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Should Transportation Output be Included as Part of the Coincident Indicators System?

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Abstract

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 transportation services output index (TSI) as an additional coincident indicator in determining the peaks and troughs of U.S. economy. The index represents a service sector that plays a central role in facilitating economic activities between sectors and across regions, and can be very useful in monitoring the current state of aggregate economy. We evaluate the marginal contribution of TSI to correctly identify cyclical turning points in the context of four currently used NBER indicators. TSI is found to have additional advantage over the composite index of coincident indicators in identifying the turning points, and has been of critical importance in recent recessions.

Keywords: Transportation services Index (TSI), Business cycles; Coincident indicators.

JEL classification: E32; C10

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1. Introduction

The U.S. economy has become increasingly more service-intensive in the postwar period. For instance, the data for U.S. GDP by major type of products during 1953: I-2009: II shows that 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%. The relative change in the share of employment providing these two types of products in total non-farm employment is even wider. Moore (1987) points out that the ability of the service sectors to create jobs has differentiated business cycles since 1980s from their earlier counterparts, and has led economy-wide recessions to be shorter and less severe. This is reflected as mild declines in employment of service sectors and its dominance in the total nonfarm employment, see in Figure 1a. Kim and Nelson (1999), McConnell and Perez-Quiros (2000), and Stock and Watson (2002) have also found that U.S. economy has become more stable since mid-1980s. A comparison of several central economic variables by Nordhaus (2002) indicates that the 2001 recession was the mildest in the postwar period. The current recession, which has clearly been very severe, started in the financial services sector. All these stylized facts of U.S. business cycles are heavily related to the growing importance of service-providing sectors relative to goods-producing sectors, though the latter has drawn most attention in business cycle studies thus far. Figure 1b depicts growth in real GDP by major type of products obtained from National Income and Product Account (NIPA). Since 1985 services sector never had a negative growth, which has largely neutralized the volatility in goods and structures, and resulted in more stable economy as measured by total GDP. Contribution of services to GDP during postwar recessions is more clearly recorded in Table 1. On average, decline in real GDP during recessions would have been at least 70% more severe without the stabilization effect from services. The information from the services thus has also become essential to the understanding of fluctuations in the modern economy. Yet among four coincident indicators that NBER dating committee uses to date the turning points, none of them specifically represents the service-providing sectors. In short, services are underrepresented in NBER's decisions on U.S. recessions (Layton and Moore, 1989).

Transportation-related sectors (*viz.*, transportation services, transportation equipment and transportation infrastructure) 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 economy, and even proposed that regulation of the railways be part of stabilization policies. More interestingly, a number of transportation indicators were included as part of the twenty-one cyclical indicators in the original NBER lists refined by Mitchell and Burns (1938) and Moore (1950).[1] Burns and Mitchell (1946, p. 373) and Hultgren (1948) found that the cyclical movements in railway coincided with the prosperities and depressions of the economy at large. Moore (1961, volume I, pp. 48-50), based on updated data through 1958, find 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, in the 1950's, of many of the monthly transportation indicators. For more information on the history of cyclical indicators, see the NBER Macrohistory database available online (Feenberg and Miron, 1997). Today, with increasing competition, inventories and sales have become more integrated, and consequently transportation has become critical to business operations.[2] However, this part of the economy is largely ignored in business cycle studies.

Transportation represents a significant part of the U.S. economy. Using different concepts about 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 geographical and sectoral shocks in the U.S. business cycles, find that transport (and/or motor vehicles) is one of sectors highly correlated with intra-state and intra-sector shocks, thus crucial in the propagation of business cycles. Thus, a measure of transportation activities could be very useful in monitoring the current state of general economic activity.

[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] Irvine and Schuh (2003) 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 a more integrated supply chain management. Both factors are closely related with transportation.

In a project sponsored by U.S. 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) utilizes eight series on freight and passenger movements by the 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.[3] Lahiri and Yao (2004b) also find that the strong cyclical movements observed in the TSI appear to be well synchronized with the NBER-defined recessions and growth slowdowns of the U.S. economy. TSI can give early signals to the onset of economic recessions while being contemporaneous to economic recovery. Given its representation and connections, TSI thus can be an additional coincident indicator as part of NBER system in correctly dating the current turning points in a timely fashion.[4]

The paper is organized into three sections. After the Introduction, Section 2 reviews the historical NBER chronology since 1958 with the inclusion of TSI. Section 3 constructs various composite coincident indexes (CCI) with different combination of four currently used coincident indicators and TSI. Three methods are employed for this purpose: NBER nonparametric method, dynamic factor models with and without regime switching. For each of them, there is a corresponding scoring method to evaluate the relative performance of five indicators in dating economic turning points. The last section summarizes the conclusion 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 the several hundred time series under the NBER's study. After the war, Geoffrey Moore took

[3] 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.

[4] Since March 10, 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 http://www.bts.gov/xml/tsi/src/index.xml.

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. These indicators typically are measures on those sectors and processes that are affected much more by business fluctuations or more sensitive to market conditions than others, such as industrial production and inventory investment (Zarnowitz, 1975a; 1975b; 1992). The coincident indicators are used to define the current state of economy. Among the four currently used coincident indicators,[5] all employees of nonfarm industries (EMP) and personal income less transfer payments (INC) are comprehensive indicators with broad coverage. The other two, IP and manufacturing and trade Sales (Sales) measure the performance of individual sectors, namely manufacturing and trade sectors. Thus, none of the current four indicators represent the service sectors of the economy. The newly constructed TSI can be the fifth coincident indicator representing a service sector and its pervasive connections with different aspects of economy and across the nation. The seasonally adjusted data of these five indicators are depicted in Figure 2.[6] Both the current four indicators and proposed additional one are well synchronized with NBER recessions (shaded areas). But cycles in TSI, like IP, are very deep and clear with two extra turns capturing the stand-alone slowdowns in 1984 and 1995 respectively. This means that transportation output is very sensitive to change in market conditions, thus can serve as a quality indicator like IP as well.

2.2. Spider Charts for Historical Business and Growth Cycles

The historic record of these five coincident indicators during recessions can be reviewed using the spider charts[7] for eight recessions since 1958, when all four current coincident indicators became available. TSI became available in January 1979, but it can be extended to cover the recession of 1973-1975 using its largest component series, trucking tonnage index beginning January 1973. To compare the timing of each indicator relative to NBER chronology, NBER dating algorithm described in Bry and Boschan (1971), namely BB algorithm, is employed to

[5] In the November 1968 issue of Business Conditions Digest (BCD), U.S. Bureau of Economic Analysis started to produce composite indexes, where the CCI was based on five coincident indicators. In the December 1975 issue of BCD, one of them, unemployment rate (inversed) was dropped and four remained in use till today.

[6] The seasonally adjusted TSI is based on its seasonally adjusted component series adjusted using Census' X12-ARIMA with adjustment of both trading day and holiday effects if they are significant. The seasonally adjusted series of other four indicators are readily available.

[7] This is a chart where values of all depicted series are normalized to 1 at the month defined for peaks or troughs. The employed spider chart in our paper is defined by peaks, while the NBER Dating Committee present charts both peaks and troughs on its website.

identify the turning points via peak and trough dating. The NBER procedures for reference cycles (Boehm and Moore, 1984)[8] require visually identifying clusters of turning points of all series by seeking to minimize the distance between the turning points in each cluster. In reality, specific 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 for U.S. economy have reached consensus with at least one of two broad indicators, EMP or INC, regardless of the other two. While consensus among four coincident indicators at troughs have been easily reached except for the 2000 recession.

Therefore we have prepared ten spider charts, one for each of the eight recessions and two growth slowdowns and are plotted in Figures 3a through 3j, where the darker shaded areas represent the corresponding NBER recession and lightly shaded areas represent NBER defined growth slowdowns preceding or following full-fledged recessions. To have a clear picture of evolution of individual coincident indicator during recessions, we also plot federal funds rate, as a measure of monetary policy, during 1958:1 to 2003:8 in Figure 4. However, this does not assume the monetary tightening is the cause of every recession. See Zarnowitz (1992, chapter 7) and Zarnowitz and Ozyildirim (2002) for discussions on growth cycles; Gordon (1980), Zarnowitz (1992, chapter 3), McNees (1992) and Temin (1998) for excellent commentaries on the causes of American business cycles.

2.2.1. Recession of 1960:4 to 1961:2

Recession of 1960:4 to 1961:2, as depicted in Figure 3a, took place during Eisenhower's tight budgetary regime. While some people have regarded the budget surplus as a cause of contraction, the surplus was planned, in conjunction with expansionary monetary policy, to stimulate private investment (Gordon, 1980, p. 131). The cause of the recession was the drastic tightening of money supply that occurred in 1959-60, because of mistimed fears of inflation and higher interest rates, plus overoptimistic forecasts of real growth. McNees (1992) argues that this cycle may be the first and perhaps the clearest example of a recession due to a forecast error. The underlying strength of the economy was obscured by the effects of the steel

[8] From specific cycles of each indicator to the final defined NBER chronology, very limited information has been provided by the NBER dating committee on its procedures. Thus far, Boehm and Moore (1984) in dating final business cycle chronology for Australian economy have provided the clearest description of NBER procedures.

strike from July 15 to Nov. 7, 1959, including the anticipatory buildup. Once the strike was settled, economic activity would continue at a vigorous pace that all four coincident indicators had displayed in Figure 3a. The federal funds rate was staying above 3% in 1959 until August that year, and then it was adjusted downward, see Figure 4. In early 1960, monetary policy was tightened again with federal funds rate shooting up from 1.45% to 2.54%. As a result, both IP and Sales began to decline in January 1960. Labor market (EMP) responded to this shock fairly slowly, which declined three month after the manufacturing and trade sectors. Consequently, the peak of that recession was defined to have occurred in April 1960 following that of EMP. During this recession, INC did not have a clear peak or deep real decline. It declined only for two months beginning in October 1969. This recession lasted for 10 months until all four series began to recover. The trough was defined when IP and EMP started their recoveries, while Sales and INC started moving up one or two months earlier.

2.2.2. Recession of 1969:12 to 1970:11

This cycle was caused by the decline in government spending during the end of the Vietnam War (Zarnowitz, 1992, pp. 113-114). After the previous recession, new tax incentives to stimulate investment were legislated in 1962, 1964 and 1965. After 1965, the federal budget was in deficit each year except 1969. Both IP and Sales had signs of slowdown since March 1969, see Figure 3b. This date was also defined as the peak of growth slowdown. It eventually cumulated into a full-fledged recession nine months later. The peak of this cycle, defined in December 1969, is coincident with that of INC while EMP peaked three month later. The 1970 recession unfolded in two fairly distinct phases: an initial, fairly mild downturn in activity until September and a second leg associated with the 68-day strike at General Motors from September 15 to November 23, 1970. Owing to the strike, all four coincident indictors reached a clear trough in November, but it is virtually impossible to guess exactly when the trough would have been if no strike had occurred (McNees, 1992). Immediately following the recession, the Fed responded with a much easier monetary policy in which federal funds rate dramatically fell from above 6% since May 1967 to below 5% after December 1969 as shown in Figure 4 (Romer and Romer, 1994).

2.2.3. Recession of 1973:11 to 1975:3

The 1973-1973 recession produced the largest dip in economic activity in the postwar period. Many studies have discussed the characteristics and causes of this recession. There can be no doubt that the cause of this cycle was the quadrupling of oil price by 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 unprecedented oil embargo and large increases in energy costs following the outbreak of the Yom Kippur War on October 6 of 1973. However, many commentators at the time and later had argued that Fed was excessively aggressive in its attempt to limit the resulting inflation (Gordon, 1980; Zarnowitz, 1992). As we can see in Figure 4, the federal funds rate had been maintained above 10% from April through October of 1973, the month before the start of recession. This was recognized as a slowdown beginning in March 1973 followed by a recession beginning November 1973. As Figure 3c shows, substantial decline had occurred in Sales in February through August of 1973 while only 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. Like the previous recession, EMP responded sluggishly with 11-month lag at this peak.

According to Romer and Romer (1994), the Fed was quick to discern the onset of recession around February 1974, but was slow to realize its severity. It was not until October 14 the FOMC meeting of that year that the Fed acknowledged that there would be an extended decline in real activity. Beginning in September, however, the FOMC began to move the ease policy significantly, shown as a dramatic decline of federal funds rate (Figure 4). The summary of actions by the Board of Governors in September through November stated the use of the discount rate and open market operation. 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.

Like the previous one, 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 took a nose-dive. This distinction is coincident to the timing of monetary policies.

Trucking tonnage has become available since January 1973 and thus can be used as proxy for TSI. Like Sales in this period, trucking activity also had a temporary real decline in April 1973 following the monetary tightening, which corresponded to the slowdown preceding that recession. Then a much severe decline had occurred in trucking industry exactly during the month when IP, Sales and INC began their decline, which is November 1973. 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 has decreased by 30%. Part of the reason is that this recession had a great deal to do with oil shocks, which actually hit the trucking industry from both supply and demand sides. Like two other sectoral measures (IP, Sales), trucking tonnage is also very sensitive to monetary policy and market changes. But cyclical behavior of trucking tonnage is more correlated with Sales, the realization of which involves delivery.

2.2.4. Recession of 1980:1 to 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. Price of spot oil had a sudden dramatic surge in 1979 when the revolution in Iran disrupted the world oil market, which raised the price from $14.85 to $32.5/barrel by January 1980. Driven by high energy cost, the annual inflation rate had been at double-digit level up to 18% during 1979 and 1980. To combat high inflation, the Fed had kept the federal funds rate constantly above 10% with a huge increase in March and April of 1979. From August 1979 to January 1980, the rate had been raised again from 9% to 19%, a record-breaking high. Following these factors, both IP and Sales, shown in Figure 3d, began their real decline in March 1979, corresponding to the growth recession 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. Nevertheless, labor market had been stagnated in late 1970s and early 1980s with recession and recovery was hard to be identified. 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 until the spring of 1980. Then from the third quarter of

1980, the combination of weak money growth and unfavorable news about real GDP pushed the FOMC to lower the federal funds rate really sharply, which actually brought all four coincident indicators to the end of this cycle around July 1980.

The TSI has become available for the recession of 1980:1 to 1980:7. Like trucking tonnage in the previous recession, cycles in TSI plotted in Figure 3d are always very sharp and clear. Based on the above analysis, it is also very sensitive to policy and market condition changes, even more than IP and Sales. In response to oil price shock and hyperinflation, TSI began to decline in March 1979, the same time as IP and Sales, and continued till 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 gives very clear signal to the start of slowdown and that of recovery in this episode.

2.2.5. Recession of 1981:7 to 1982:11

Although being taken as continuation of the previous cycle, the recession starting in 1981 is attributed to additional reasons besides oil crisis, in part due to Paul Volcker's influence who was appointed as the Chairman of the Fed by President Carter. Monetary policy in early 1980s was a departure from the Fed policy during the 1970s and 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 3e reveals that IP, Sales, TSI and INC also started to have real declines from December 1980. The decline in TSI and Sales had continued until the end of recession around November 1982, while the other two (IP and INC) only dropped slightly, subsequently recovered from April that year until January 1981, and fell again into a recession. The peak of the recession was defined based on that of IP and INC, while EMP again peaked one month later. Both TSI and Sales also reflected two surges in the corresponding economic activity in January 1981 and February 1982 respectively, corresponding to Fed's action of lowering the federal funds rate.

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

2.2.6. Slowdown of 1984:9 to 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 compared with classical business cycles, there has been not much work studying them.[9] We value them simply because recessions are usually preceded by long slowdowns, which may or may not develop into recessions due to different reasons including concerns and discretional policy of the Federal Reserve. But by the sensitive nature of cyclical indicators, they 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 coincident indicators, as depicted in Figure 3f. IP, as the measure of manufacturing output, had been stagnated through the period from September 1984 to January 1987 while TSI, as the measure of transportation output, began to slow down two months earlier and ended in December 1985, about 13 months prior to IP. The cycle in the latter is also clearer with larger amplitude. As we see in Figure 4, FOMC actually raised the federal funds rate all along since early 1983 through the third and fourth quarter of 1984. Slowdowns in IP and TSI could be responses to this monetary tightening.

2.2.7. Recession of 1990:7 to 1991:3

The 1990 recession was due to a fall in consumption even though economists have argued whether the fall was exogenous or endogenous (Temin, 1998; Blanchard, 1993; Hall 1993; Hansen and Prescott, 1993). It is true that real consumption had declined in fourth quarter of 1990 and first quarter of 1991, but signs of slowdown had appeared long back in 1989. McNees (1992) argues that this recession was the natural result when “soft landing” was not achieved after a long lasting boom. In Figure 3g, we see that IP and Sales started to decline from January 1989 and had been slowly recovering since July that year until they were finally hit by consumption shocks in the third quarter of 1990. TSI had a similar scenario, but it peaked even three months earlier than both IP and Sales at the start of slowdown. It also had been recovered since July 1989 until the economic recession began. For the other two

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[9] A recent exception is Zarnowitz and Ozyildirim (2006).

indicators, a mild slowdown occurred to INC in early 1989 while nothing significantly affected EMP.

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, it was fairly slow for Fed to realize that a recession was actually under way during the fall of 1990 and take effective measures. Not until November 1990 did the FOMC decide for some slight immediate easing of severe conditions. The federal funds rate was lowered in early 1989 and additional reduction was not made until November 1990, see Figure 4. In 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 track, recovering 10 months after the over all trough.

Immediately following the recession, economy did not have a strong recovery like those in 1980s or earlier. Instead, all the series were undergoing slowdowns until December 1991 or even later. Therefore, the recession of 1990 and the one we will discuss next are 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). Similar characteristic is also found in IP and Sales. Recall the discussions on the so-called 'great moderation' in the United States: as service-providing sectors have become increasingly more important and supply chain management and monetary policies have became more fine tuned, U.S. economy has witnessed more stability since mid-1980s. Various factors have made recession shorter and less severe. But as we see, the reduced part of recession has possibly been accounted as part of growth slowdowns, which can only be reflected in these highly sensitive sectoral measures such as IP, Sales and TSI, rather than the broad measures. As Figure 4 reveals, although the duration of recessions since 1990 has been shorter, duration of recessions and their neighboring growth cycles have not. Thus, it is expected that identifying the turning points of recession in the future, in particular troughs, will more likely to rely on the sectoral measures.

2.2.8. Slowdown of 1995:1 to 1996:1

Between recession of 1990 and that of 2001 is a long-lasting boom. In the middle, there is also a stand-alone slowdown that did culminate into a full-fledged recession. In Figure 3h, we see that IP, Sales and INC had signs of decelerations over the period of 1995:1 to 1996:1. Declines in IP and INC were lighter than that in Sales. While in TSI, this had been a severe sector-wide recession during the period of 1994:12 to 1996:1 with a drop of 11%, about its average decline during recessions but worse than the 1990 recession (6%). Thus, TSI also gave signal for economy-wide slowdown. In Figure 4, we see that this decline followed a series of small increments in federal funds rate since November 1993. Thus, declines in TSI, IP and Sales could be responses to this monetary tightening.

2.2.9. Recession of 2001:3 to 2001:11

In the 1990s, U.S. economy experienced the longest expansion in the history. Being cautious of the possible "irrational exuberance", the FOMC has raised federal funds rate beginning June 1999, which was the first credit tightening in more than two years. The raise 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 had signs of stagnation since January through December 2000, its peak occurred 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 featured a double recession: first phase is the period from 1999:11 to 2000:4 when this sector began recovering, and the second is from 2000:11 to 2001:9, which still gave early signal to economic peak by four months. Combining the first phase, TSI would have an 11-month lead-time relative to the economic recession.

The peak of this cycle was defined when EMP reached its peak, and relative to it, INC peaked 3 months earlier. Since then, the federal funds rate had been lowered below 2%. A special event during this recession was the September 11 event did have a profound effect on TSI (dropped by 12%), while only slight effect on Sales and not much on other series, see Figure 3i. This immediately marked that month as the trough of TSI.[10] The trough of this cycle was defined at somewhere between Sales, INC and IP, closer to INC. Like in the recession of

[10] But without this event, TSI would have reached its trough in November 2001 as well. Using Census X12-ARIMA procedure, removal of this kind of irregular movements result in trend-cycle component of the original TSI, which shows a trough in November 2001.

1990, EMP has not recovered since then till the third quarter of 2003, about 2 years after the economic trough.

2.2.10. Recession of 2007:12

The bankruptcy of Lehman Brothers in September 2008 precipitated what, in retrospect, is likely to be judged 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 purchase. 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 $400 billon. In July 2008, oil prices peaked at $147 a barrel and a gallon of gasoline was more than $4 across most of the USA. Needless to say, the U.S. monetary policy contributed to the recession by excessive money creation. Figure 4.3j reveals that, compared to EMP and INC, the sectoral indices like IP, Sales and TSI again issued a very clear signal for a peak around December 2007. The same indicators together with INC are suggesting a trough of the cycle around June 2009 – thus that the current recession would have lasted over 16 months. In Figure 5, we have plotted TSI and its freight and passenger components from 1979: till 2010:3. The deviation of TSI from it HP trend is also depicted. We clearly see that during the last recession that began in November 2007, TSI has been almost coincident with the peak and the presumed trough. The role of TSI as a faithful coincident indicator both at the peak and the trough is again established.

The above episodic analysis of 10 recessions and slowdowns suggests that every recession and growth slowdown had something to do with monetary policies that might have either caused recessions or stimulated the recoveries. Either way, TSI, IP and Sales are very sensitive to these policy changes or shocks. Since 1958, every recession is preceded by a fairly long slowdown.[11] Cycles in these three measures 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

[11] The only exception from the NBER-dated chronology is the recession of 1981, but it did have additional short and mild cycle right before it, as we see from Figure 3e.

phase gave clear signals for a slowdown while second high corresponded to the next phase of the economic recession. During the latest peak of 2007 recession, TSI again signaled 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 gives early and clear signals for economic recessions.

The timing of these five coincident indicators relative to the NBER chronology is reported in Table 2. At the troughs of last few recessions, recovery of EMP appears very weak, much lagging behind the other aspects of overall economy, which is partly due to the improved productivity since mid-1980s. This basically fails EMP as a useful indicator in identifying the economic trough. This missing role of labor data can be well made up by the TSI, whose recoveries could have always started at the same time as economic recoveries, should event of 9/11 have not happened. Nevertheless, the dating power of TSI for troughs of U.S. economy is better than any of the four currently used coincident indicators. At peaks, TSI tend to always peak earlier, by 7 months on the average. Unlike IP or Sales that may lead, lag or coincide with the economic peaks, TSI leads the onset of economic recessions with constant regularity. Given the observation that the NBER committee places special importance to the two broad indicators (EMP and/or INC) to identify the peak of U.S. economy, TSI as a sectoral measure is very useful in correctly dating the peaks if combined with two board indicators. Moreover, transportation output represents an important service sector that relates to various stages of fabrication. Thus, adding TSI as additional coincident indicator can broaden the representation of the current NBER dating system and add additional determinativeness.

3. CCIs with TSI

NBER studies of business cycles, inherited from Burns and Mitchell (1946), have two key features: comovement and regime switch (Diebold and Rudebusch, 1996). Extracting the comovement among coincident indicators leads to the creation of CCI. There are two different methods to construct CCI: non-parametric method of NBER (Conference Board, 2001) and parametric methods through the use of dynamic factor models without (Stock and Watson, 1989) or with regime switching (Kim and Nelson, 1998). CCI obtained from these three methods are named as NBER index, SW index and KN index respectively.

3.1. NBER Index

The NBER index is created by assigning fixed standardization factors as weights to growth rate of each component and taking the average. In details, four steps are involved.

1) Month-to-month changes (x_t) are computed for each component (X_t) using the conventional formula: $x_t = 200 * (X_t - X_{t-1}) / (X_t + X_{t-1})$.
2) The month-to-month changes are adjusted to equalize the volatility of each component using the standardization factors, the standardization factor for each component (w_x) is the inverse of standard deviation over sample period, then normalized to sum = 1, *i.e.*, $r_x = w_x / \Sigma_x (w_x)$ and $m_t = r_t * x_t$.
3) The level of the index is computed using the symmetric percent change formula: first, change of the index, i_t, is the average of adjusted month-to-month change of individual components; second, when getting back to the level of the index, the first month's value is $I_1 = (200 + i_1) / (200 – i_1)$, from second month forward, it is $I_t = I_{t-1} * (200 + i_t) / (200 – i_t)$.
4) The index is re-based to be average 100 in 1996 to make a formal NBER index.

By using the inverse of the standard deviation as weight, the contribution of change in each series to the final index is well balanced. These factors for constructing a NBER index from all five indicators are reported in Table 3. Besides this index, denoted as NBER index (5), alternatives would be indexes using every four indicators by removing one 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 6. Their cyclical movements are largely identical with only subtle differences in their slopes.

To compare the performance of these six indexes, 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 4. Historically, all CCIs has the same turning points as the NBER chronology except that NBER index (4: w/o EMP) results in a peak ten month earlier than that in NBER chronology for 1980 recession, which is consistent with turning points of IP, Sales and TSI. For the latest peak defined to have occurred in March 2001, three indexes suggest being in November 2000, two for December 2000 and one for October 2000, but none of them is for March 2001. They also suggest a trough around November 2001 as defined by the committee. All the indexes also detected a new peak either in December 2002 or January 2003.

We also use the index of concordance proposed by Harding and Pagan (2002) to measure the concurrence of turning points of each of these NBER indexes with NBER chronology. The Harding-Pagan index has the form

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

given a sample size of T and state variables (0 for recession and 1 for recovery) defined for series *x* and *y* using the BB algorithm. It ranges between 0 ~ 1. 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) would show the marginal contribution of the removed variables to the total five indicators. INC and Sales have negative contribution in correctly dating peaks and troughs of U.S. economy, and dating performance would be improved without them. EMP has the largest contribution among the group of coincident indicators.

3.2. Stock-Watson Index

Besides NBER index, an alternative would be using techniques of modern time-series analysis to develop dynamic factor models with regime switching (Kim-Nelson) or without (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.

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:

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

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 term w_t and ε_{it} respectively.

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

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

These two noise terms are assumed to be independent of each other. The equation (2) ~ (4) defines the Stock-Watson model and the state variable estimated from the model is thus the SW index. Our model specification is identical to original Stock-Watson model where three lags of state variables are used for employment variable to account for its lagging nature, while no lag is used for newly added TSI. Like NBER index, we estimate six SW indexes using different combinations of five coincident indicators. The estimation results are reported in Table 5, where the index estimated from all five indicators can be considered as an unrestricted model while others 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.[12] In Table 5, coefficient estimates are very similar across different models. Then the estimated SW index with five indicators and that with currently four coincident indicators are plotted in Figure 7. They are almost identical to each other. 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.[13] The transitions of different regimes (μ_{st}), incorporated into (2), 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 6. 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 8. Both indexes capture the double-dip feature shared by three sectoral measures (IP, Sales and TSI), as well as mild slowdowns in 1985 and 1995. All the indexes suggest that economic peak for the 2000 recession to have occurred at

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[12] 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.

[13] Both models were estimated using computer routines described in Kim and Nelson (1998).

the end of 2000, but they largely disagree on the date of the trough. The index without IP is the only one to recover from November 2001, and the rest picked up a little later.

The coefficient estimates of Stock-Watson and Kim-Nelson models with 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 a 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 9. Compared to Kim-Nelson, 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). These observations are consistent with those in Kim and Nelson's original paper.

As a byproduct, the Kim-Nelson model estimates the posterior probability that economy is in recession, as plotted in Figure 10. These probabilities inferred from the model feature the 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 also. The recession probabilities in Figure 10 also suggests that the 2000 recession started a little bit earlier and ended a little bit later compared the NBER chronology of March 2001 and November 2001 respectively. It also marks increasing probabilities of another possible recession around January 2003. To compare the performance of each KN index from different combinations among 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:

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

which rangers 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 realizations and assessed probabilities see Diebold and Rudebusch (1989) for more discussions. To account for undetermined regime since December 2002, we calculate the QPS for the sample period from January 1979 to December 2002 and they are reported in the last row of Table 6. All six KN indexes have QPS lower than 0.2, which suggests that they have a 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, and the index excluding TSI has the lowest accuracy with the highest QPS. Thus, adding TSI into the dating system would not improve the real-time dating performance based on probabilities form regime switching models as much as in the previous scoring methods.

4. Conclusion

In this paper we examined the usefulness of TSI as an additional coincident indicator to determine the peak and trough of business cycles in the U.S. economy. Transportation represents a service sector that plays an important role in propagating sectoral or geographical shocks into the overall economy. Adding the TSI into the NBER system would help the NBER dating committee to account for several important changes that has taken place in the economy since mid-1980s, such as reduced volatility in real GDP since 1984, decreasing importance of industrial production, increasing share of services sector, and failure of the employment indicator to co-move with other coincident indicators. The marginal contribution of TSI to the NBER business cycle dating chronology is carefully evaluated 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 give early signal, which combined with one of two broad measures would significantly save the time and confusion in correctly dating peaks in a timely fashion. CCI can be constructed using NBER, Stock-Watson and Kim-Nelson methodologies with six combinations of these five coincident indicators. For each such combination using the three alternative methodologies, we evaluated the marginal contribution of an individual indicator to the system. In every case, TSI was found to contribute significantly to the objectives of a dependable composite coincident indicator system with a performance better than the average.

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FIG. 1a Growth Rates in Employment

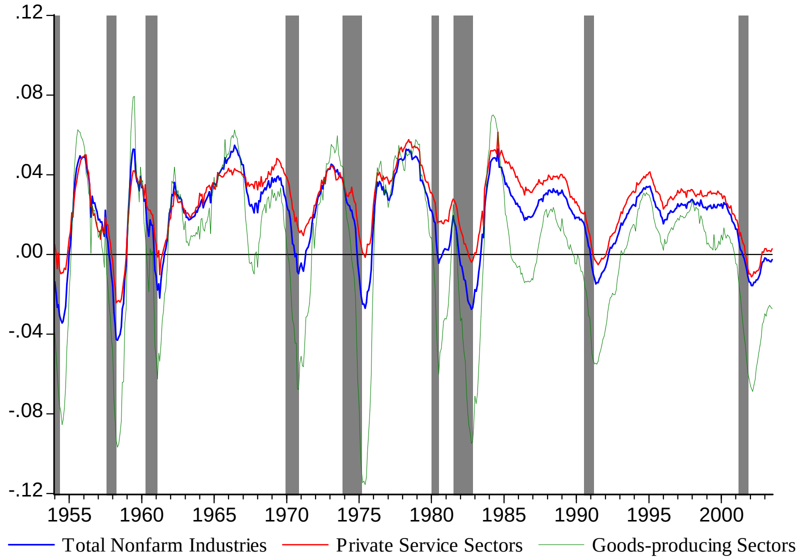


FIG. 1b Growth Rates in Real GDP by Major Type of Products

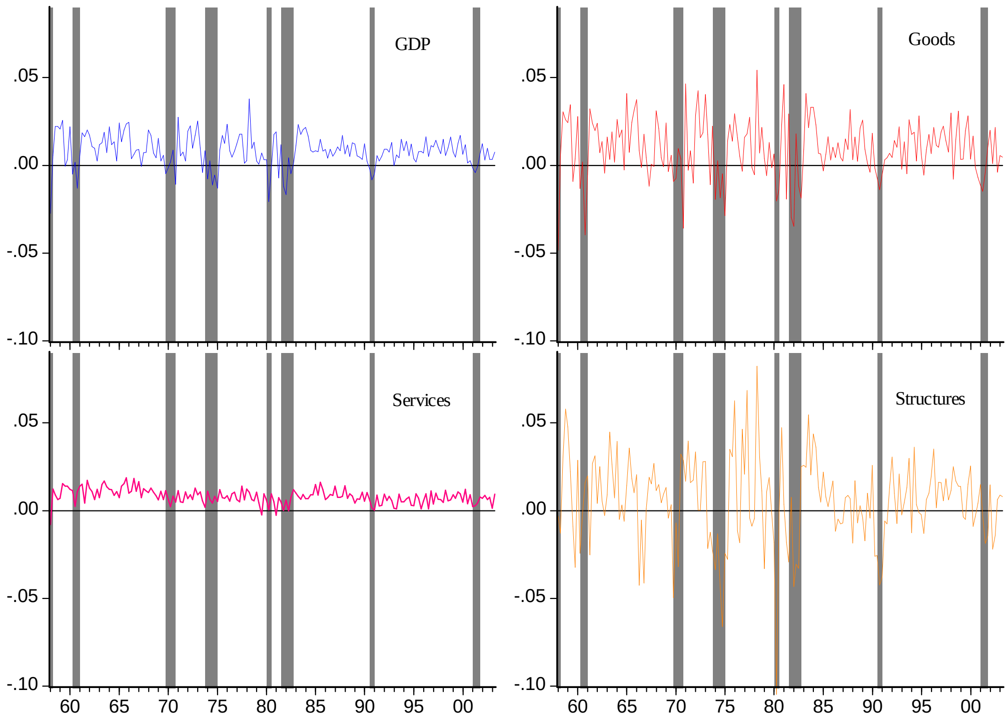


FIG. 2 Proposed TSI and Four Current Coincident Indicators of U.S. Economy

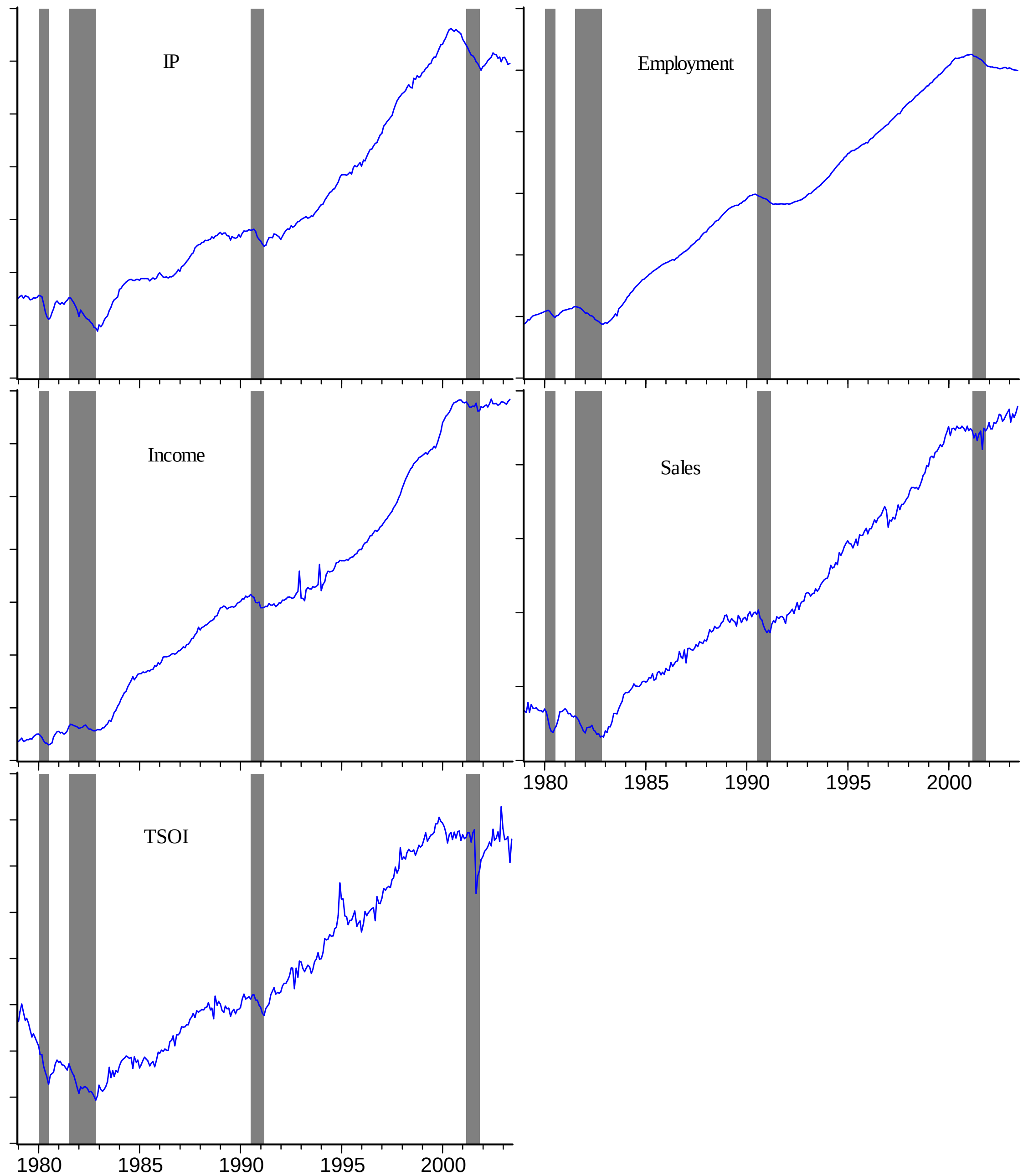


FIG. 3a

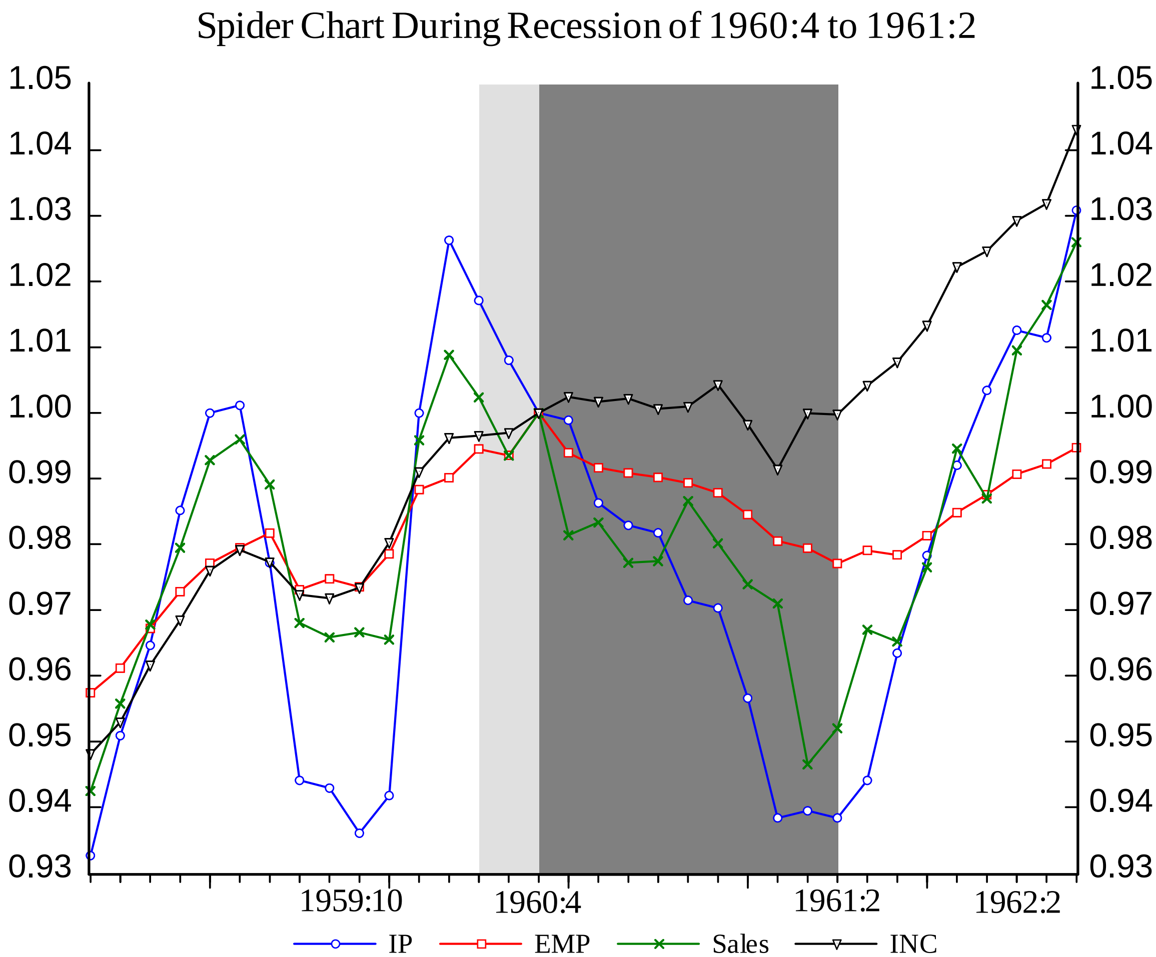

Spider Chart During Recession of 1960:4 to 1961:2
1.05
1.04
1.03
1.02
1.01
1.00
0.99
0.98
0.97
0.96
0.95
0.94
0.93
1959:10
1960:4
1961:2
1962:2
IP
EMP
Sales
INC

FIG. 3b

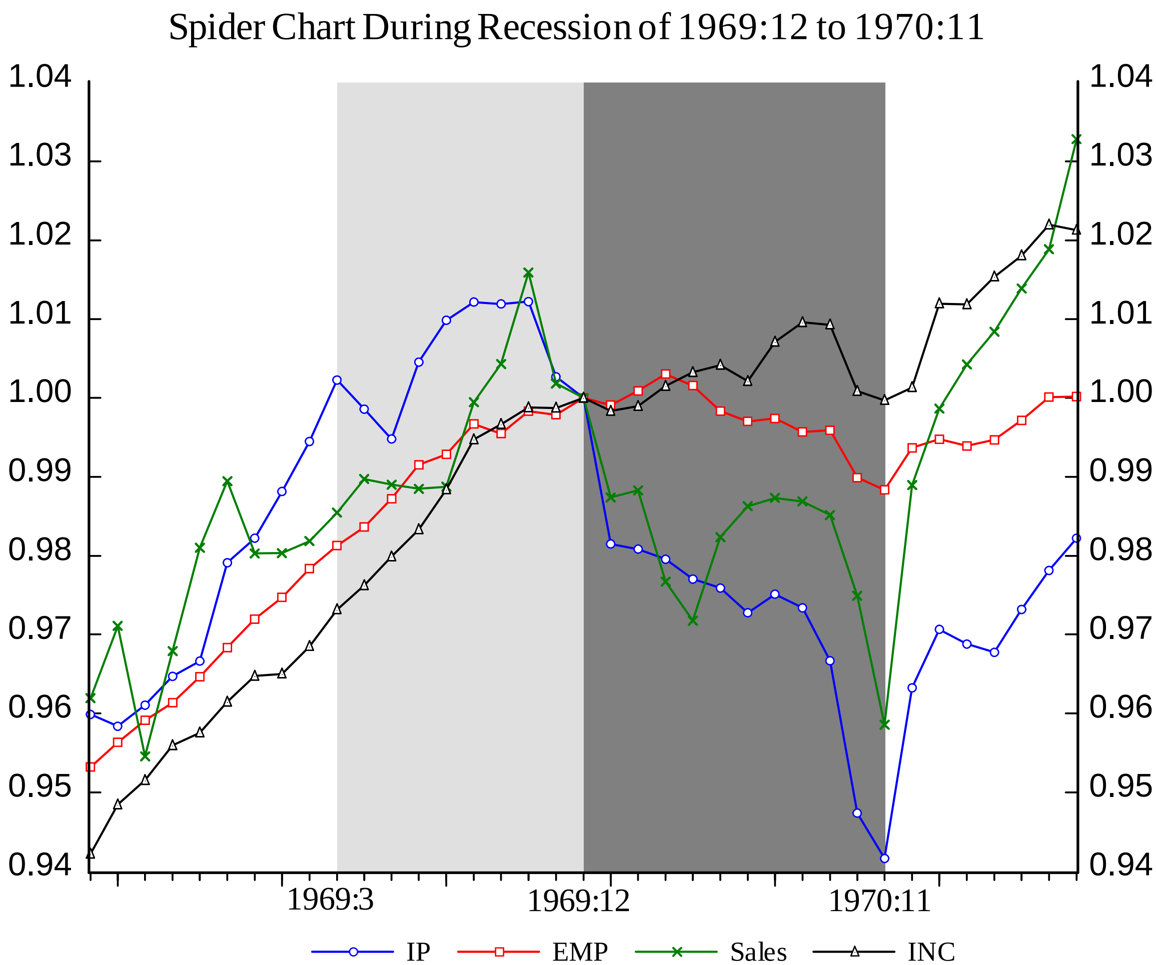
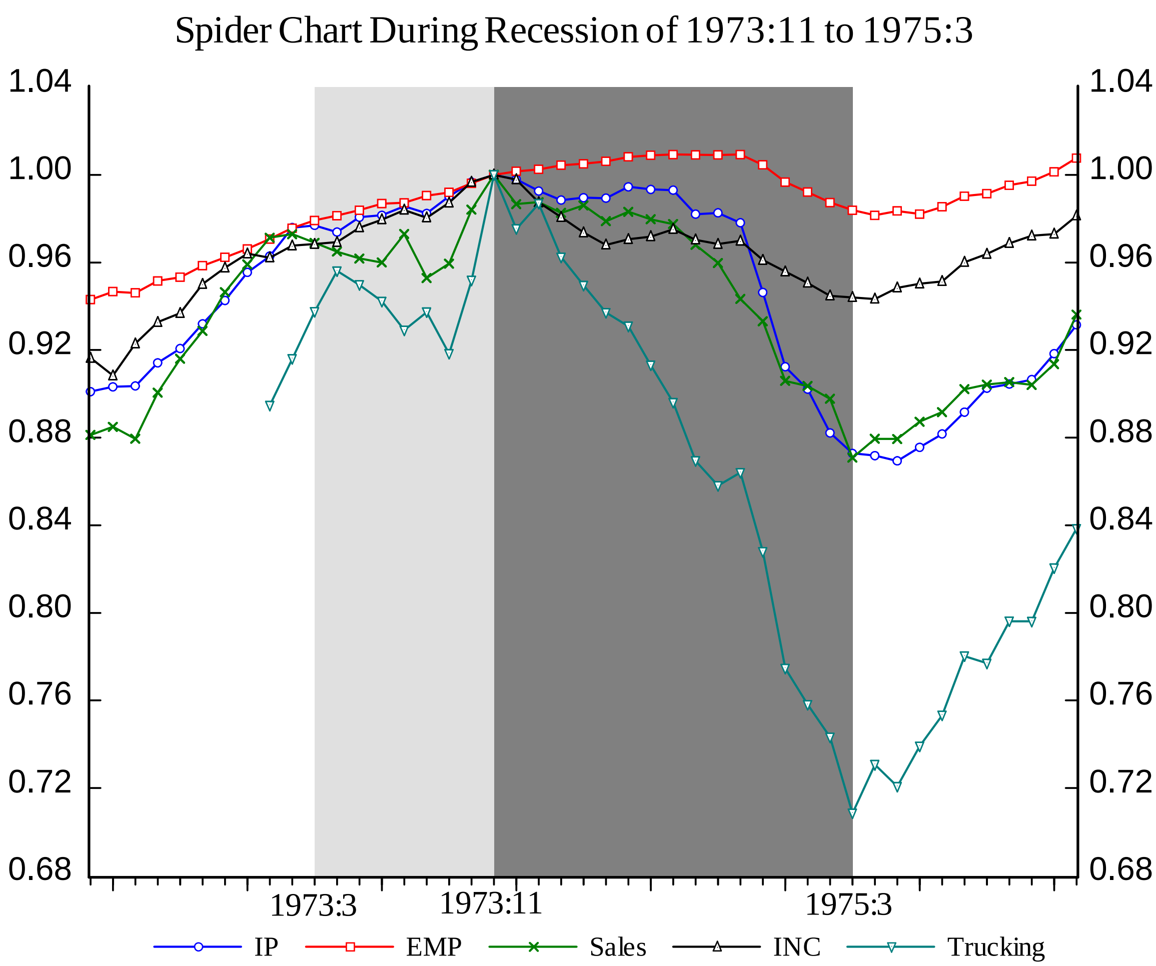

Spider Chart During Recession of 1969:12 to 1970:11
1.04
1.03
1.02
1.01
1.00
0.99
0.98
0.97
0.96
0.95
0.94
1969:3
1969:12
1970:11
IP
EMP
Sales
INC

FIG. 3c



Spider Chart During Recession of 1973:11 to 1975:3
1.04
1.00
0.96
0.92
0.88
0.84
0.80
0.76
0.72
0.68
1973:3
1973:11
1975:3
IP
EMP
Sales
INC
Trucking

FIG. 3d

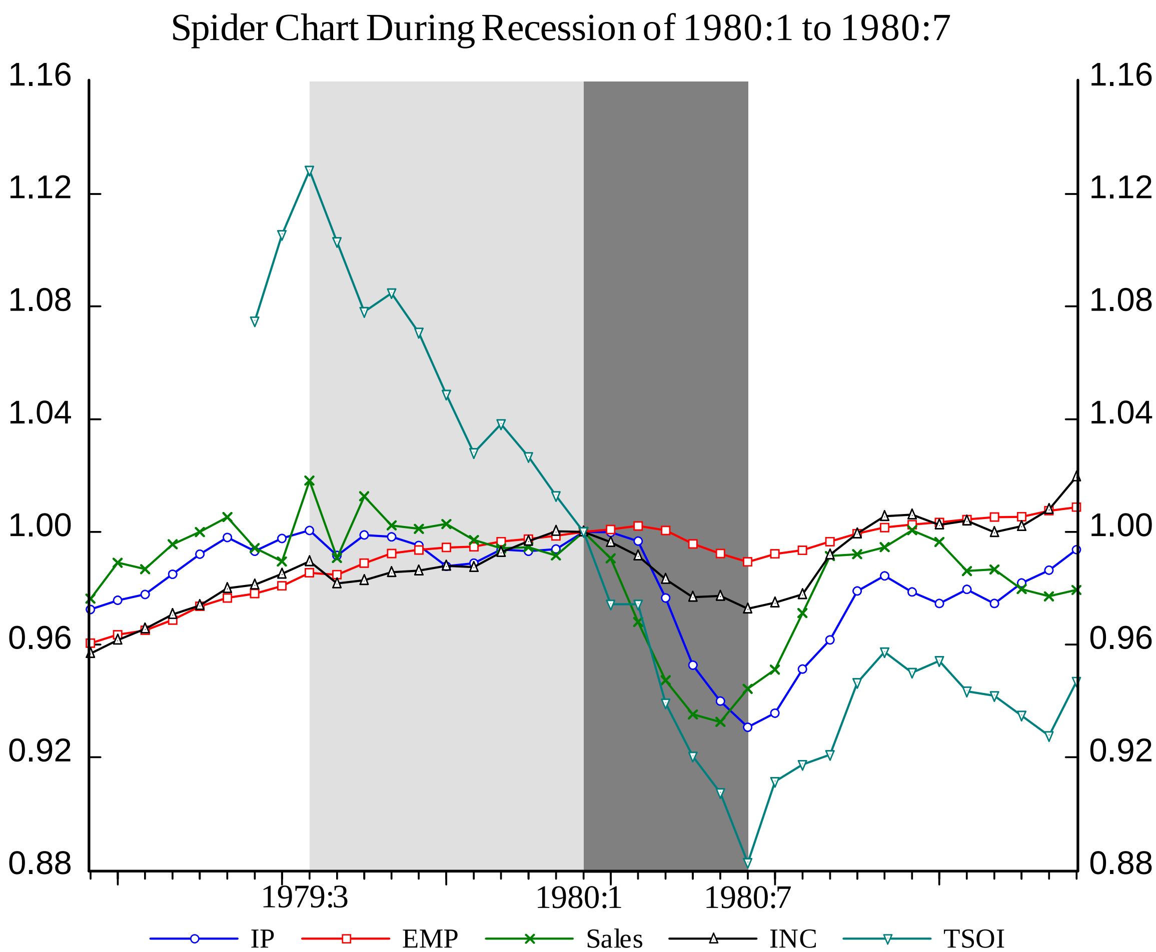

Spider Chart During Recession of 1980:1 to 1980:7
1.16
1.12
1.08
1.04
1.00
0.96
0.92
0.88
1979:3
1980:1
1980:7
IP
EMP
Sales
INC
TSOI

FIG. 3e

Spider Chart During Recession of 1981:7 to 1982:11

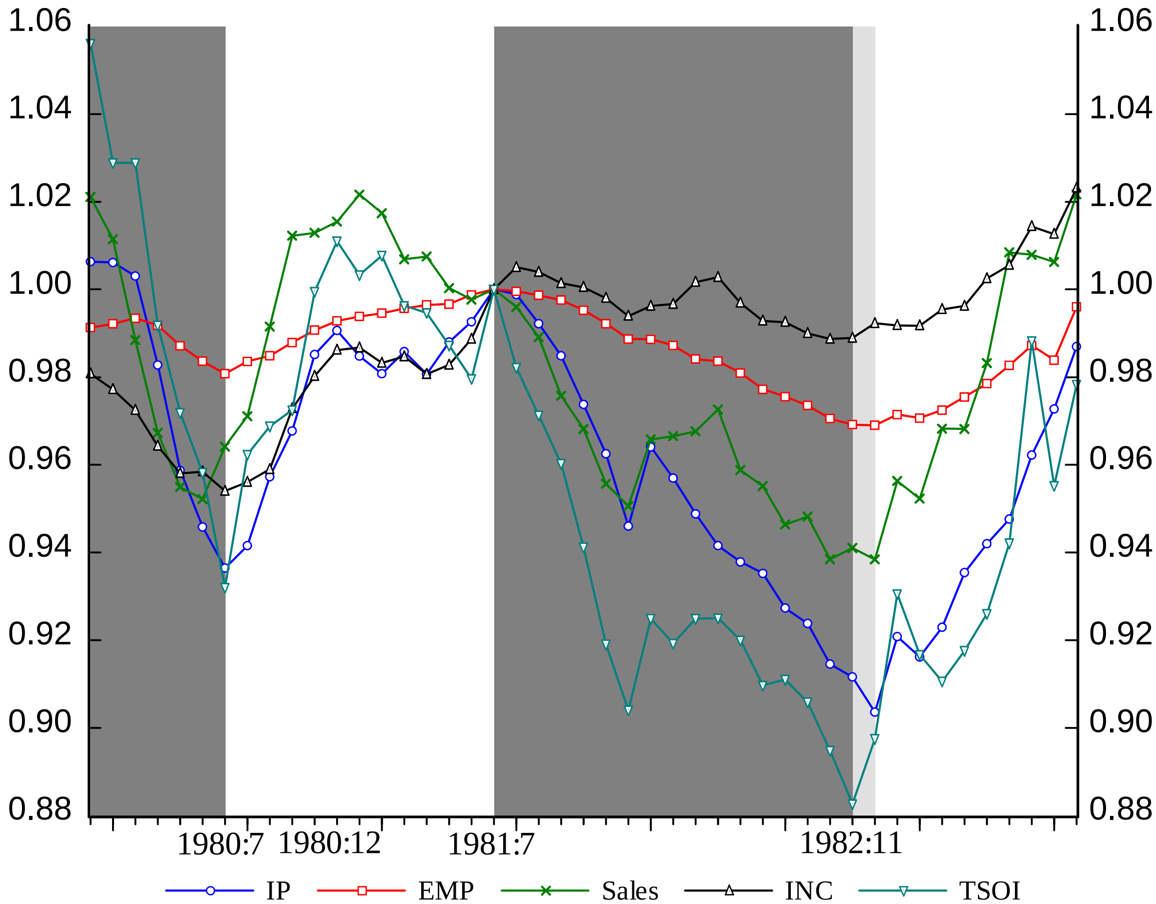
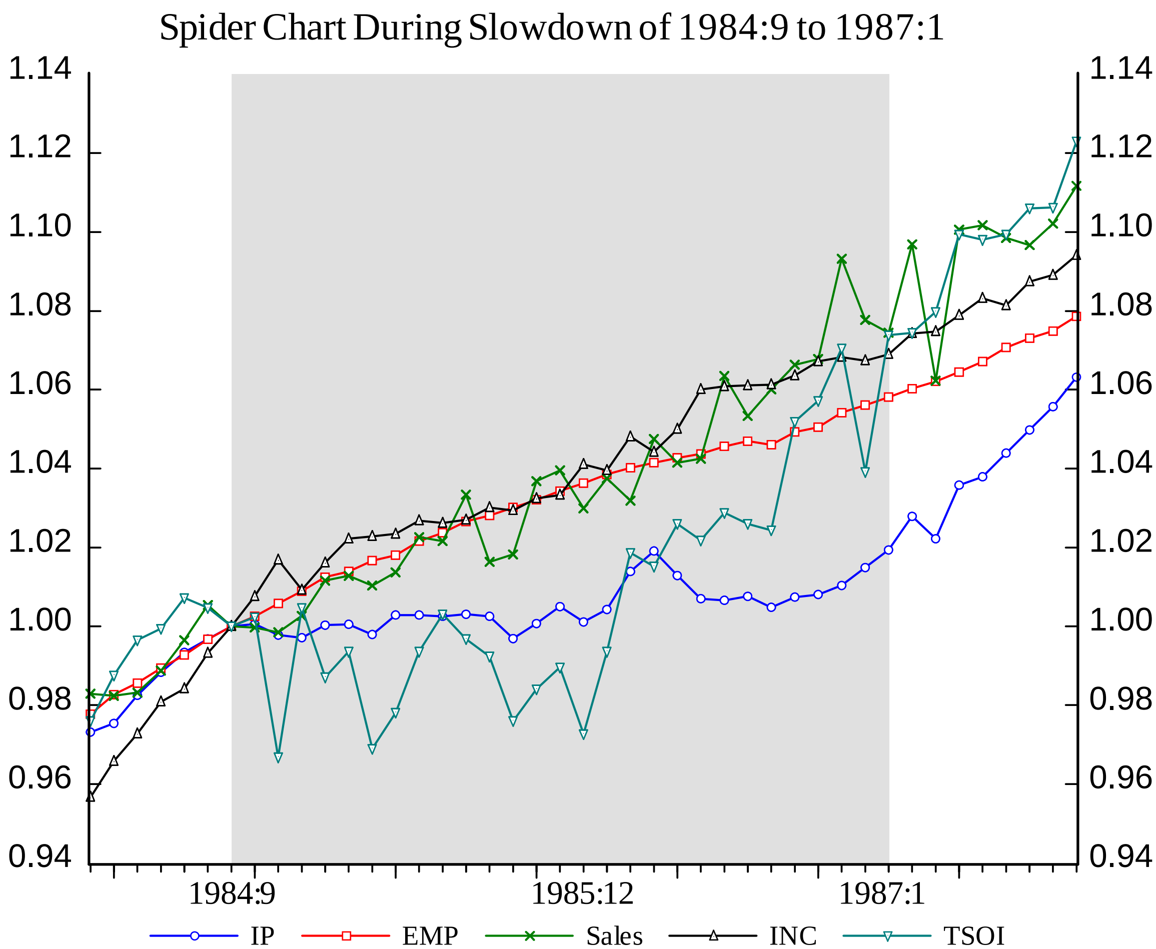


FIG. 3f



Spider Chart During Slowdown of 1984:9 to 1987:1
1.14
1.12
1.10
1.08
1.06
1.04
1.02
1.00
0.98
0.96
0.94
1984:9
1985:12
1987:1
IP
EMP
Sales
INC
TSOI

FIG. 3g

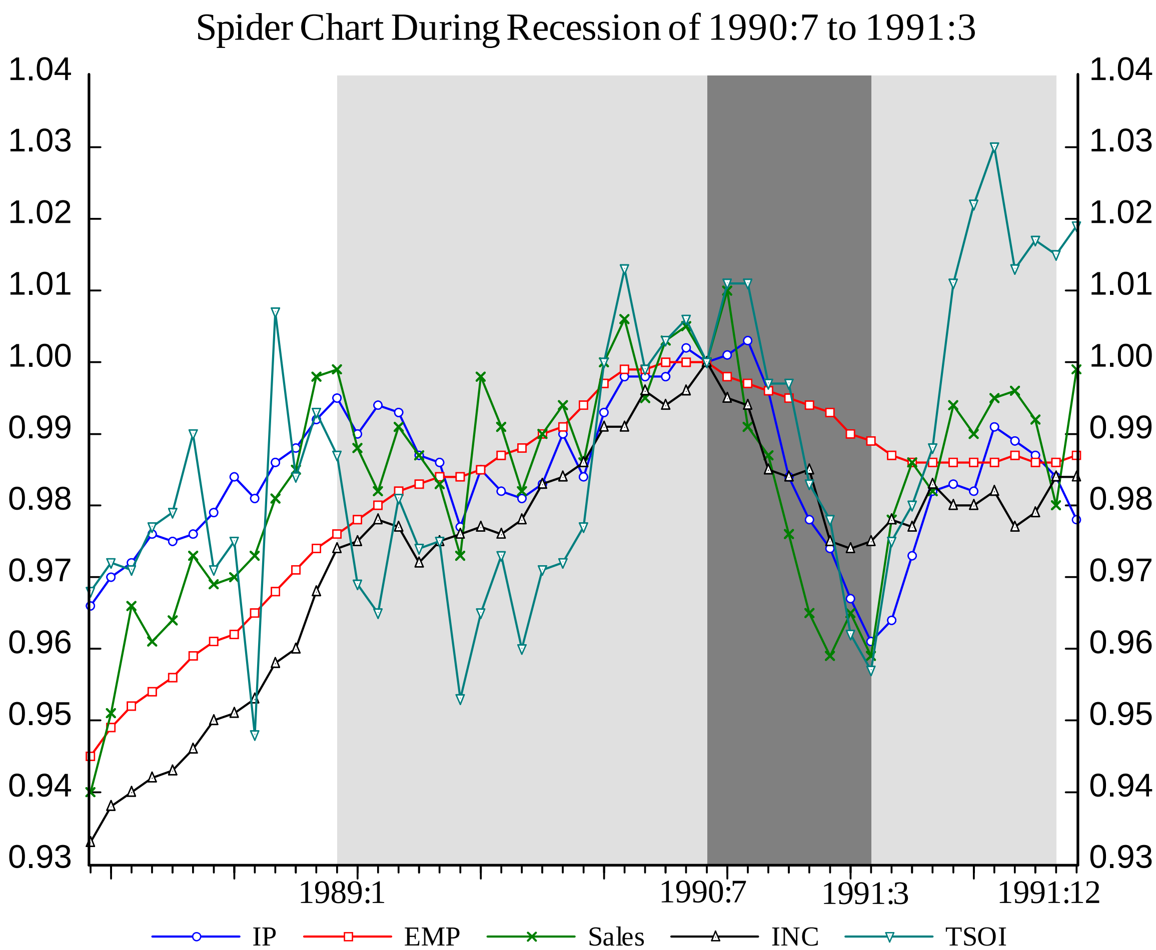

Spider Chart During Recession of 1990:7 to 1991:3
1.04
1.03
1.02
1.01
1.00
0.99
0.98
0.97
0.96
0.95
0.94
0.93
1989:1
1990:7
1991:3
1991:12
IP
EMP
Sales
INC
TSOI

FIG. 3h

Spider Chart During Slowdown of 1995:1 to 1996:1

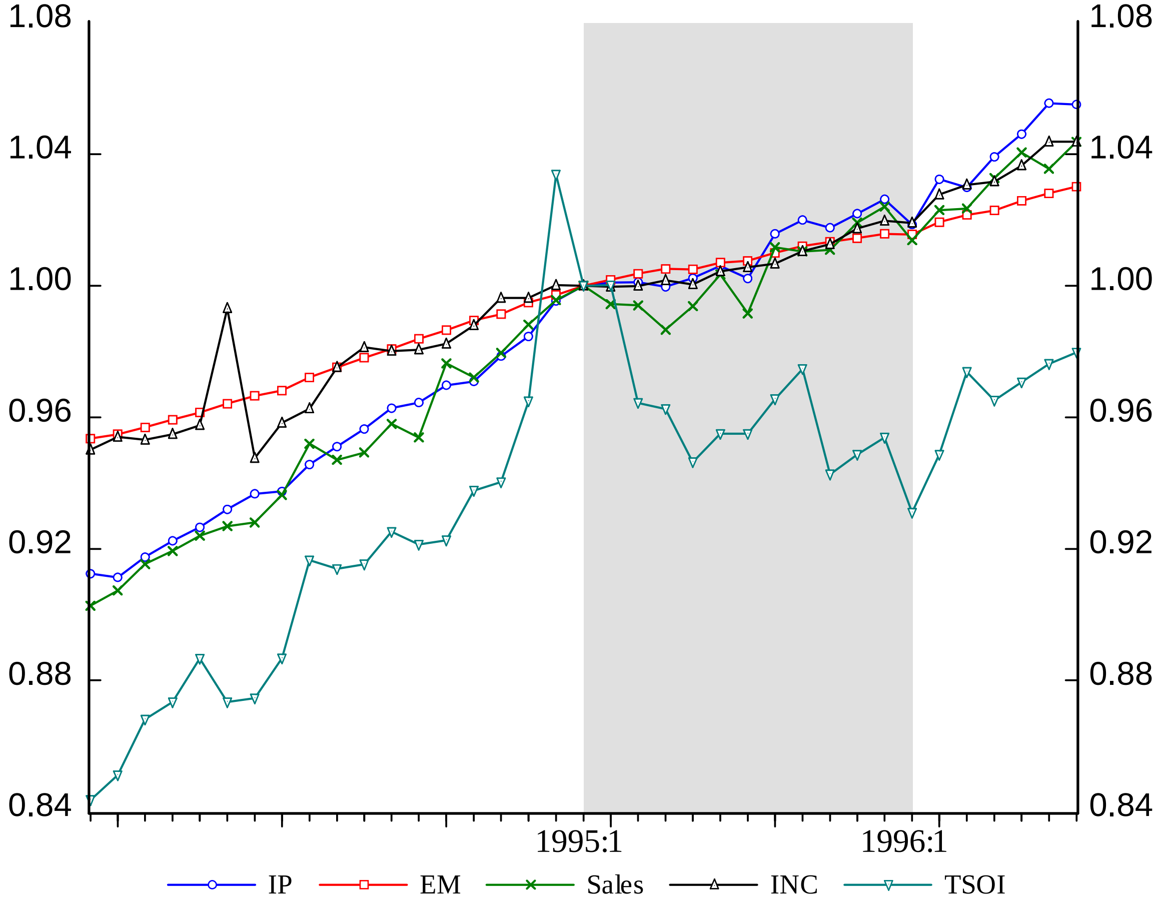


FIG. 3i

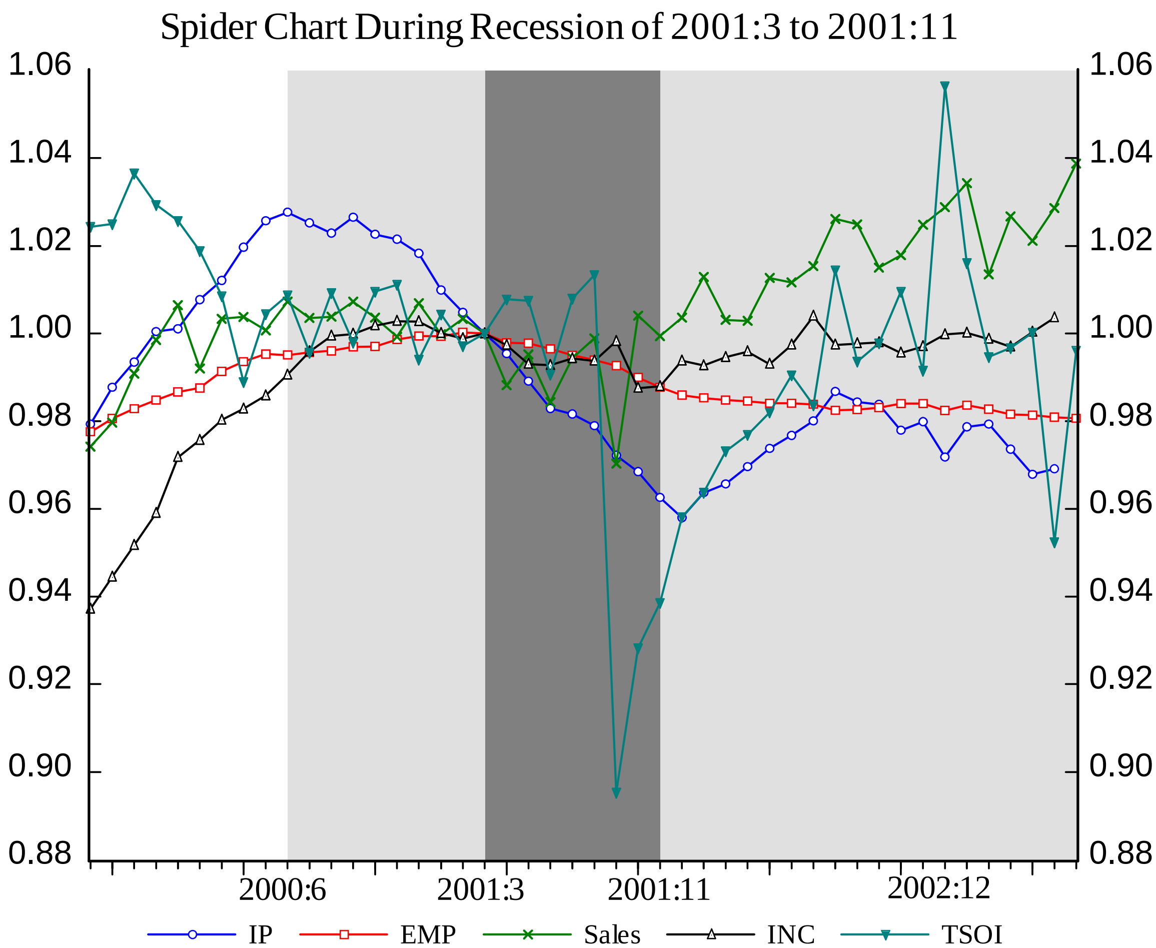

Spider Chart During Recession of 2001:3 to 2001:11
1.06
1.04
1.02
1.00
0.98
0.96
0.94
0.92
0.90
0.88
2000:6
2001:3
2001:11
2002:12
IP
EMP
Sales
INC
TSOI

Figure 3j
Spider Chart During Recession of 2007:12 to 2009:03 (Tentative)

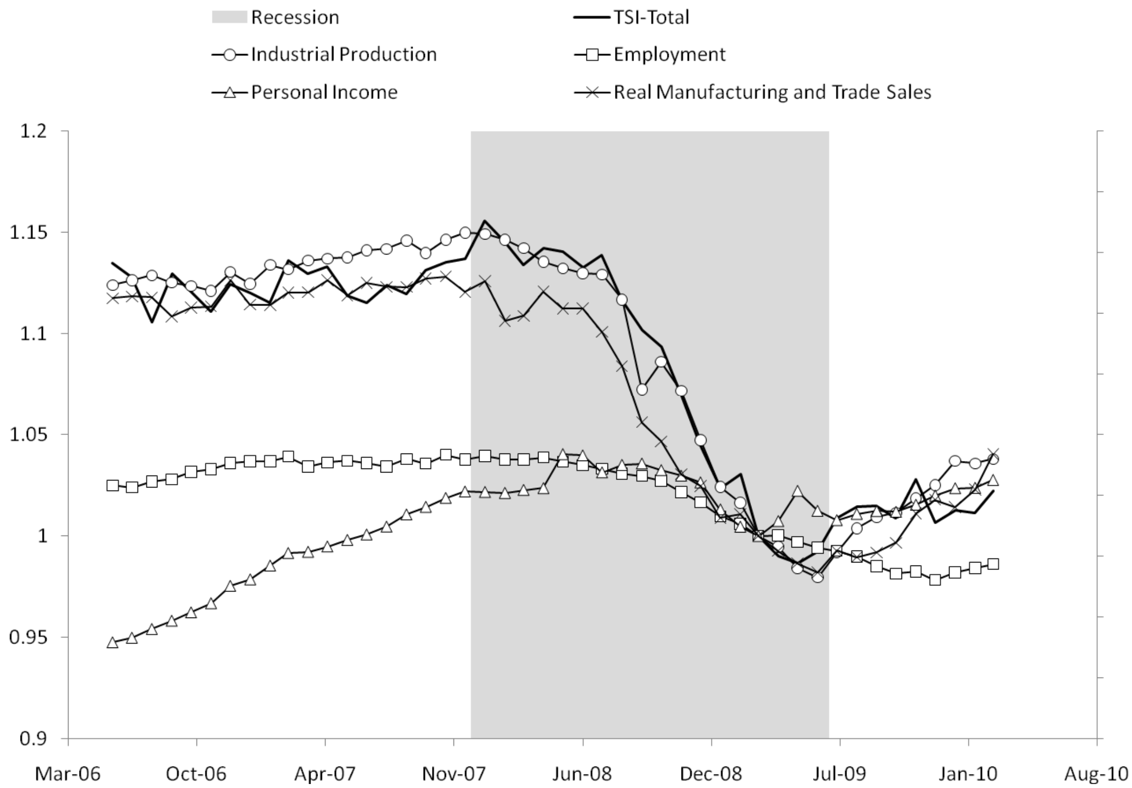


FIG. 4. Federal Funds Rate

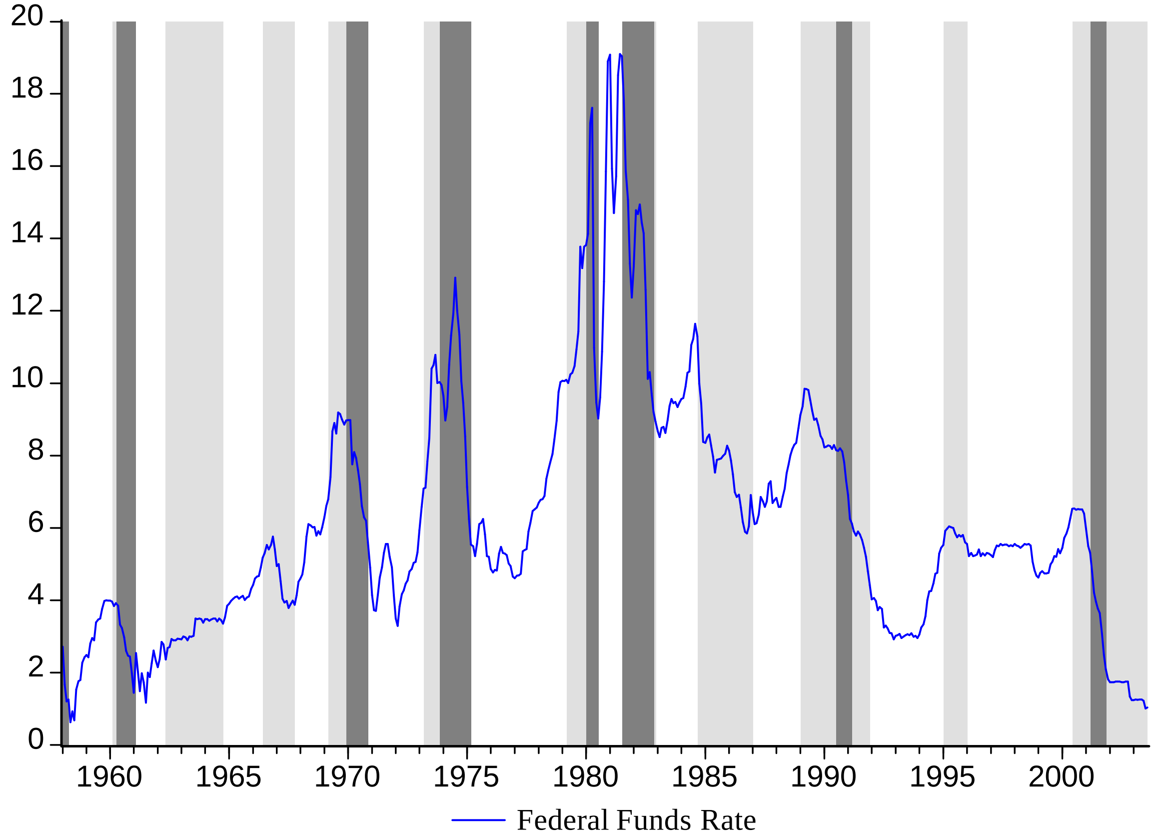


Figure 5. TSI Total, its Components and Growth Cycles

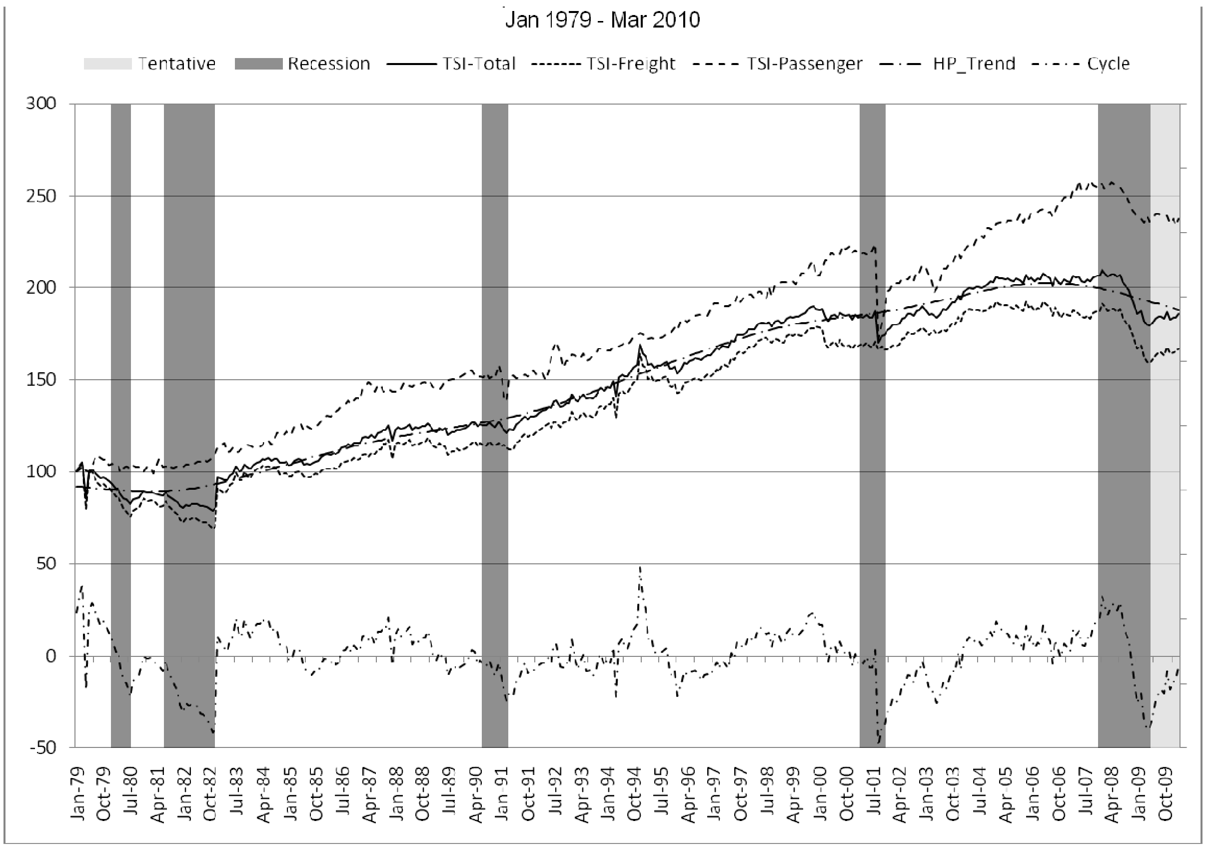


FIG. 6. NBER Indexes with Different Combinations of Five Coincident Indicators

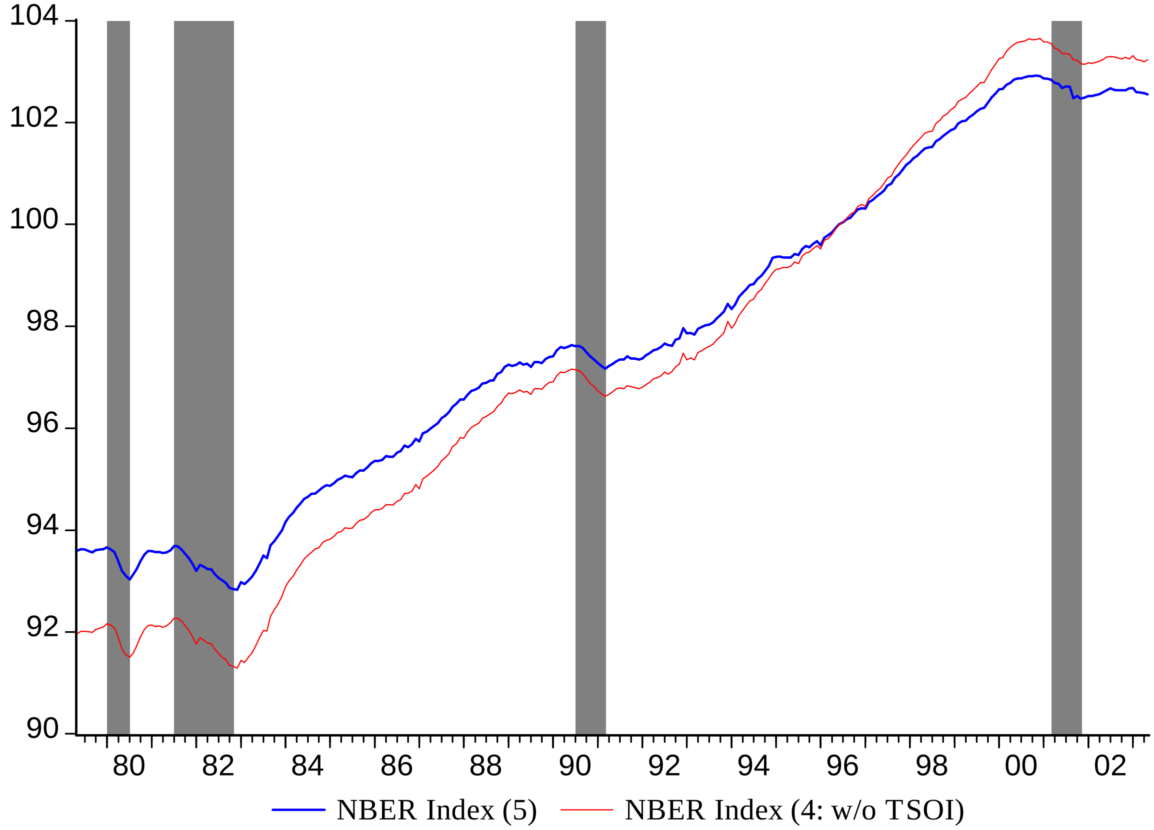


FIG. 7. SW Indexes with Different Combinations of Five Coincident Indicators

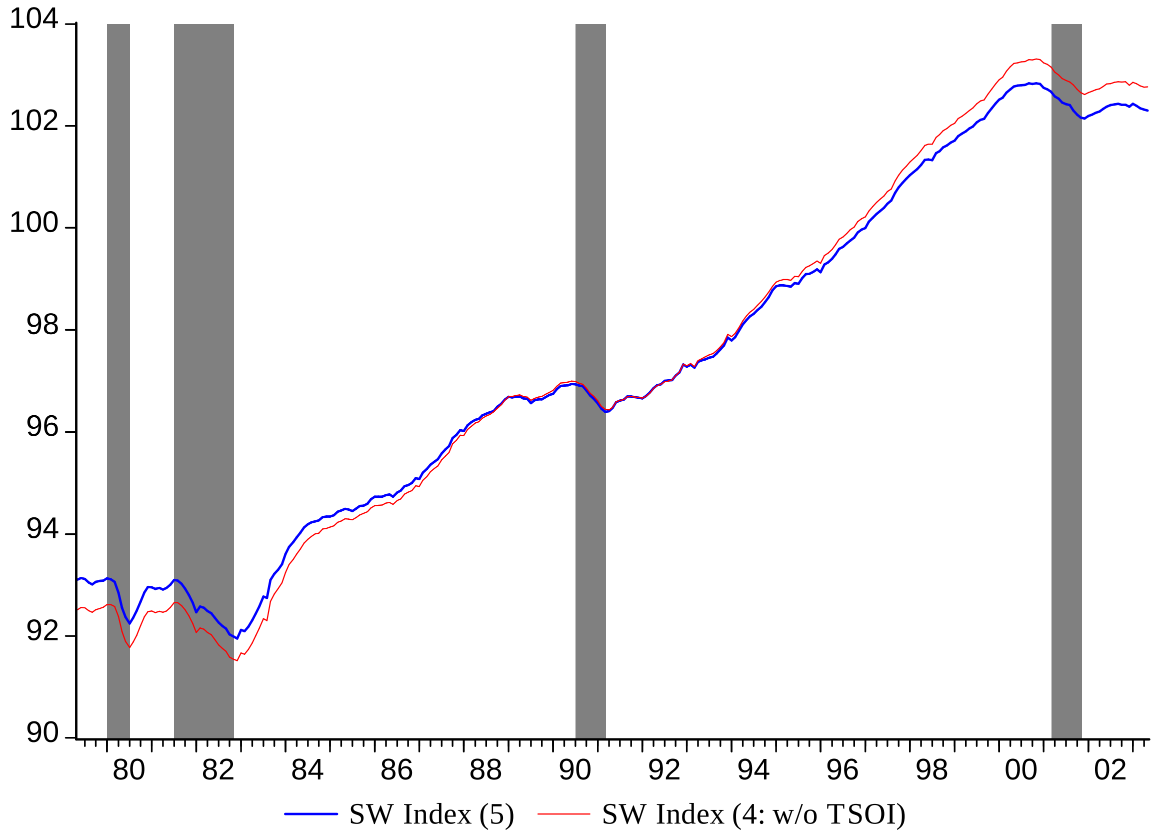


FIG. 8. KN Indexes with Different Combinations of Five Coincident Indicators

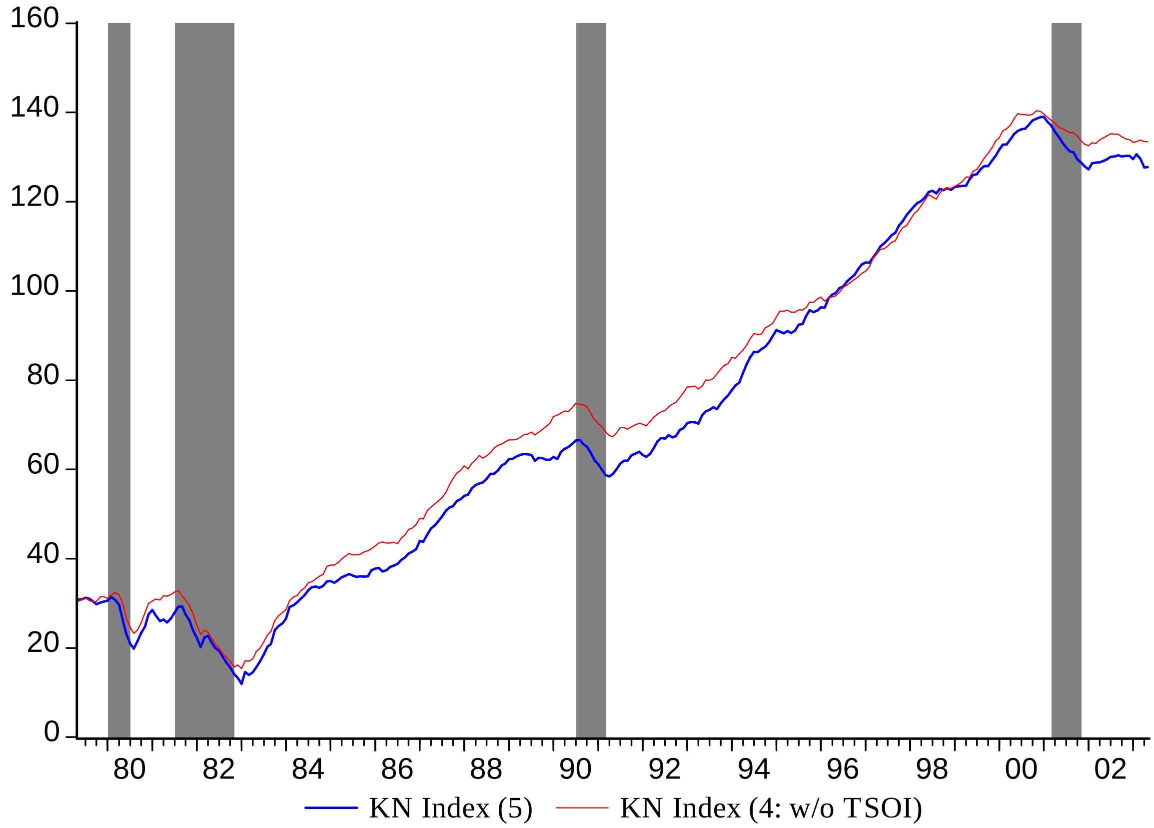
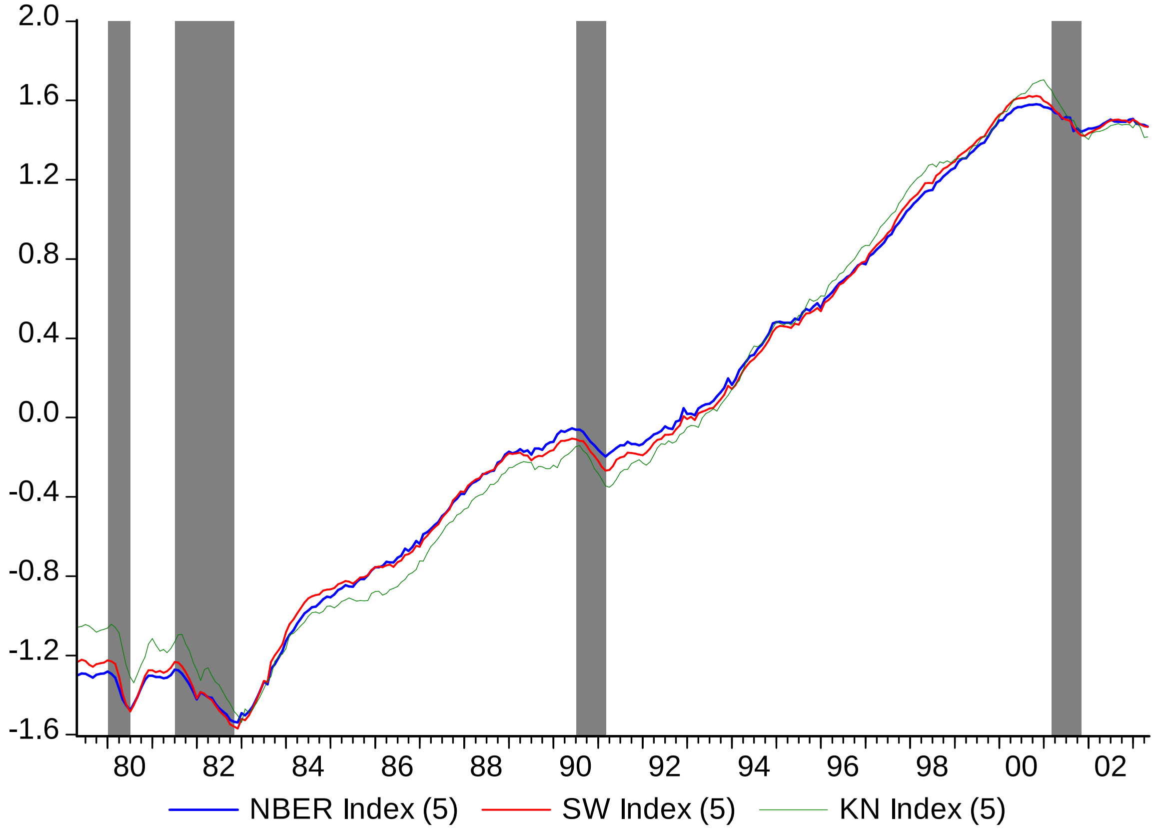


FIG. 9. Three CCIs based on Five Coincident Indicators



Note: the scale for three indexes has been normalized.

FIG. 10. Probability that Economy is in Recession Implied from Kim-Nelson Models

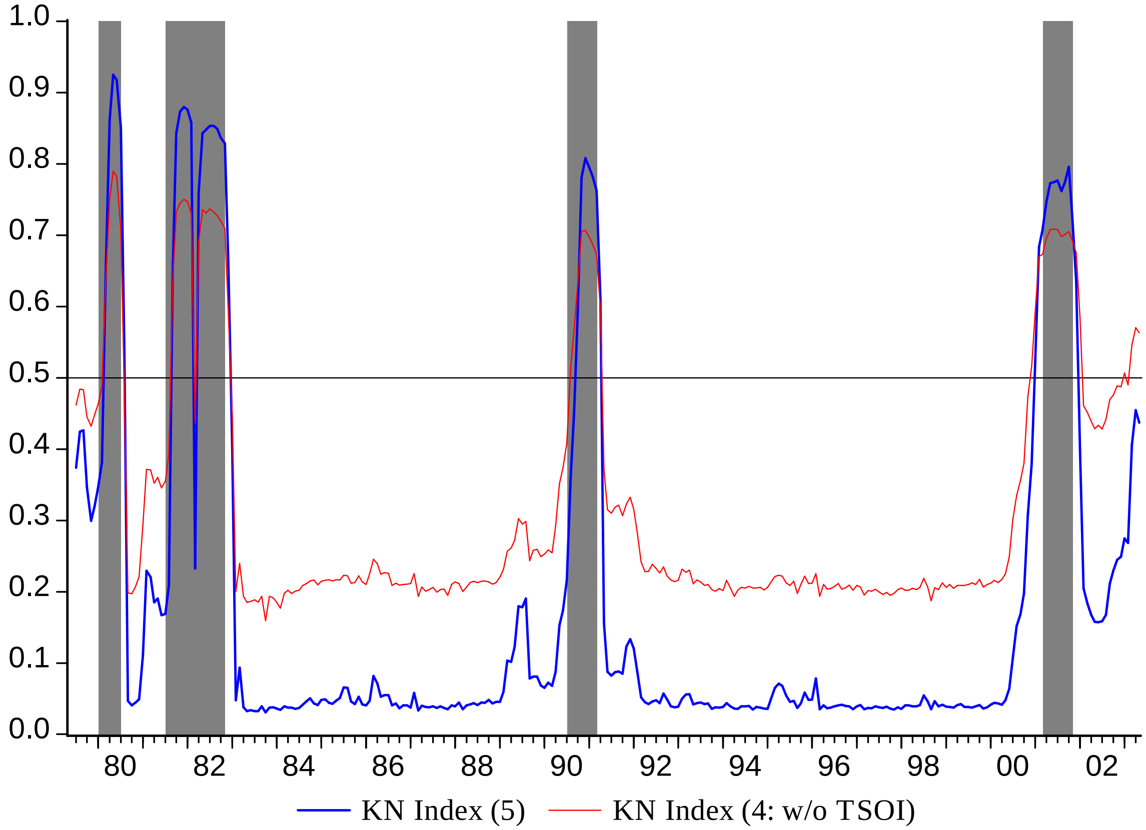


TABLE 1. Contribution of Major Type of Products to Real GDP in Recessions

NBER-defined Recessions	Decline from Peak to Trough	Real GDP by Major Type of Products				Total GDP
		Goods	Services	Structures	Residual	
1960:Q2~ 1961:Q1	Decline	-39.1	31.9	-3.4	-27.5	-38.1
	Contribution (%)	102.6	-83.7	8.9	72.2	100.0
1969:Q4~ 1970:Q4	Decline	-19.5	35.0	-25.9	-11.4	-21.8
	Contribution (%)	89.4	-160.6	118.8	52.3	100.0
1973:Q4~ 1975:Q1	Decline	-93.5	79.4	-85.5	-41.5	-141.1
	Contribution (%)	66.3	-56.3	60.6	29.4	100.0
1980:Q1~ 1980:Q3	Decline	-82.0	70.8	-56.2	-53.0	-120.4
	Contribution (%)	68.1	-58.8	46.7	44.0	100.0
1981:Q3~ 1982:Q4	Decline	-100.1	36.6	-49.2	-32.0	-144.7
	Contribution (%)	69.2	-25.3	34.0	22.1	100.0
1990:Q3~ 1991:Q1	Decline	-62.4	30.3	-62.6	-5.6	-100.3
	Contribution (%)	62.2	-30.2	62.4	5.6	100.0
2001:Q1~ 2001:Q4	Decline	-108.4	46.1	-5.5	10.4	-57.4
	Contribution (%)	188.9	-80.3	9.6	-18.1	100.0
Average	Decline	-72.1	47.2	-41.2	-22.9	-89.1
	Contribution (%)	92.4	-70.7	48.7	29.6	100.0

Source: Table 1.4. Real Gross Domestic Product by Major Type of Product from U.S. NIPA. Declines are noted in billions of chained dollars.

TABLE 2 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
Apr-60~Feb-61	-3	0	0	0	-3	-1	1	-2	-1.5	-0.5	-	-
Dec-69~Nov-70	-2	0	3	0	-2	0	0	0	-1	0	-	-
Nov-73~Mar-75	0	2	8	0	0	0	0	0	0	0	0*	0*
Jan-80~Jul-80	-10	0	2	0	-10	-1	0	0	-5	0	-10	0
Jul-81~Nov-82	0	0	0	0	-6	0	1	-1	0	0	-7	0
Jul-90~Mar-91	2	0	-1	10	1	0	0	-2	0.5	4	-4	0
Mar-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

* These two turning points are based on Trucking Tonnage Index beginning Jan-73, the dominant component of TSI that starts only from Jan-79.

TABLE 3 Standardization Factors to Construct NBER Index

Components of CCI	Standardization 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 deviation during 1979:1 to 2003:06.

TABLE 4 Timing of NBER Indexes (CCI) Relative to NBER Chronology

NBER-defined Recessions	Five Coincident Indicators Excluding											
	None**		TSI		IP		EMP		Sales		INC	
	P	T	P	T	P	T	P	T	P	T	P	T
Jan-80~Jul-80	0	0	0	0	0	0	-10	0	0	0	0	0
Jul-81~Nov-82	0	1	0	1	0	0	0	1	0	0	0	1
Jul-90~Mar-91	-1	0	-1	0	-1	0	1	0	-1	0	-1	0
Mar-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
Concurrence w/ NBER Chronology	0.979		0.979		0.979		0.935		0.986		0.983	

** CCI from five coincident indicators.

TABLE 5 Estimation Results of SW Models with Five Coincident Indicators

SW Models		5 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)
IN	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)
SA	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)
EM	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)	-	-
TS	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	

TABLE 6 Estimation Results of KN Models with Five Coincident Indicators

KN Model		5 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)
IN	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)
SA	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)
EM	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)	-	-
TS	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	

Note: QTS is calculated for the sample period of Jan-79~Dec-02.