The Society for Economic Measurement 2022, Session A1: Measuring Property Prices.

Constructing Building Price Index Using Administrative Data

-A Method for Estimating an Output-type Building Price Index Using Individual Data from the Statistics on Building Starts-

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1. Motivations

Motivations

- **Improving the accuracy of deflators is crucial for measuring real GDP and growth rates.**

- However, construction prices are often difficult to measure.
  - Buildings and civil engineering structures of the same quality and content are usually not traded repeatedly →Buildings and civil engineering structures are ***completely custom-made products***: ***Highly heterogeneous.***
  - It is difficult to create an ***"output-type"*** construction price index with ***constant quality*** because it is not possible to continuously observe changes in market transaction prices: ***Quality adjustment problem.***
  - Strong ***data constraints*** make empirical research impossible: ***Data availability problem.***

The deflator and *Construction Sector*

The high share of the construction industry in GDP **(12%)** and the high impact of the construction investment share in the capital stock.

→On the measurement of productivity.

→***Price index*** for the construction industry.

(Construction investment in 2019, Total GDP: 557 trillion yen)

Subject property	private	public	Total
Housing	19.3 trillion yen (28%)	0.3 trillion yen (0%)	19.6 trillion yen (28%)
Nonresidential Building	11.8 trillion yen (17%)	2.8 trillion yen (4%)	14.6 trillion yen (21%)
Building Repair	10.1 trillion yen (15%)	1.8 trillion yen (3%)	11.8 trillion yen (17%)
Public works	6.7 trillion yen (10%)	16.3 trillion yen (24%)	23.0 trillion yen (33%)
Total	47.9 trillion yen (69%)	21.2 trillion yen (31%)	69.0 trillion yen (100%)

Capital Stock and GDP

- Construction investment is counted as **gross fixed capital formation and increases the capital stock**.
  - Compared to machinery and equipment, its share in the capital stock is extremely high due to its ***long useful life***.
  - The accuracy of the construction price index is expected to have a significant impact on the capital stock in nominal terms as well as in real terms when converted to market value.
  - Furthermore, the impact on ***the measurement of productivity (TFP)*** using the real capital stock is expected to be significant.
  - Since the accuracy of the construction price index has a large impact on the capital stock, it will also have a large impact on ***"fixed capital depreciation"*** through the conversion of the capital stock to market value.

Statistics Commission Japan: the Third Basic Plan of Promotion of Statistical Reform.

- The "Final Summary" in 2016 of the Council for the ***Promotion of Statistical Reform*** points out the improvement of the deflator.
- **The "Third Basic Plan for the Development of Official Statistics".**
  - Based on the results of joint research conducted by the Bank of Japan with the participation of the Ministry of Land, Infrastructure, Transport and Tourism.
  - In providing data and related information from MLIT to the Bank of Japan will also consider how to utilize a series of research results.

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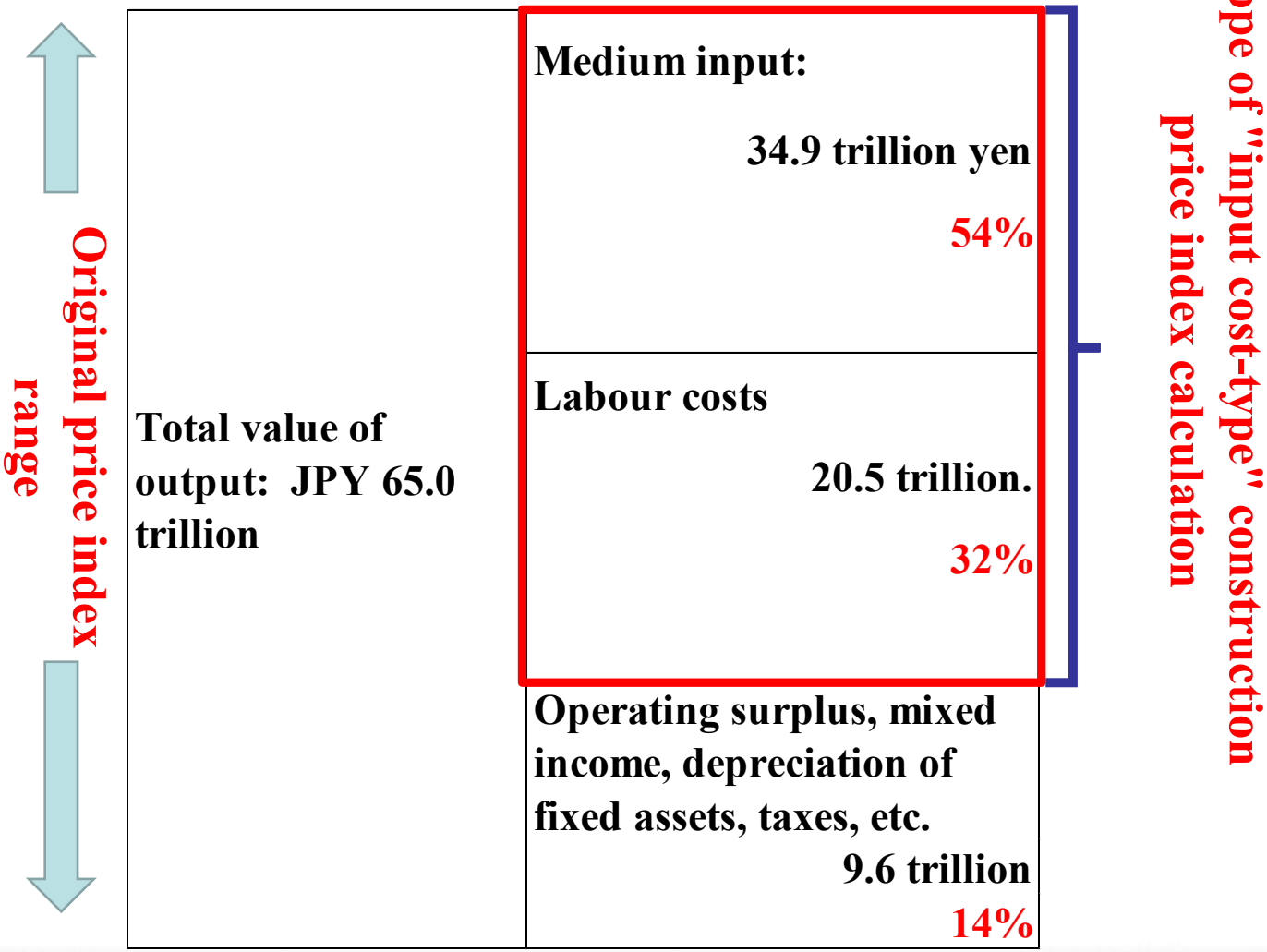
2. Output-Type Construction Price Indices

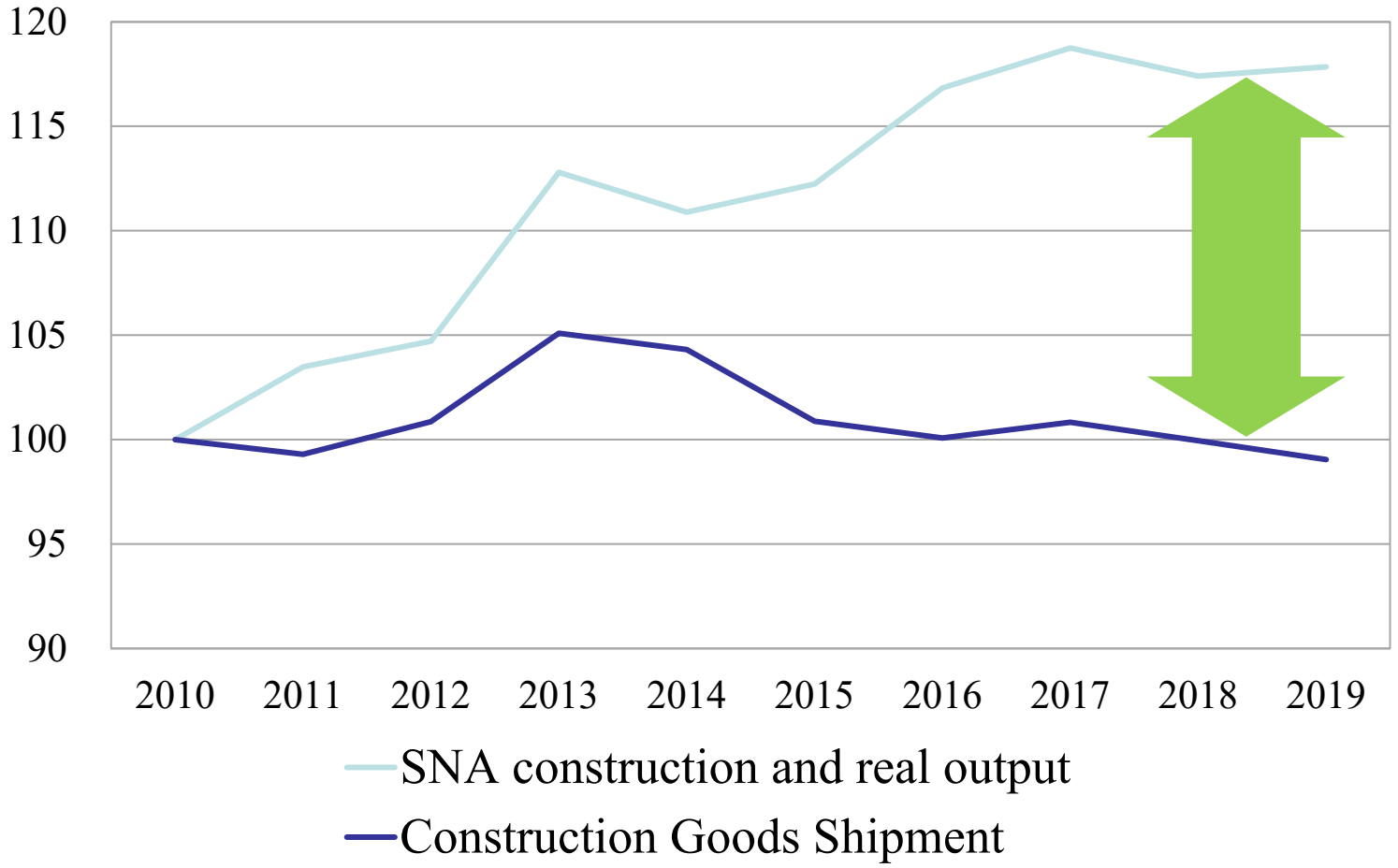
Output-Type Construction Price Indices

- The price index used as a deflator must match the nominal amount and parity with respect to the coverage (**range of calculation of the amount**).
  - The value of output (value of shipments) is deflated by the price index at the producer stage (corporate price index and service price index for firms), and the value of household consumption expenditure is deflated by the price index at the consumer purchase stage (consumer price index), respectively.
- Due to the difficulty of creating a market transaction price-based construction price index, SNA calculated an **"input cost-type" construction price index** as an alternative method and used it as a deflator.

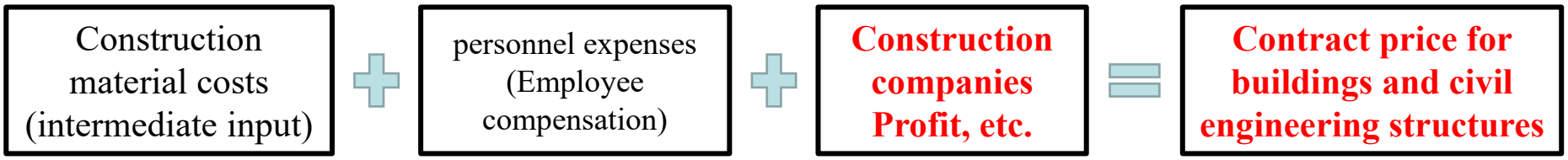
Input/output structure of the construction industry: 2017



Real output of construction and construction goods shipments do not run parallel.



An “output” type price index that directly measures market prices is needed.



- Changes in the supply and demand environment in the construction market cause construction companies' profits to fluctuate widely.
- For this reason, the “input cost-type” price index, which is a weighted average of the price index for construction materials and wage statistics for labor costs, does not provide information on market prices (contract prices) for buildings and civil engineering structures.

Alternative price index to “output cost" type price index.

- OECD (1997) introduces the following six methods to construct a price index:
- **(1) Model price method**
- (2) Quoted prices method
- (3) List prices method
- (4) Matched models method
- **(5) Stratification method**
- **(6) Hedonic method**

Problems with the "Model pricing approach".

1. The possibility that price indices will no longer reflect the actual situation if some production factors in the building and construction models lose their representativeness.
   - In the U.S., the model's representativeness is ensured by regularly reviewing the building model together with experts (construction cost estimating firms).
2. Since the model price is the totalized price of the hypothetical model and not the actual transaction price, it may deviate from the actual price. It is important to confirm that the model price reflects the actual situation.
   - Each month in the U.S., when each contractor responds, they check factors that affect bid prices, such as order backlogs, complexity and size of construction projects, and economic conditions. Devised so that the prevailing price can be surveyed.

Problems with the "Model pricing approach" *in Japan*.

- The cost of producing statistics is high, including the need to secure ***personnel with construction expertise*** in the statistical production department to design the model.
- The reporting person burden for construction companies and ***contractors who report hypothetical estimated prices monthly is also heavy***.

- It is difficult to produce accurate construction price indexes using the "***model price approach***" under the Japanese statistical production environment, where expert statistical resources are extremely scarce and it is difficult to increase the reporting burden on companies.

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3. Estimation of Output-Type Construction Price Indices Using the Administrative Data.

Data.

- Under ***the Building Standard Law***, the building owner is required to submit a ***"building construction notification"*** to the prefectural governor (actually via the ward or municipality) when constructing a building (10 ㎡ or more).
  - The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) publishes "Statistics on Construction Starts" by compiling "Building Construction Notifications".
  - January 2005 to December 2020: 16 years, 7.92 million (average of 500,000 per year).
  - Attribute information available includes the estimated construction cost of the building, as well as the building owner, structure, use, type of construction, number of floors above and below ground, and floor area.

	attribute (specification) item	contents
Housing	Building method	Prefabricated, two -by-four, other (conventional construction method)
	Building (e.g., house)	Single-family houses, row houses, and apartment buildings
	Structure	Wooden construction, steel -framed reinforced concrete construction, reinforced concrete construction, steel construction, and concrete block construction, among others
	Administrative divisions of Japan	47 Prefectures
	Usage restrictions, limitations	Owner-occupied houses, rental houses, salaried housing, and condominiums
Non-housing	Versatile or not	Multi-purpose buildings, among others
	Purpose	Standard Industrial Classification (Middle Classification)
	Structure	Wooden construction, steel -framed reinforced concrete construction, reinforced concrete construction, steel construction, and concrete block construction, among others
	Administrative divisions of Japan	47 Prefectures

Methods in “Output-type” building price index.

Stratification Approach

Building method	Structure	Housing Type	Prefecture	Usage restrictions, limitations	…	…	Jan-10	Feb-10	Mar-10	Apr-10	May-10	…
Prefabricated construction method	Wooden structure	Single-family houses	Hokkaido	Owner-occupied house	…	…	20.27	19.73	20.98	19.69	19.81	…
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Prefabricated construction method	Reinforced concrete structure	Single-family houses	Tokyo	Owner-occupied house	…	…	25.97	24.82	24.36	24.82	26.56	…
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Frame wall construction method	Wooden structure	Apartment houses	Fukuoka	Rental house	…	…	10.97	11.90	12.92	11.91	11.85	…
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Hedonic approach

$$\log p_i = \alpha + \sum_{j=1}^{n} \beta_j x_{i,j} + \sum_{k=1}^{m} \delta_k d_{i,k} + \sum_{t=1}^{T} \gamma_t TD_{i,t} + u_i$$

Stratification Approach.

Building method	Structure	Housing Type	Prefecture	Usage restrictions, limitations	…	…	Jan-10	Feb-10	Mar-10	Apr-10	May-10	…
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Stratification approach: 4 steps.

- The index is divided into two major categories: residential and non-residential buildings.
  - wooden, steel-framed, reinforced concrete, and other.
- The index is created using quarterly averages: The geometric mean is used in the exponential formula.
  - ①**The data is classified (called "stratification") based on attributes such as building structure, construction method, region, and use** (such as owner-occupied house, rental house, and condominium house)
  - ②**For each subdivided strata, the estimated construction cost and total floor area of all properties included in the strata are summed, and the unit price per floor area of the estimated construction cost** (estimated construction cost / total floor area) is calculated.

Stratification approach: 4 steps.

- ③**Unit price per floor space is indexed by FY 2011 = 100, and individual indexes are created for each strata.**
  - For layers for which data do not exist (empty value), the same layer is supplemented with values from the previous quarter ("previous quarter horizontal supplementation").
- ④**The individual indexes for each tier are weighted and averaged by the weight of each tier calculated from the estimated construction cost or the number of construction projects in FY2011 to create price indexes for the upper tiers** (residential wooden structures, residential steel-framed structures, nonresidential wooden structures, nonresidential steel-framed structures, etc.).

Hedonic approach.

- Diewert (2003), we use log-transformed values.

- We use rolling hedonic estimation, in which estimates are made in staggered 12-month windows; a total of 181 estimates are made over the 192-month data period from January 2005 to December 2020.
  - Same method used in the “Property Price Index" of the Ministry of Land, Infrastructure, Transport and Tourism.

Hedonic approach.

$$\log p_i = \alpha + \sum_{j=1}^{n} \beta_j x_{i,j} + \sum_{k=2}^{m} \delta_k d_{i,k} + \sum_{t=2}^{T} \gamma_t TD_{i,t} + u_i$$

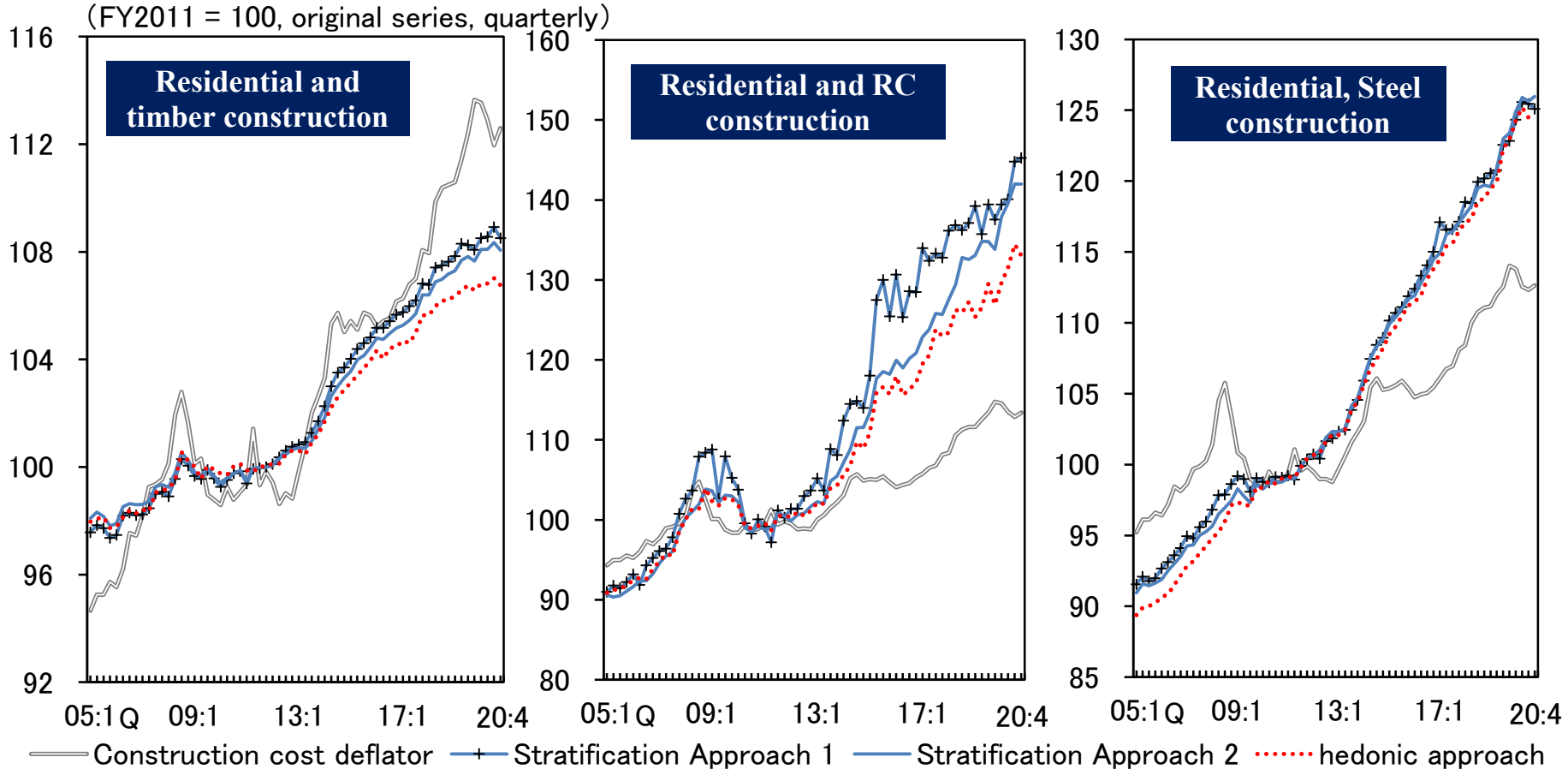
- p_i : square meter unit price of building i,α: constant term,
- $x_{i,j}$: the jth attribute (numeric) of building i, and β_j : numerical data parameter, $d_{i,k}$: kth attribute (dummy) of building i, and δ_k: dummy variable parameter,
- $TD_{i,t}$: survey month t of building i (time dummy), and γ_t : parameter of the time dummy, (representing quality-adjusted prices),
- u_i : error term

Estimated results in Hedonic Regression

			Adj. R^2				Number of Obs.			
			Min.	Max.	Ave.	Med.	Min.	Max.	Ave.	Med.
Housing	Wooden		0.154	0.179	0.167	0.166	317,311	424,311	375,686	375,116
	Non-Wooden	RC	0.250	0.414	0.314	0.312	6,534	18,581	10,307	9,219
		S	0.197	0.298	0.253	0.264	39,063	82,629	58,796	57,874
		Others	0.100	0.372	0.208	0.201	966	1,659	1,234	1,193
Non-Housing	Wooden		0.143	0.337	0.259	0.267	13,759	18,087	15,574	15,580
	Non-Wooden	RC	0.079	0.205	0.131	0.129	2,234	4,607	3,082	3,055
		S	0.230	0.368	0.294	0.291	21,539	40,179	28,777	27,986
		Others	0.331	0.514	0.410	0.409	1,170	1,815	1,447	1,412

Note: These values are taken for 181 rolling estimaion results.
Source: Estimation by Authors

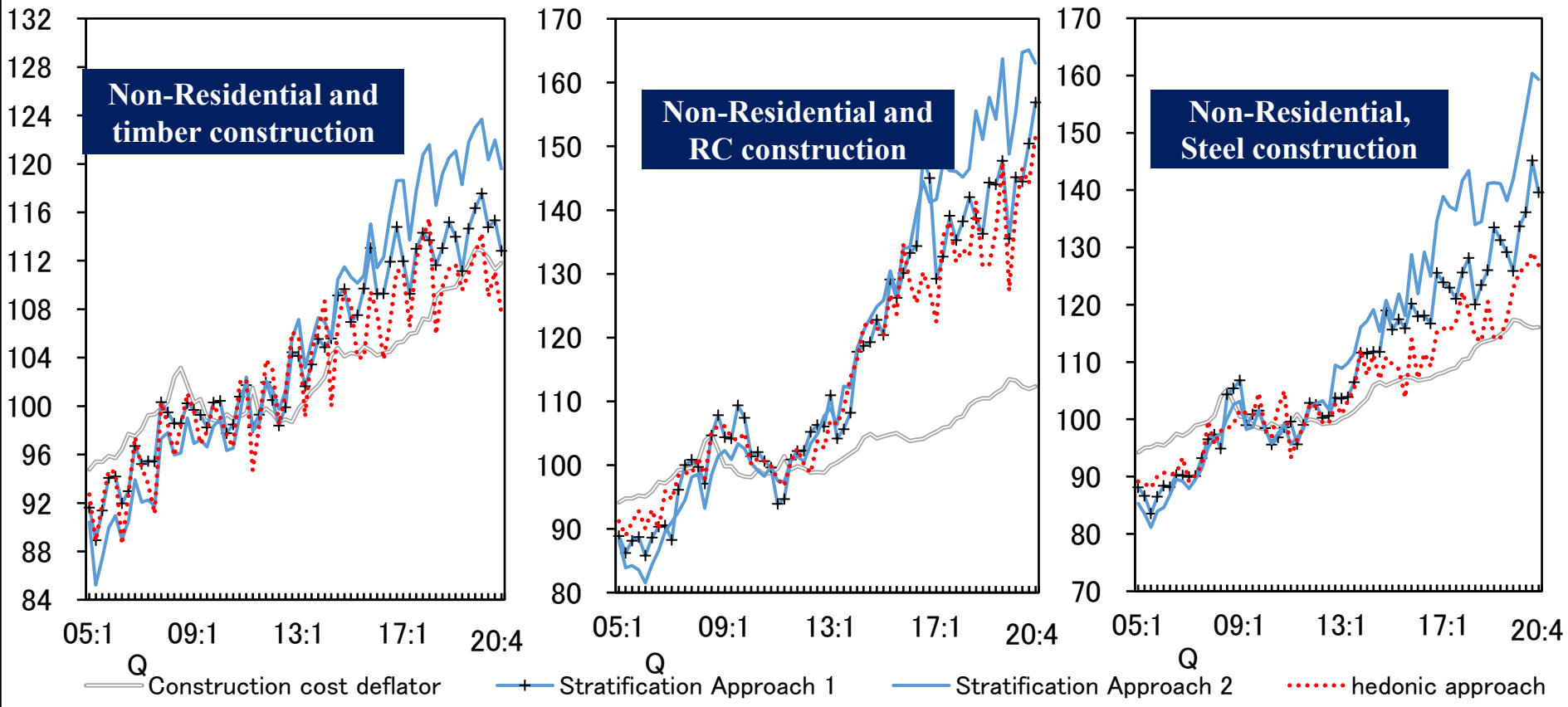
Baseline estimation results: residential



Note: Stratified Approach 1 and Stratified Approach 2 are weighted by "estimated construction cost" and "number of construction projects," respectively.

Baseline estimation results: non-residential

(FY2011 = 100, original series, quarterly)



Note: Stratified Approach 1 and Stratified Approach 2 are weighted by "estimated construction cost" and "number of construction projects," respectively.

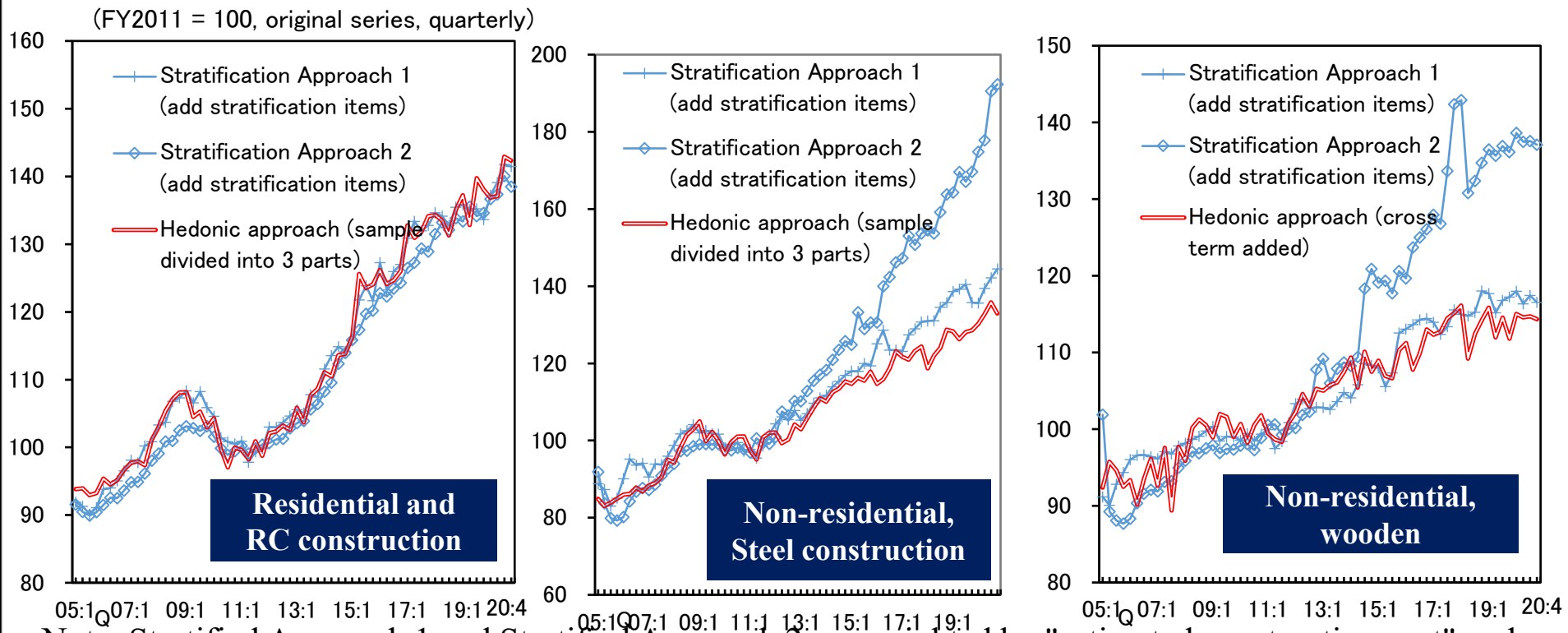
Housing/ Non-housing	Structure	Stratification v.s. CCD	Hedonic v.s. CCD	Stratification v.s. Hedonic
Housing	wooden	medium gap	medium gap	medium gap
	reinforced concrete construction	large gap	large gap	large gap
	steel construction	medium gap	medium gap	small gap
Non-housing	wooden	large gap	medium gap	large gap
	reinforced concrete construction	large gap	large gap	small gap
	steel construction	large gap	medium gap	large gap

Additional Items in the Stratification Method

Housing/ Non-housing	Baseline	Addition of stratification and subdivision items
Housing	Building method, construction method, structure, prefecture, and use relationship	**Baseline;** Builder, capital stock category, city planning zoning, basement, retired housing, funds for new housing, use (building with housing industrial use)
Non-housing	Multi-use or not, use, structure, and prefecture	**Baseline;** Architect, capital stock category, city planning zoning, underground

Expanded Models

The stratification approach was refined by adding stratification items, and the hedonic approach was refined by dividing the sample by building size and adding dummy variables, etc. The gap between the indices by the two approaches narrowed.



Note: Stratified Approach 1 and Stratified Approach 2 are weighted by "estimated construction cost" and "number of construction projects," respectively.

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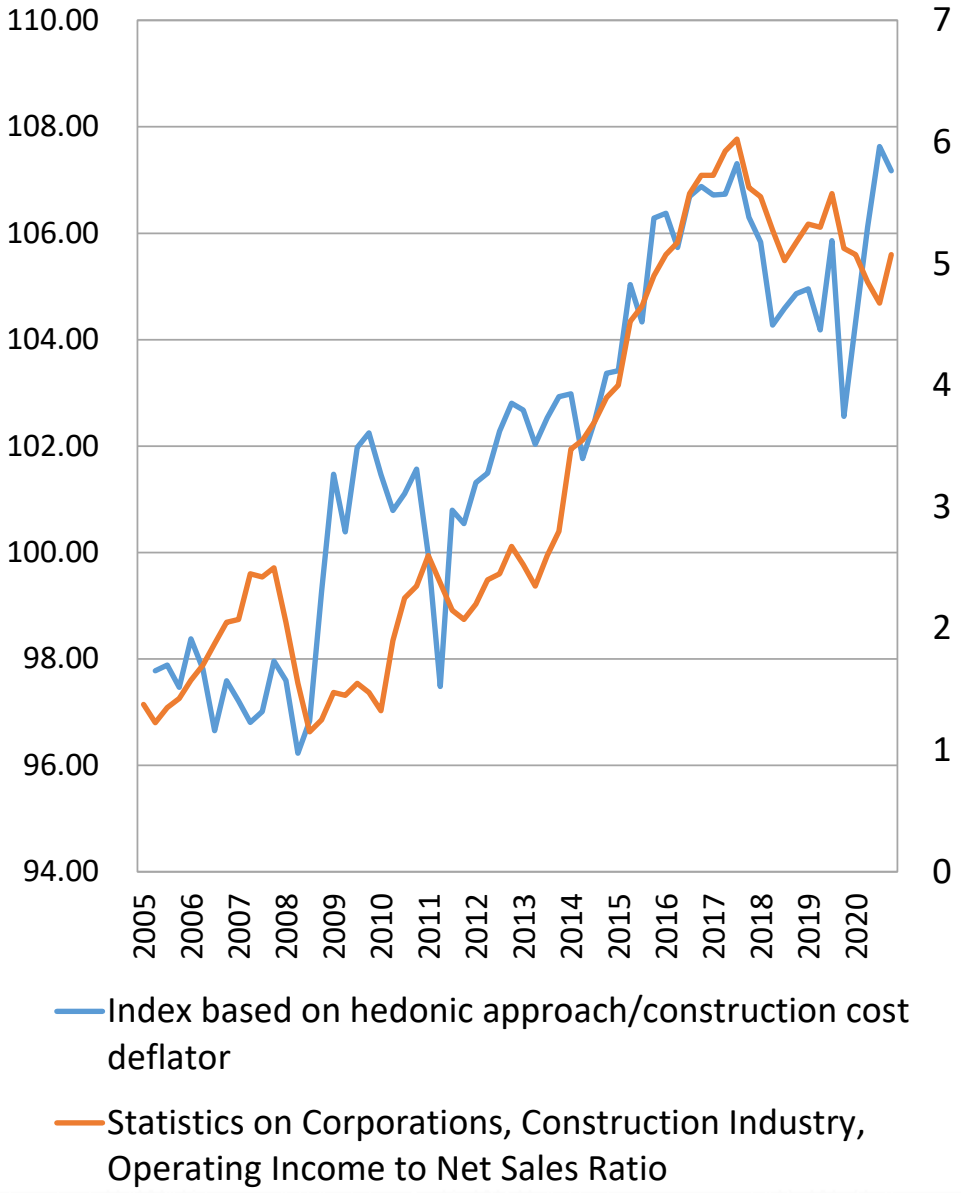
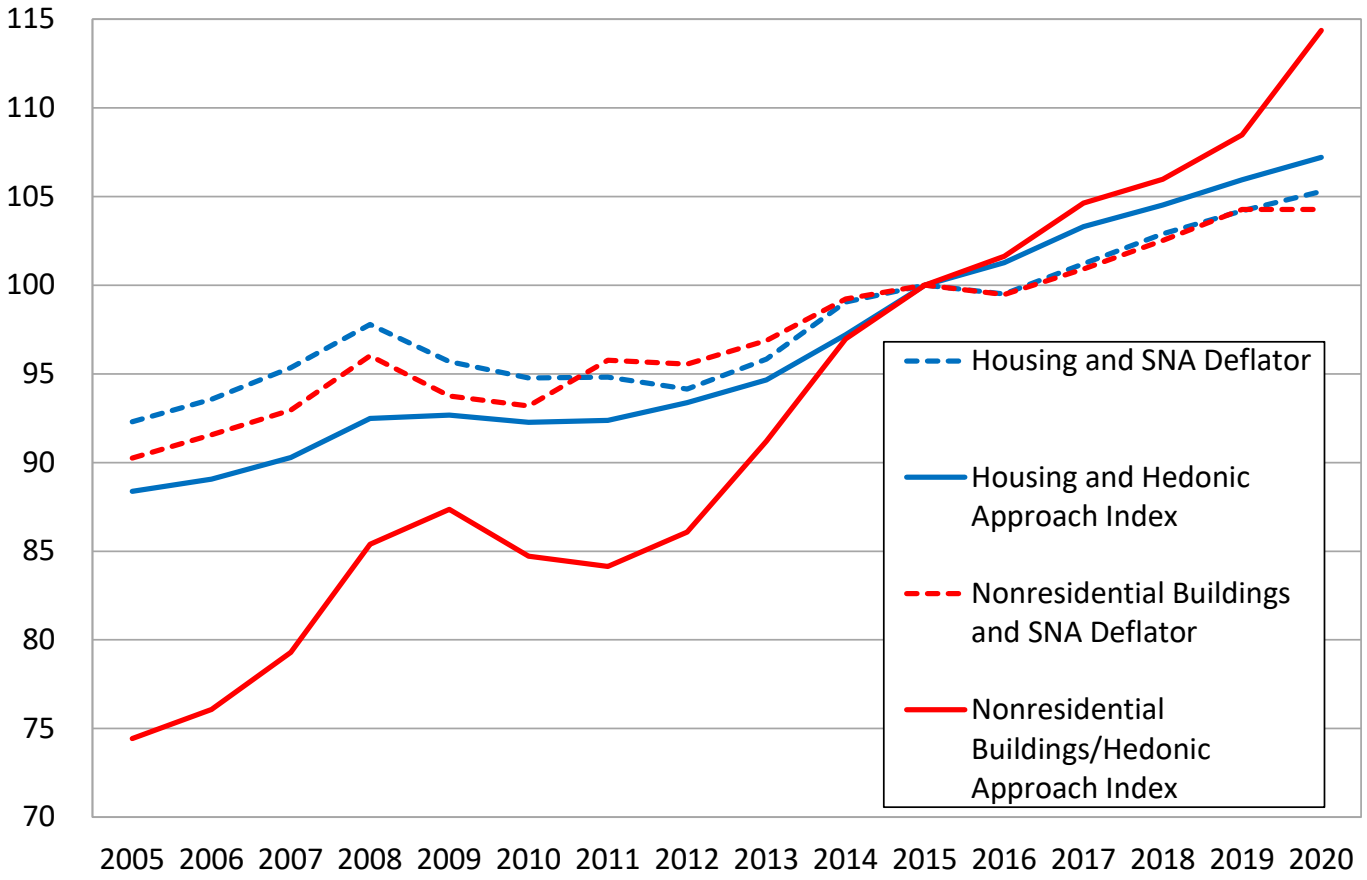
4. Estimation Results of the Output-Type Building Price Index.



The "output-type" building price index estimated by the stratification and hedonic approaches can be evaluated as accurately reflecting "changes in construction sector earnings" = "changes in market prices.

(Note: Operating income to net sales (right scale: %) is a backward-looking four-period moving average.
(Source: Corporate Statistics, Ministry of Finance

Impact on price index and deflator: 2015 average = 100



5. Conclusion.

What "output-type" building price indexes *can* and cannot do?

- An "output-type" building price index based on the stratification and hedonic approaches **can capture "cyclical price changes reflecting profit changes in the construction sector"** that cannot be captured by an "input cost-type" index.
  - Consistent with changes in construction sector revenues; accurate with movements in TFP and construction investment. Consistent with real estate price movements. Price indexes are useful for economic analysis.

What "output-type" building price indexes can and *cannot* do?

- "Output-type" building price indexes based on the stratification and hedonic approaches ***cannot capture changes in building quality*** (seismic strength, building grade such as interior, and quality improvement through design and facility improvement) that are not covered by the survey items of the "Statistics on Building Construction Starts".
  - It is difficult to capture mid- to long-term ***quality improvement***.

Next stages.

- Publication of an index that can capture “business-cycle price fluctuations associated with profit fluctuations,” which is difficult to do with the current "input cost-type" price indexes.
  - In order to realize a “better” price index, it is desirable to create and publish an “output-type” building price index using information from the “Statistics on Building Construction Starts”.
- In the long run, it is necessary to construct a database that can capture ***quality improvement***.

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