On the Measurement and Forecasting of Business Cycles and Growth Cycles in the Global Economy

Ataman Ozyildirim, ataman.ozyildiri@conference-board.org

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Key Questions for a Global Leading Economic Index

- Where is global growth trending this quarter?
- Is the global cycle more or less synchronized across countries/regions and between mature and emerging economies?
- What is the probability of a slowdown or recession in the next quarter or two?
- What is the current impact and importance of cyclical (short-term) versus structural (long-term) factors in the global cycle?
- How do financial and nonfinancial indicators behave, and how do they interact?
- How does the interconnectivity of regional economies work, and what is their impact on the global economy?
- What does this mean for the global economic outlook for the remainder of the year and next year?
Increased trade and financial integration have strengthened correlations across aggregate measures of economic activity – particularly output.

**Real GDP Growth**

*Year-over-year Percent Change*

| Correlations | World | G20   | OECD  | G7   |
|              |       |       |       |      |
| World        | -     | 0.8523| 0.8171| 0.8116|
| G20          | 0.8523| -     | 0.9072| 0.8665|
| OECD         | 0.8171| 0.9072| -     | 0.9837|
| G7           | 0.8116| 0.8665| 0.9837| -     |

Source: IMF; OECD; The Conference Board
The recent update of TCB’s Business Cycle Reference Dates mirrors this degree of conformity across economies in the BCI program.

### Business Cycle Reference Dates

<table>
<thead>
<tr>
<th>North America</th>
<th>Europe</th>
<th>Asia-Pacific</th>
<th>Latin America</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>Mexico</td>
<td>Euro Area</td>
<td>France</td>
</tr>
<tr>
<td>Dates at Business Cycle Peaks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1940s</td>
<td>Feb-45</td>
<td></td>
<td></td>
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<tr>
<td>1950s</td>
<td>Jul-39</td>
<td></td>
<td></td>
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<tr>
<td>1960s</td>
<td>May-66</td>
<td>May-69</td>
<td>May-73</td>
</tr>
<tr>
<td>1970s</td>
<td>Jun-80</td>
<td>May-82</td>
<td>Jul-84</td>
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<tr>
<td>1980s</td>
<td>Jan-91</td>
<td>Feb-92</td>
<td>May-94</td>
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<tr>
<td>1990s</td>
<td>Jul-99</td>
<td>Aug-01</td>
<td>Sep-03</td>
</tr>
<tr>
<td>2000s</td>
<td>Feb-08</td>
<td>Mar-10</td>
<td>May-12</td>
</tr>
<tr>
<td>2010s</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Dates at Business Cycle Troughs | | | | | | | | | | | |
| 1940s | Oct-45 | | | | | | | | | | |
| 1950s | Apr-54 | | | | | | | | | | |
| 1960s | Jan-62 | Jun-65 | | | | | | | | | |
| 1970s | Aug-72 | | | | | | | | | | |
| 1980s | Sep-82 | | | | | | | | | | |
| 1990s | Oct-92 | | | | | | | | | | |
| 2000s | Nov-02 | | | | | | | | | | |
| 2010s | Dec-11 | | | | | | | | | | |

Source: NBER; IBRE/FGV; The Conference Board

**Burns & Mitchell (1946) established business cycle dating; Bry & Boschan (1971) and Harding & Pagan (2002) provide updates via computerized algorithms.**

**Examine cyclical peaks and troughs in coincident economic indicators, in accordance set rules regarding phases and cycles.**

Source: The Conference Board
Some economists contend that global GDP growth falling below a threshold of 2.8% delineates a global recession.

Real GDP Growth
Year-over-year Percent Change

Global GDP Growth Chart
- Global
- Advanced Economies
- Emerging & Developing Economies

Note: Shaded regions depict hypothetical recession as quarters during which global GDP growth was below 2.8%
Source: IMF; The Conference Board
There is an ample literature on the global business cycle, much of which adopts techniques used in country-level business cycle research.

### Global Business Cycle Literature

<table>
<thead>
<tr>
<th>Source</th>
<th>Summary</th>
</tr>
</thead>
</table>
| **Kose, Otrok, and Whiteman (2003)** | - Using a Bayesian dynamic latent factor model, the authors show that a **common world factor is an important source of volatility** across a large sample of economies.  
- Consumption and Investment cycles, in comparison to growth cycles, are more so determined by country and idiosyncratic factors across multiple economies. |
| **Hirata, Kose, and Otkro (2013)** | - Regional business cycles have become increasingly important, especially in areas with **growing levels of international trade and financial regionalization and integration**.  
- The strong business cycle synchronization of the 1970s and 1980s reflected systemic “shocks” (e.g. oil price shocks) that were uniformly destabilizing. |
| **Kose, Otkro, and Prasad (2008)** | - Global business cycles can be decomposed into global, group (e.g. emerging), country, and idiosyncratic portions.  
- Variance decomposition shows the amounts attributable to each individual factor.  
- **Group factors have become less important since the era of globalization.** |
| **Duval et. al. (2014)** | - The authors identify a strong positive impact of **trade intensity** on business cycle synchronization.  
- Additionally, they find that **bilateral intra-industry trade and trade specialization** correlation increase co-movement of business cycle dynamics. |
More recently, the notion that economies within certain regions follow similar cyclical trends has been developed.

Cooke, Kose, Otrok, and Owyang (2015)

- The degree to which business cycles synchronize across countries might depend on, among other things, physical distance, the amount of bilateral trade, similarities in institutions or language, or historical trade routes.

- The business cycles of most African and Asian (developed and developing) countries do not appear to co-move with either their regional neighbors or the rest of the world.

Ravazzolo and Vespignani (2015)

- Even single economic data series—World Steel Production—have a salient ability to predict global business cycles with a requisite lag, and in some cases, outperform existing indicators or groups of indicators.

Source: Cooke, Kose, Otrok, and Owyang (2015)
Diffusion of business cycle movements across the global economy creates a need for more stylized research and timely monitoring.

**Synchronization of Business Cycles**
Percent of Economies (by Gross Domestic Product) in Business Cycle Recession

Source: The Conference Board
Individual economic data series often contain noise and lack substantial breadth – both in geography and in sector.

Difficulty in Defining the Global Business Cycle

Can one composite measure capture different sectors and regions of the global economy in a comprehensive and meaningful way?

Source: The Conference Board
Developing a more precise definition of the global business cycle provides a benchmark against which to measure the Global LEI prototypes.

**Global Business Cycle**

Percent of Economies (by Gross Domestic Product) in Business Cycle Recession

<table>
<thead>
<tr>
<th>Business Cycle Analysis of Recession Share Series</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>by GDP Share</strong></td>
</tr>
<tr>
<td><strong>35% Threshold</strong></td>
</tr>
<tr>
<td>Peaks ($P$) and Troughs ($T$)</td>
</tr>
<tr>
<td>Duration in months of business cycles and phases</td>
</tr>
<tr>
<td>$P$</td>
</tr>
<tr>
<td>(1)</td>
</tr>
<tr>
<td>Jul-80</td>
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<td>Jul-81</td>
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<td>Jul-90</td>
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<tr>
<td>Feb-08</td>
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<tr>
<td>Jul-11</td>
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<tr>
<td>Mean</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>St. Deviation</td>
</tr>
</tbody>
</table>

*Note: Shaded regions depict global recession dates*

Source: The Conference Board
Global Business Cycle Indicators (BCI) at The Conference Board

- Modeled after U.S. system of monthly leading economic indexes
- Aggregated from CEIs and LEIs for 13 countries/areas:
  ✓ U.S., Brazil, Mexico, Japan, South Korea, China, India, Australia, U.K., Euro Area, Germany, France and Spain
- Composite indices:
  ✓ Bring cycles and turning points into focus
  ✓ Used to define and anticipate turning points in business cycles
  ✓ Help to identify growth cycles vs. business cycles
  ✓ Help in forecasting and economic outlook
“Classical” business cycles vs. growth cycles

Level of economic activity vs. time

BCP: business cycle peak
BCT: business cycle trough

Deviation from long term trend vs. time

GCP: growth cycle peak
GCT: growth cycle trough
When developing both CEIs and LEIs, components are selected based on six criteria of cyclical performance

<table>
<thead>
<tr>
<th></th>
<th><strong>Criteria</strong></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Consistent Timing</strong></td>
<td>The series must exhibit a consistent timing pattern as a leading, coincident, or lagging indicator</td>
</tr>
<tr>
<td>2</td>
<td><strong>Conformity</strong></td>
<td>The series must conform well to the business cycle</td>
</tr>
<tr>
<td>3</td>
<td><strong>Smoothness</strong></td>
<td>Month-to-month movements must not be too erratic</td>
</tr>
<tr>
<td>4</td>
<td><strong>Economic Significance</strong></td>
<td>Cyclical timing must have economic meaning and be logical</td>
</tr>
<tr>
<td>5</td>
<td><strong>Statistical Adequacy</strong></td>
<td>Data must be collected and processed in a statistically reliable way; no large and frequent revisions</td>
</tr>
<tr>
<td>6</td>
<td><strong>Currency or Timeliness</strong></td>
<td>Series must be published on a reasonably prompt schedule – preferably on a monthly basis.</td>
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</tbody>
</table>

## Global CEI Components

<table>
<thead>
<tr>
<th>United States</th>
<th>Australia</th>
<th>Japan</th>
<th>Korea</th>
<th>Mexico</th>
<th>United Kingdom</th>
<th>China</th>
<th>Brazil</th>
<th>Euro Area</th>
<th>India</th>
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</thead>
<tbody>
<tr>
<td>Retail</td>
<td>Manufacturing and Trade Sales</td>
<td>Retail Sales</td>
<td>Retail, Wholesale, and Manufacturing Sales</td>
<td>Wholesale and Retail Sales</td>
<td>Retail Sales</td>
<td>Retail Sales</td>
<td>Retail Sales of Consumer Goods</td>
<td>Volume of Sales of the Retail Market</td>
<td>Retail Trade</td>
</tr>
<tr>
<td>Income</td>
<td>Personal Income less Transfer Payments</td>
<td>Household Gross Disposable Income</td>
<td>Wage and Salary Income</td>
<td>Monthly Cash Earnings</td>
<td>Real Household Disposable Income</td>
<td>Average Real Income of Workers</td>
<td></td>
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<tr>
<td>Production</td>
<td>Industrial Production</td>
<td>Industrial Production</td>
<td>Industrial Production</td>
<td>Industrial Production</td>
<td>Industrial Production</td>
<td>Industrial Production</td>
<td>Industrial Production: Value-Added Electricity Production</td>
<td>Industrial Production</td>
<td>Industrial Production</td>
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<td>Industrial Electric Energy Consumption</td>
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<td></td>
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<td></td>
<td>Shipments of Corrugated Paper</td>
<td>Manufacturing Turnover</td>
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<td></td>
<td>Total Imports</td>
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</table>
## Global LEI Components

<table>
<thead>
<tr>
<th>Financial</th>
<th>United States</th>
<th>Australia</th>
<th>Japan</th>
<th>Korea</th>
<th>Mexico</th>
<th>United Kingdom</th>
<th>China</th>
<th>Brazil</th>
<th>Euro Area</th>
<th>India</th>
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</thead>
<tbody>
<tr>
<td>Interests Rate Spread (10-yr T-Bond Less Policy Rate (cumulated))</td>
<td>Yield Spread, 10-yr T-Bond Less Policy Rate (cumulated)</td>
<td>Yield Spread of Government Public Bonds</td>
<td>Federal Funds Rate</td>
<td>Yield Spread (cumulated)</td>
<td>Yield Spread (cumulated)</td>
<td>Swap Rate, 360 days</td>
<td>Yield Spread (cumulated)</td>
<td>Yield spread (10 Yr 90 Day)</td>
<td></td>
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</tr>
<tr>
<td>Stock Price Index, Ordinary Share</td>
<td>Stock Prices</td>
<td>Stock Prices</td>
<td>Share Price Index, Stock</td>
<td>Loan: Financial Institution</td>
<td>Stock Prices (Bovespa Index)</td>
<td>Eurostoxx Index</td>
<td>Systemic Stress Indicator</td>
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<tr>
<td>Money Supply, M3</td>
<td>Real Money Supply, M2</td>
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<th>External</th>
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<tbody>
<tr>
<td>Rural Goods Exports</td>
<td>Real Exports FOB</td>
<td>Real Exchange Rate</td>
<td></td>
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<td></td>
<td>Terms of Trade Index</td>
<td>Exports Volume Index</td>
<td></td>
<td>REER: 36 Currencies</td>
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</thead>
<tbody>
<tr>
<td>ISM New Order Index</td>
<td>Ratio of Sales to Inventories, Nonfarm</td>
<td>New Orders for Machinery and Construction</td>
<td>Index of Inventories to Shipments</td>
<td>Net Insufficient Inventories</td>
<td>Volume of Expected Output</td>
<td>PMI: Mfg Supplier Delivery</td>
<td>Manufacturing Survey: Expectations Index</td>
<td>Services Sector Survey: Expectations Index</td>
<td></td>
</tr>
<tr>
<td>Building permits for new private housing units</td>
<td>Building Approvals</td>
<td>Real Operating Profits</td>
<td>Private Construction Orders</td>
<td>Industrial Production, Construction</td>
<td>Operating Surplus of Corporations</td>
<td></td>
<td>Markit PMI Manufacturing New Orders</td>
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<td>Floor Space Started</td>
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<td>Markit Business Expectations, Services</td>
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<td></td>
<td></td>
<td>PMI: Services Business Activity</td>
<td>Cargo Handles</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consumers &amp; Expectations</th>
<th>Avg. consumer expectations for business conditions</th>
<th>Business Failures</th>
<th>U.S. Refiners’ Acquisition cost of Domestic &amp; Imported crude oil</th>
<th>Consumer Confidence</th>
<th>Consumer Expectation Index</th>
<th>Consumers Survey: Expectations Index</th>
<th>Consumer expectation of general economy in next 12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Weekly Hours, Manufacturing</td>
<td></td>
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<tr>
<td>Average Weekly Claims, Unemployment Insurance</td>
<td>Index of Overtime Worked</td>
<td>6-Month Growth Rate of Labor Productivity</td>
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</tbody>
</table>

Methodology calculates a composite index: CEI and LEI

<table>
<thead>
<tr>
<th>STEP 1</th>
<th>Compute Monthly Changes in Indexes</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ Compute month-to-month changes for each individual component.</td>
<td></td>
</tr>
<tr>
<td>▶ All BCI Program Indices are used with the exception of the France, Germany, and Spain Indices, given that the Euro Area Index is used.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STEP 2</th>
<th>Standardization</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ Because monthly changes in the indexes of each individual index can have substantial differences (see previous slide), the monthly changes are standardized in order to account for regional volatilities.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STEP 3</th>
<th>GDP Weights x Std. Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ Each standardized change in the index is weighted by that country’s GDP share of the entire BCI Program GDP, which encompasses about 66% of total output.</td>
<td></td>
</tr>
<tr>
<td>▶ The standardized change is multiplied by the GDP weight to compute the contribution to the Index’s change.</td>
<td></td>
</tr>
<tr>
<td>▶ Source for GDP: The Conference Board’s Total Economy Database.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STEP 4</th>
<th>Sum Contributions &amp; Index to 2010 = 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ The contributions to the percent change in the index values are summed across all ten economies.</td>
<td></td>
</tr>
<tr>
<td>▶ These percent changes are then applied to an index level that in 2004 = 100.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STEP 5</th>
<th>Trend Adjustment (for LEI only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ The LEI is adjusted to the trend of the CEI, as is the practice with each individual economy.</td>
<td></td>
</tr>
<tr>
<td>▶ The level index is computed, along with monthly, six-month, and annual percent changes.</td>
<td></td>
</tr>
</tbody>
</table>
While each country exhibits its own business cycle, major global cyclical downturns affect them all.

Source: The Conference Board
# Global Business Cycle Chronologies

<table>
<thead>
<tr>
<th>North America</th>
<th>Europe</th>
<th>Asia-Pacific</th>
<th>LatAm</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.S.</td>
<td>Mexico</td>
<td>Euro Area</td>
<td>France</td>
</tr>
<tr>
<td>Date at Business Cycle Peak</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1940s</td>
<td>Feb-45</td>
<td>Nov-48</td>
<td></td>
</tr>
<tr>
<td>1950s</td>
<td>Jul-53</td>
<td>Aug-57</td>
<td></td>
</tr>
<tr>
<td>1960s</td>
<td>Apr-60</td>
<td>May-66</td>
<td>Dec-69</td>
</tr>
<tr>
<td>1980s</td>
<td>Jan-80</td>
<td>Nov-81</td>
<td>Feb-80</td>
</tr>
<tr>
<td>2000s</td>
<td>Mar-01</td>
<td>Oct-00</td>
<td>Feb-08</td>
</tr>
<tr>
<td>2010s</td>
<td>Jul-11</td>
<td>Feb-12</td>
<td>Jun-10</td>
</tr>
<tr>
<td>Date at Business Cycle Trough</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1940s</td>
<td>Oct-45</td>
<td>Oct-49</td>
<td></td>
</tr>
<tr>
<td>1950s</td>
<td>May-54</td>
<td>Apr-58</td>
<td></td>
</tr>
<tr>
<td>1960s</td>
<td>Feb-61</td>
<td></td>
<td>Jun-67</td>
</tr>
<tr>
<td>1970s</td>
<td>Nov-70</td>
<td>May-75</td>
<td>Oct-75</td>
</tr>
<tr>
<td>2000s</td>
<td>Nov-01</td>
<td>Mar-02</td>
<td>Aug-09</td>
</tr>
<tr>
<td>2010s</td>
<td>Feb-13</td>
<td>Mar-13</td>
<td>Apr-13</td>
</tr>
</tbody>
</table>
Accurate weighting economies in the Global LEI is a crucial consideration – BCI economies currently comprise 66%* of global output

Share of Global GDP

1. Australia - 1.0%
2. Brazil - 2.9%
3. China - 16.7%
4. Euro Area - 12.5%
5. India - 6.2%
6. Japan - 4.5%
7. Korea - 1.7%
8. Mexico - 2.0%
9. United Kingdom - 2.4%
10. United States - 16.5%

Note: This calculation includes the entire Euro Area and excludes France, Germany, and Spain
Source: The Conference Board, Total Economy Database
Alternatively, weighting by global trade volume share may better capture and weight cyclical contributions.
Each method has trade-offs when considering its viability as an index construction method

**Pros:**
- Higher frequency data
- Fewer data revisions and omissions
- Easy to explain to non-technical audience
- Ease of replicability

**Cons:**
- Does not use advanced statistical techniques that can provide for better fit and average lead times.
- Can overly emphasize countries’ idiosyncrasies (i.e. policy interventions)

**Pros:**
- Avoids dealing with issues of trade, value added, or GDP-weighting various components
- Easy to explain to non-technical audience
- Requires fewer “balancing” of aggregated dates

**Cons:**
- Regional data is often not as high frequency and is updated/published infrequently
- Can overly emphasize countries’ idiosyncrasies (i.e. policy interventions)

**Pros:**
- Higher frequency data
- Fewer data revisions and omissions
- Highly-technical methods can produce strong goodness of fit and smooth lead times

**Cons:**
- Can overly emphasize countries’ idiosyncrasies
- Difficult to explain to a non-technical audience
- Parsimonious models can perform equally as well

**Pros:**
- Avoids dealing with issues of trade, value added, or GDP-weighting various components
- Highly-technical methods can produce strong goodness of fit and lead times

**Cons:**
- Regional data is often not as high frequency and is updated/published infrequently
- Difficult to explain to a non-technical audience
- Parsimonious models can perform equally as well

Source: The Conference Board
Global Coincident Economic Index (CEI) is a measure of the global cycle and the Global LEI leads its peaks and troughs.

Annual percent change

Note: Shaded areas represent global growth cycle recessions as determined by The Conference Board.
Source: The Conference Board
Decomposition analysis demonstrates the relative contributions of mature vs. emerging economies 2014-15

Contribution to Global LEI Percent Change

Source: The Conference Board
Decomposition analysis demonstrates the relative contributions of mature vs. emerging economies 2007-2009

**Contribution to Global LEI Percent Change**

Percentage Points

- Australia
- Brazil
- China
- India
- Japan
- Korea
- Mexico
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Global CEI and World GDP have a high contemporaneous correlation

Correlations

<table>
<thead>
<tr>
<th>Quarter Fwd</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0Q Fwd</td>
<td>0.7511</td>
</tr>
<tr>
<td>1Q Fwd</td>
<td>0.6275</td>
</tr>
<tr>
<td>2Q Fwd</td>
<td>0.4119</td>
</tr>
<tr>
<td>3Q Fwd</td>
<td>0.1730</td>
</tr>
<tr>
<td>4Q Fwd</td>
<td>-0.0304</td>
</tr>
</tbody>
</table>

Source: IMF; The Conference Board
Global LEI can be used as an early warning signal for downturns in global output.

Source: IMF; The Conference Board

Correlations:
- 0Q Fwd: 0.7170
- 1Q Fwd: 0.7290
- 2Q Fwd: 0.6235
- 3Q Fwd: 0.4477
- 4Q Fwd: 0.2575
Sub-indexes both for mature economies…

Source: The Conference Board
...and emerging market economies can help analyze the diffusion and prevalence of global cyclical movements.

Source: The Conference Board
There is a high degree of correlation between the Global LEI and the CPB World Trade Monitor Index of Global Trade

Annual Percent Change

Source: The Conference Board

Correlations

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0M Fwd</td>
<td>0.8093</td>
</tr>
<tr>
<td>1M Fwd</td>
<td>0.8249</td>
</tr>
<tr>
<td>2M Fwd</td>
<td>0.8117</td>
</tr>
<tr>
<td>3M Fwd</td>
<td>0.7839</td>
</tr>
<tr>
<td>4M Fwd</td>
<td>0.7292</td>
</tr>
<tr>
<td>5M Fwd</td>
<td>0.6589</td>
</tr>
<tr>
<td>6M Fwd</td>
<td>0.5719</td>
</tr>
</tbody>
</table>
Global LEI and World GDP per capita have a strong correlation, but the frequency aggregation diminishes its usefulness.
The three initial Global LEI prototypes produce quite uniform results, with common trends and cycles.

GDP weighting is the most sensitive to EM growth.
Global LEI Prototypes (2 of 3)

Trade-weighting increases volatility during expansions and downturns, while the component prototypes appear structurally dissimilar

Source: The Conference Board

Component methodologies don’t show similar trend as other indexes– weak growth especially post Great Recession
The principal component prototypes show similar cyclical movements with varying degrees of volatility based on underlying composition.

Global LEI Prototypes (3 of 3)

Index Value

Global LEI: Principal Component: 6M Chg. (lhs axis)
Global LEI: Principal Component: 12M Chg. (lhs axis)
Global LEI: Principal Component: Five Series* (rhs axis)

Annual Percent Change

Note: Principal Component of World Industrial Production, World Trade, Dow Jones Global Index, the Baltic Dry Index, and Brent Crude Oil Prices
Source: The Conference Board
A pseudo real-time recession probability modeling exercise shows that four methodologies excel far beyond the others.

### Out-of-Sample Recession Probability Modeling

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Forecast Proportion (%)</th>
<th>Theil’s U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global LEI: GDP x Index Method</td>
<td>0.4</td>
<td>0.370</td>
</tr>
<tr>
<td>Global LEI: GDP Weighted</td>
<td>0.0</td>
<td>0.373</td>
</tr>
<tr>
<td>Global LEI: Trade Weighted</td>
<td>0.3</td>
<td>0.375</td>
</tr>
<tr>
<td>Global LEI: Trade x Index Method</td>
<td>1.4</td>
<td>0.390</td>
</tr>
<tr>
<td>Global LEI: Index Method</td>
<td>1.5</td>
<td>0.411</td>
</tr>
<tr>
<td>Global LEI: Component Index Method</td>
<td>12.8</td>
<td>0.445</td>
</tr>
<tr>
<td>Global LEI: Component GDP x Index Method</td>
<td>7.7</td>
<td>0.484</td>
</tr>
</tbody>
</table>

**U = 0 is Perfect Forecast**  
**U = 1 is Naive Guess**

**Bias = Systematic Error**  
**Variance = Fluctuation in Actual vs. Forecast**  
**Covariance = Proportion due to Unsystematic Error**

---

**Note:** See Appendix regarding details of model specification and explanation of statistical tests; forecast proportions may not sum to 100% due to rounding.  
Source: The Conference Board
An out-of-sample growth forecasting exercise highlights the LEIs ability to forecast trends in key global economic data.

### Out-of-Sample Growth Forecasting: “Horse Race”

<table>
<thead>
<tr>
<th>Forecasting Global Industrial Production</th>
<th>Relative FMSE</th>
<th>DM Statistic</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global LEI: GDP Weighted</td>
<td>0.889</td>
<td>2.100</td>
<td>0.018</td>
</tr>
<tr>
<td>Global LEI: GDP Weighted Index Methodology</td>
<td>0.915</td>
<td>1.757</td>
<td>0.039</td>
</tr>
<tr>
<td>Global LEI: Trade Weighted</td>
<td>0.917</td>
<td>1.699</td>
<td>0.045</td>
</tr>
<tr>
<td>Global LEI: Trade Weighted Index Methodology</td>
<td>0.936</td>
<td>1.322</td>
<td>0.093</td>
</tr>
<tr>
<td><strong>Benchmark: Global LEI: Index Methodology</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Global LEI: Principal Component: Five Series</td>
<td>1.147</td>
<td>-1.451</td>
<td>0.073</td>
</tr>
<tr>
<td>Global LEI: Component Index Methodology</td>
<td>1.169</td>
<td>-2.082</td>
<td>0.019</td>
</tr>
<tr>
<td>Global LEI: Component GDP Weighted Index Methodology</td>
<td>1.227</td>
<td>-2.095</td>
<td>0.018</td>
</tr>
<tr>
<td>Global LEI: Principal Component of 12 Mo. Growth</td>
<td>1.251</td>
<td>-1.880</td>
<td>0.030</td>
</tr>
<tr>
<td>Global LEI: Principal Component of 6 Mo. Growth</td>
<td>1.447</td>
<td>-1.387</td>
<td>0.083</td>
</tr>
</tbody>
</table>

*Note: See Appendix regarding details of model specification and explanation of statistical tests*

Source: McGuckin, Ozyildirim, and Zarnowitz (2004); The Conference Board
Next steps: remaining research issues

- Global LEI and CEI (and subindexes) are feasible, but more research needed around the weighting of the countries and the correlations
- Complete benchmarking studies of the existing European LEIs and the China LEI
- Explore inclusion of other economies
- Model global recession risk probabilities, and financial and nonfinancial indexes
- Link more formally with global growth forecasts
Existing measures of the global cycle
The OECD Leading Economic Indicator anticipates peaks and troughs in OECD GDP with a strong one-quarter-forward correlation.

OECD GDP Growth and OECD Leading Economic Indicator
Year-over-year Percent Change

Source: OECD; The Conference Board
When compared against global GDP, the OECD LEI performs with relatively good strength, yet appears more coincident.
Goldman Sachs’ leading indicator, constructed from ten underlying components, leads turning points in global industrial production.

Goldman Sachs Global Leading Indicator (GLI)

Underlying Components


Note: See Appendix for details regarding the methodology.
Source: Goldman Sachs Global Investment Research
Brookings’ tracking indexes provide group and activity classifications; however, infrequent publishing and lack of a target series reduce their utility.

Brookings Tracking Indexes for the Global Economic Recovery (TIGER) Indexes

Group Classifications
1. Total
2. Advanced Economies
3. Emerging Market Economies
4. Euro Periphery

Activity Classifications
1. Overall Growth Index
2. Real Activity Index
3. Financial Index
4. Confidence Index

Principal Component Analysis
“…enables one to construct indicators of co-movement across all variables in a dataset or a subset of them. This procedure is ideal for creating the TIGER indexes as it allows us to combine information from different types of economic variables and multiple countries.”