

# Feasibility Study Report

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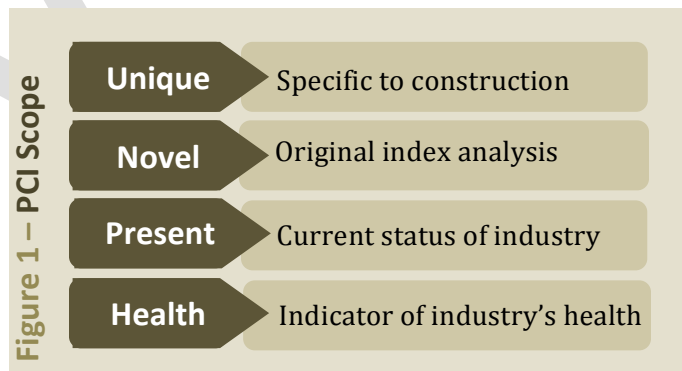
## What is PCI?

Purdue Construction Index (PCI) is a research effort to develop a unique index analysis framework for construction industry. The Architectural/Engineering/Construction (AEC) industry involves significant portion of global economy contributing to 12 percent of GDP in the US. Entangled with crucial upstream and downstream industries, AEC also plays an important role in the global supply chain. Therefore, monitoring trajectory of the industry is important for people who are directly/indirectly involved in the industry. Nevertheless, analysts are deprived of tools specifically devised to evaluate health of the construction industry. Available indices are essentially finance driven and generic disregarding specific characteristics of construction industry. Construction is known as a high risk, capital and asset intensive industry, involving large scale projects with longer payback periods. Purdue Construction Index (PCI) aims to fill this gap providing a trend analysis prototype that portrays the trajectory of health for construction industry. This report will discuss the philosophy behind PCI, establishes fundamental definitions concerning PCI, and describes the prototype. Next section presents a brief review of current index analysis approaches as well as needs and potential target users.

## Introduction

Index analysis provides a structured approach to identify trends, performances, and bottlenecks. The most common example of index analysis is financial indices which are used extensively in different industries. For instance many construction companies use net income per full time equivalent (FTE) to examine their financial performance and efficiency.

Gauging health of construction is crucial given the importance of construction industry in the global economy. PCI aims to provide decision makers in construction industry with clear, quick to understand and lucid indication of current health of construction industry. Objectives of the PCI are enumerated through four salient characteristics for the proposed index analysis framework (Fig. 1) Accordingly PCI is supposed to be *uniquely* designed for construction capturing exclusive characteristics of the industry. It offers a



*novel* approach that is not provided by existing indices. The main focus of PCI is on *contemporary* status of the industry. This decision has been made based on the fact that many indices are historical or prognostic in nature while the gap exists for indices that gauge current conditions. Indices that focus on present status may help identifying bottlenecks within industry and help in channeling the strategies to

prevent undesirable consequences. Current pulse of the industry is of importance for decision makers of different levels specifically in an industry where decisions have long term consequences. It should be mentioned that current pulse of the industry still depends on preceding status. Therefore, with the focus to provide assessment of current status PCI may make use of the data that are historical or prognostic in nature. Finally, the study has narrowed down the objective to indices that would explain health of the industry so as to provide the users with quick proxies to answer the question: “How healthy the

construction industry is at the moment?” An analogy for more illustration might be health of an individual, or a company. Health of an individual might be approximated by indices such as pulse, blood pressure, temperature, respiratory rate, etc. All these sign will give quick overlook of the physical health conditions and will direct diagnostic efforts to more specific examinations. Physical health along with other factors such as well-being, social interactions, etc. will determine overall health of the individual. Similarly, PCI framework presents quick overview of health of construction industry helping decision makers to structure their strategies.

## PCI Philosophy

In order to devise the prototype it is crucial to define “Health” of the construction industry. The core philosophy of PCI is based on the definition of health for the construction industry. PCI regards construction as a healthy industry if it (Fig. 2):

- Generates profit with steady growth
- Has a resilience towards shocks from outside the industry such as financial, political or natural crisis
- Provides amiable working atmosphere for individuals involved in the industry
- Applies best of the expertise, science, and technology in the production process
- And produces high quality products for its users

Core of this definition is the fact that health of the construction industry is beyond the financial performance. Financial performance -similar to physical health of individual- involves an important dimension of the health. However, the overall health of the industry –and an individual- includes other dimensions as well.

Economy of the industry is the most important (and most common) sign to its health since revenue generation is the foremost purpose of involved individuals and entities. Another higher level dimension of the health of the industry is its resilience to any deviations in the external conditions. An industry with buffered resilience to external shocks is more predictable for planning for future and provides security for



business activities. If we consider economy as physiological dimension of the health of the industry (referring to Maslow pyramid (1943)), social atmosphere of the industry can be psychological dimension of its health. The industry has to offer desirable working atmosphere for its workforce. Social interactions and satisfaction of individuals defines a higher level of the industry's health. Furthermore, the development of the industry in terms of proficiency in performing the business activities and tasks will be another dimension of the health of an industry. This proficiency can be in terms of human resources such as academic and professional education and expertise of human resources. It can be also deemed as innovative technologies and sciences applied within the industry. Research and development (R&D) investment can be an example of this dimension of the industry. Referring to Maslow's pyramid this level can be an analogy to self-actualization on

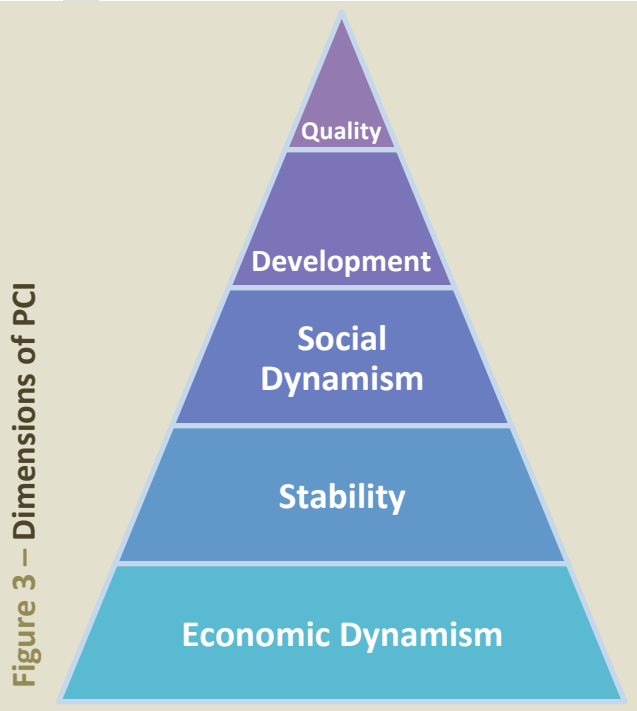
individuals. Finally, quality of the outcomes (as projects, plans, designs, rehabilitations, etc.) comprises another dimension of the health of the industry, since the industry is known by its outcomes. Satisfaction of the users with the output will bring respect and esteem to the industry. Hence, quality of the product and consequently users' satisfaction mark another dimension of the health of the construction industry. Changes and deviations in this indicator will also result in changes in economy of the industry in longer terms. On the other hand, identifying the changes in this trend will help construction industry to avoid any adverse consequences in future. It should be noted that different dimensions of health of industry are defined regardless of Maslow's pyramid for individuals' needs<sup>i</sup> and the pyramid has been used ex-post to provide an analogical example for more clear definition.

## PCI Prototype

PCI philosophy, discussed in previous section, is further developed to devise prototype of PCI. This prototype involves five dimensions for PCI that address health of the construction industry. The five dimensions of PCI, developed based on the philosophy of PCI, include (Fig. 3):

1. Economic Dynamism
2. Stability
3. Social Dynamism
4. Development
5. Quality

Initial scope is to promote an index for each hierarchical dimension considering the most important variables of that dimension. However, any index analysis will have a dynamic nature as its efficiency would be examined through time. PCI is no exception to this trend and will be gradually modified



accordingly to provide more realistic approximation of the health of the industry. PCI will provide these five indices for major specialties within construction since some specialties in construction have different structure. This diversity in structure should be reflected in indicators for the health. A holistic index as an average for the industry would also be provided. Following specialties may be considered for index development:

- Design and Consulting
- Building Construction
- Industrial/Petroleum
- Power
- Transportation
- Telecommunication
- Water and Hydraulics
- Hazardous Waste
- Others

Prior to establishing detailed prototype for the PCI, following items should be established:

- Clear definition of each dimension
- Prominent variables for each dimension
- Target users for each index

Following sections will discuss these three issues in more detail. The study sets concrete definition for each dimension. Thereafter prominent variables in each dimension would be discussed so as to assess resources that can be considered for each specific index. Afterwards potential users targeted by each dimension would be identified. Identifying target users in each dimension will delineate needs and consequently the focus area for each dimension and clarifies the use of each dimension.

## PCI Definitions

### 1. Economic Dynamism

This index will indicate current economic health and growth rate of the construction industry. It may use some indices that are financial in nature. The ultimate index may consider specific economical characteristics of the construction industry specialties in terms of asset requirements, fixed costs and variable costs, equity requirement, etc. Economic status may have different sub-dimensions by itself such as financial performance, employment rate, etc. Prominent variables within these sub-dimensions may be:

- New investments
- Prospects of the industry
- Growth trajectory
- Backlog
- Average Rate of Return within the sector
- Payback period
- Market elasticity
- Rate of employment

- Market willingness to pay

### 2. Stability

Stability is an important dimension of any industry that determines prospects, and risks. Stability is tightly interrelated with the confidence level in the industry. This index indicates resistance of the industry to external shocks from economy, disasters, etc. It can help decision makers to diversify their portfolio and direct their dependencies on risky trends. Clear example of application area for this index may be the recent economic crisis and its multifaceted effect on construction industry. Prominent variables for this dimension include:

- Dependencies
- Diversifications
- Governance consistency
- Rate of Bankruptcies
- Employment or layoff trends

### 3. Social Dynamism

Social dynamism deals with social quality of the industry in terms of individuals'

satisfaction and collective social well-being within the whole industry. It will represent work atmosphere of the industry in terms of ethics, employees' satisfaction and motivation, public appeal of industry, safety of the industry etc. This is an important index for people who want to decide on their professional career or academic major as well as people who want to apply for jobs. It can also be used to improve social well-being of the industry. Several studies have proved influence of organizational and social well-being on economic performance of the firms<sup>ii</sup>.

- Job security
- Safety related incidents
- Average level of salaries
- Benefits (Healthcare, etc.)
- Union workers

#### 4. Development

This index deals with both human and non-human resources of construction and their level of advancement. It is an indicator of the degree of expertise, and technological and scientific advancement level of the industry. It would also consider innovation within the industry. This degree is very important to diagnose wherever there is lack of development and expertise and how the resources should be allocated to development of the industry. It can also

be used to find trends where investment in development has resulted in higher future economical outcomes. Development index essentially indicates the investment of the industry for sustaining future performance.

- Research and development investments
- Application of new methodologies and technologies
- Innovation
- Academic/non-academic education
- Availability of expertise

#### 5. Quality [of the output]

This index will target level of quality in projects, designs and other outputs of the industry. It indicates value generation trends and degree of excellence of the industry. This index is important as the most practical indicator which is assessed by industry users. The external judgment about the output will aid professionals with the clear understanding of the market. It will also influence future economic and social status of the industry as better quality will upgrade the picture of industry within policy makers and individuals who invest in the industry.

- Owners' satisfaction
- Users' satisfaction
- Changes and modifications
- Green products
- Major construction failures

## PCI Target Users

Identifying target users will help to define applicable index prototype. This section will enumerate potential users for each dimension of the PCI.

#### 1. Economic Dynamism

- Construction firms:
  - Define investment trend
  - Select focus of work
  - Define size of human capital
  - Asset management policies
  - Financial decisions

- Angel investors
- Job market

#### 2. Stability

- Construction firms
- Upstream suppliers of the industry
- Job market
- Investors
- Policy makers

#### 3. Social Dynamism

- Policy makers
- Individuals deciding on their professional career
- Insurance companies
- Individuals who search for job
- Human resource managers
- Job market
- Unions

4. Development

- Educational institutions
- Individuals deciding on their professional career

- Companies with open positions
- Innovators
- Investors
- Technology suppliers

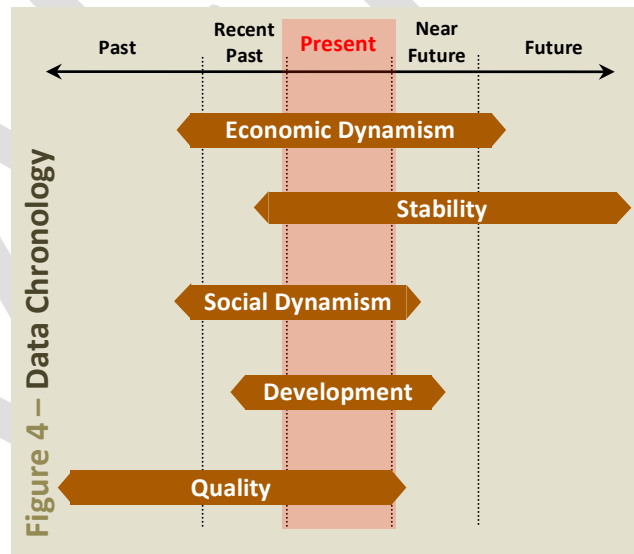
5. Quality [of Output]

- Owners [Users of the output]
- Quality control institutions
- Construction firms
- Suppliers
- Educational centers
- Standard institutions
- Policy makers

## Data Collection

Indicators of each dimension will be defined according to basic foundation of PCI including its philosophy, definitions, needs, and characteristics of the users. This section will discuss data collection for each dimension along with the related implications. First step in determining formulation of each index is to establish data chronology of each dimension. Since the PCI aims to address *current* status of the industry, the contemporary nature should be reflected within each dimension. Therefore, considering 5 time-spans of past, recent past, present, near future, and future; there is a need to establish: 1) what is the chronological implication of the current index in each dimension, 2) what is the time-line of data sources for each dimension. For example, current stability depends on prospects of the future. As a result, the data source for this dimension is based on the future trends and prospects of the industry. On the other hand, current quality index depends on previous projects and their performance, their performance, and outcomes. Thus, the index for current status of the industry in terms of quality is derived from historical data. Figure 4 depicts chronological spans relevant to each dimension.

The data sources for determination of each index should also be clearly defined.



Each indicator will have a separate source of data that should be easily accessible to the PCI team and can provide an input with an acceptable quality of the data to assure the required quality of the outcome.

Economic dynamism is based on the total monetary input of the construction in recent past, present, and near future which will be available through industry income. The prospect of the contract size in near future may be determined through future growth in countries GDP and the coefficient for historical influence of this trend on income of the construction industry. Stability

may be determined through downstream industries that provide work for the construction industry. Growth of each upstream industry can be assessed by stock market futures in that industry so as to determine the weighted average of the influence on construction stability. Social dynamism requires data for average income as well as statistics of the incidents and their related loss. Development requires data from educational practices common in construction which can be determined as an

average portion of employees with different training. It also needs data regarding investment in health of the industry which will be determined taking out costs related to current performance from the total outgoing accounts. Quality dimension index requires data on any rework due to lack of quality, any fines and reimbursement thereof, as well as major incidents related to construction projects (such as I-35W Minnesota bridge.)

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<sup>i</sup> A. H. Maslow (1943) "A Theory of Human Motivation", *Psychological Review*, Vol. 50, No. 4, Pg. 370-396.

<sup>ii</sup> Smet, A., and Palmer, R., and Schaninger, W., (2007) "The Missing Link, Connecting Organizational and Financial Performance" *McKinsey Quarterly*, 2007(3), Pg.6-9.

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## Appendix-Existing Indices

A study was conducted to explore existing indices applicable to construction industry. The existing indices identified through this research which are applicable to the construction industry, were divided into nine categories as: financial, economic, cost, labor, material, social, construction volume, equipment and procurement.

Various indices under each specific category were studied and after a detailed review conclusion were reached as following:

### 1) Financial indices

Identified indices include Dow Jones, Russell, and S&P, Wilshire, among only S&P index Select industry indices was found to be directly applicable to construction. Still other indices can be used to understand the health of the current economy or to forecast the future trends. Considering dependencies between construction and general economy these indices would help for that forecast.

#### **S&P Select Industry Indices:**

- The S&P Select Industry Indices is one of the many indices owned and maintained by Standard & Poor's, a division of McGraw-Hill. S&P measure the performance of 19 indices for the 10 different narrow Global Industry Classification Standard (GICS®) sub-industries and 1 index is for construction industry. For construction industry, there exists sub-classification which includes Building & Construction Building Products, Construction & Engineering, Construction & Farm Machinery & Heavy Trucks, and Construction Materials.
- Every index measures and calculates annualized risks (standard deviation), return, Sharpe ratio (return/investment) for 1, 3, and 5 year periods as a percentage. It clearly indicates how much risk and returns are expected in a time frame of 1, 3 or 5 yrs for 100,000 dollars of *investment*.

### 2) Economic Indices

Gross Domestic Price inflator Index, Producer Price Index, Consumer Price Index, US Export and Import Price Index are widely used economic indices.

Gross domestic product (GDP) refers to the market value of all goods and services produced within a country in a given period and generally indicates standard of living.

Consumer Price Index (CPI) -also known as cost of living index- compiled periodically by the U.S. Department of Labor. The Consumer Price Index (CPI) is a measure of the average change over time in the prices paid by urban consumers for a market basket of consumer goods and services. It is typically used as an economic indicator, as a deflator of other economic series, and as a mean of adjusting dollar values.

Both GDP and CPI are used as general indicators of the nation's economy in terms of standard and cost of living, indicating if the denizens there are able to support cost of living conditions existing.

Producer Price Index measures the average changes over time in the selling prices, received by the domestic producers for their output. Producer price indices have a separate set of indices for construction materials and supply units to different types of construction (heavy, single unit residential etc.), equipment, and subcontractor prices. Every value is referenced to base value of 1982 as 100. Therefore a value higher would mean prices have increased in case of materials or the volume of construction has increased in case of construction.



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US Import and Export Indices provide value of commodities imported or exported such as fuel, steel. These commodities are widely used in construction industry and so making this indicator relevant for construction economy.

### 3) Material Indices

As the name suggests material indices indicate material prices, availability, sales, availability of purchasers and suppliers. The indices identified were the price index for material published by ENR, PPI Construction Materials Index and an indicator (ratio) showing impact of weather conditions and purchaser/supplier availability on sales.

PPI indices and their methodology have been discussed earlier as a material index which forms a sub-part of construction indices that PPI publishes.

ENR material Index tracks the weighted price movement of structural steel, Portland cement, and 2 X 4 lumbers. A table of cement, concrete, and aggregate prices are published in the first weekly issue every month, pipe prices the second week, lumber, drywall and insulation prices the third week, and steel prices the fourth week. Besides the current value percentage change from the value in the last issue and to the previous year's average value is also reported.

Construction Material Sales Ratio is published by Reed Construction in their construction equipment magazine and it calculates effect on material production, prices, orders, shipments, unfilled orders, inventory and inventory per sales ratio in the form of percentage change during past month, past 3 months, 1 year, and 3 years. It also comments on the effects of weather on material production and gives a more detailed analysis on ENR index.

### 4) Procurement Index

Under procurement index section, non manufacturing index has been found which has data on suppliers to the construction industry. The Non-Manufacturing Index gauges business activities of various industries including Utilities; Construction; Wholesale Trade; Transportation & Warehousing; Information; Finance & Insurance; Real Estate, Rental & Leasing and Other Services (services such as Equipment & Machinery Repairing;). The ISM Non-Manufacturing Index is based on a sample survey of purchasing and supply executives, weighted according to industry contribution to GDP. The Index is calculated using 50% as the centerline between positive and negative expectations; the figure is reported in headlines as the percent change. The ISM Non-Manufacturing Index is based on a sample survey of purchasing and supply executives, weighted according to industry contribution to GDP. The Index is calculated using 50% as the centerline between positive and negative expectations reported as percentage change. Anything less than 42% is an indication of recession.

### 5) Equipment Index

Equipment Indices are used to track changes in equipment lease, rentals, revenue, operations, etc. There are different indices for construction equipment from rentals, lease to operations, maintenance and non-operating costs such as depreciation etc.

- Construction Equipment Revenue Trends index is published by association of equipment manufacturers and measures revenue generated by trading equipment from the suppliers side.
- Wright Fuel Index is an index which tracks fuel consumption by U.S. construction Companies monthly.
- Foundation Monthly Confidence Index or the Equipment Finance Industry (MCI-EFI) includes reports as qualitative assessment of both the prevailing business conditions and expectations for the future from a 650 billion dollar equipment finance sector.

## 6) Labor Index

Labor Indices indicate employment trends such as pay scale, BLS Cost index, Employment trends Index for construction employees/employers.

- BLS Employment Cost Index computes changes in compensation costs for every occupation in construction. It offers quarterly detailed information based on gender, work categories (hourly and salary based).  
ENR Labor index computes two types of indices: Skilled labor index which tracks union wages, plus fringe benefits, for carpenters, bricklayers and iron workers. And Common Labor Index which tracks the union wage, plus fringe benefits for laborers.
- The Employment Trends Index offers a short-term, forward look at employment on its own. It gives economists and investors a new forecasting tool. It also helps business executives sharpen their short- to medium-term hiring and compensation planning

The eight labor-market indicators aggregated into the Employment Trends Index include:

- Percentage of Respondents Who Say They Find “Jobs Hard to Get” (The Conference Board **Consumer Confidence Survey**<sup>®</sup>)
- Initial Claims for Unemployment Insurance (U.S. Department of Labor)
- Percentage of Firms With Positions Not Able to Fill Right Now (© National Federation of Independent Business Research Foundation)
- Number of Employees Hired by the Temporary-Help Industry (U.S. Bureau of Labor Statistics)
- Part-Time Workers for Economic Reasons (BLS)
- Job Openings (BLS)
- Industrial Production (Federal Reserve Board)
- Real Manufacturing and Trade Sales (U.S. Bureau of Economic Analysis)

It is referenced to value 100 taken at the base year 1950 and any value greater than 100 shows positive trend and less than 100 shows negative trend.

- The PayScale Index tracks quarterly compensation trends. Specifically, it tracks changes in total cash compensation for full-time private industry employees in the United States. The PayScale Index has not been adjusted for inflation. It is based on the actual wages. In addition to the national index, it includes separate indices for specific industries, metropolitan areas, and company sizes.
- The PayScale Index measures the change over time in what an employer must pay to fill a specific job with a worker who has certain skills, abilities, education, experience and other compensable factors.

The PayScale Index's view into compensation trends can be used in several ways.

**Employers** can use The PayScale Index to understand overall trends in compensation and how average wages are changing nationally, and by industry, metropolitan area, and company size.

**Political and business leaders**, and others interested in the U.S. economy, can use The PayScale Index to understand trends in available income full-time workers for spendings. When The PayScale Index is below the Consumer Price Index, the average employed worker's ability to buy goods and services is declining. Such a decline would be in addition to any reduction in aggregate wages caused by rising unemployment.

**Individual employees** can use The PayScale Index to understand how the market prices (expected wages) for their services as employees are changing on average. This is not correlated to changes in their experience level or responsibilities which could also impact their individual market price.

### 7) Social Index

Social indices such as Quality of Life Index, American Human Development Index, Happy Planet Index are general measures of quality of life of a country's nationals irrespective of their occupation, age, sex etc.

Besides, work ability index shows the average retiring age of construction workers. OSHA publishes safety index every year which is computed using the number of fatalities, accidents, near misses that occur on a job site.

There also exists ENR Construction industry confidence that measures industry sentiment about the construction market, including market sectors, expectations and trends. The Construction Confidence Index is based on a scale of 100, where a value of 100 indicates all respondents report "improving" activity and a value of 50 means all respondents report "stable" activity.

### 8) Construction Volume

There are many indices in the market indicating volume of work being done currently, pending volume and predict places which are expected to have construction activity.

Expansion Index is published by Reed Construction Data is a 12 to 18 month "look ahead" at the construction market place. It indicates whether a location's construction volume is expected to expand or shrink in the upcoming 12 months while shrinking construction markets have an Expansion Index of 1.0 or less. Locations with expanding construction markets have an Expansion Index greater than 1.0, and "Hot spots" as locations that are rapidly growing are indicated by an Expansion Index greater than 5.0. Construction volume in these locations is predicted to expand dramatically in the next 12 month period.

Pending Home Sales Index: "The NATIONAL ASSOCIATION OF REALTOR, developed the Pending Home Sales Index (PHSI), a new leading indicator of housing market activity based on the data from Multiple Listing Services (MLSs) and large brokers. It provides advanced information on future home-sales activities and changes in the direction of the market. Specifically Pending Home Sales become Existing-Home Sales one-to-two months later.

Housing Starts is a very good tool to gauge building permits and can be used to identify business cycle pivot points. Sample size covers approximately 95% of all residential construction in the U.S. Housing starts is best to be used as a business cycle indicator and a tool for investors researching the real estate markets. The housing starts report to help creating estimates for other consumer-based indicators as people buying new homes tend to spend money on other consumer goods such as furniture, lawn and garden supplies, and home appliances.

### 9) Cost indices

Cost Indices generally indicate the cost to construct.

- ENR publishes two kind of input price indices
  - 1) The difference between BCI and CCI is in their labor component. The CCI uses 200 hours of common labor, multiplied by the 20-city average rate for wages and fringe benefits. The BCI uses 68.38 hours of skilled labor, multiplied by the 20-city wage- fringe average for three trades—bricklayers, carpenters and structural ironworkers. For their materials component, both indexes use 25 cwt of fabricated

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standard structural steel at the 20-city average price, 1.128 tons of bulk Portland cement priced locally, and 1,088 board ft of 2x4 lumbers priced locally. The ENR indexes measure how much it costs to purchase this hypothetical package of goods compared to what it was in the base year.

- 2) The two indexes apply to general construction costs. The CCI can be used where labor costs are a high proportion of total costs. The BCI is more applicable for structures.
  - Turner's Building Cost Index is published by Turner and it is widely used by the construction industry and Federal and State governments, the building costs and price trends to determine output construction costs in residential, and the commercial construction. The Cost Index is determined by several factors considered on a nationwide basis—labor rates and productivity, material prices and the competitive condition of the marketplace- while the data is collected from their own projects.
  - HUD publishes Cost index using R.S means manual cost data and publishes two indices one for construction of “average” quality and the Marshal & Swift cost index for construction of “good” quality.
  - US Census Bureau publishes three different index types for the price of new home sold or being constructed. It includes:
    - Laspeyres (Constant Quality type);
    - Paasche (Output Deflator); and
    - Fisher Ideal Index (Price Deflator)

Use of any particular index depends on the purpose as each index has its own strengths and weaknesses.

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