3-22.

Mitchell, W.C. and A.F. Burns (1938), "Statistical Indicators of Cyclical Revivals", *Bulletin 68*, New York: NBER, May, reprinted in G.H. Moore (ed.) (1961), *Business Cycle Indicators, Volume I*, Princeton, New Jersey: Princeton University Press for NBER, 162-183.

Moore, G.H. (1950), "Statistical Indicators of Cyclical Revivals and Recessions", *Occasional Paper 31*, New York: NBER, reprinted in Moore, G.H. (ed.) (1961), *Business Cycle Indicators, Volume I*, Princeton, New Jersey: Princeton University Press for NBER, 184-261.

Moore, G.H. (1987), "The Service Industries and the Business Cycle", *Business Economics*, 22, 12-17.

Moore, G.H. (1961), *Business Cycle Indicators, Volume I and Volume II*. Princeton, New Jersey: Princeton University Press for NBER.

Nordhaus, W.D. (2002), "The Mildest Recession: Output, Profits, and Stock Prices as the US Emerges from the 2001 Recession", *NBER Working Paper #8938*, NBER.

Romer, C. and D. Romer (1994), "What Ends Recessions?", in Fisher, S. and J. Rotemberg (eds.) *NBER Macroeconomics Manual*, Cambridge: MIT Press, 13-57.

Stock, J.H. and M.W. Watson (2002), "Has the Business Cycle Changed and Why?" in Mark Gertler and Ken Rogoff (eds.), *NBER Macroeconomics Annual 2002*, MIT Press.

Stock, J.H. and M.W. Watson (1989), "New Indexes of the Coincident and Leading Economic Indicators", *NBER Macroeconomics Annual*.

Temin, P. (1998), "The Causes of American Business Cycles: An Essay in Economic Historiography", in Fuhrer, J.C. and S. Schuh (eds.), *Beyond Shocks: What Causes Business Cycles*, Conference Series No. 42, Federal Reserve Bank of Boston, June.

Zarnowitz V. and A. Ozyildirim (2006), "Time Series Decomposition and Measurement of Business Cycles, Trends and Growth Cycles", *Journal of Monetary Economics*, 53, (7), 1717-1739.

Zarnowitz, V. (1992), *Business Cycles: Theory, History, Indicators, and Forecasting*, The University of Chicago Press.

Zarnowitz, V. and C. Boschan (1977), "Cyclical Indicators: An Evaluation and New Leading Indexes", *Business Conditions Digest*, US Department of Commerce, 170-179.

Zarnowitz, V. and C. Boschan (1975), "New Composite Indexes of Coincident and Lagging Indicators", *Business Conditions Digest*, pp. v-xx.