"Card Ladder Value":
The Intersection of Player Indexes & Price Modeling

I.   Player Indexes

Each player in Card Ladder has an index. These indexes are *total market indexes*. They contain every card of the player in Card Ladder's database.

Card Ladder's player indexes serve two primary purposes. First, they seek to represent fluctuations in a player's sports card market over time. Second, they aim to establish a baseline that can be used to project plausible price movements of individual cards of that player.

(A) Basic Methodology

A player's index is calculated as follows. Every card of a player is multiplied by its "last sold" value. "Last sold" means the average value for which the card sold on the most recent day that it sold. The resulting sum is divided by the total number of cards the player has. This produces the index value. This value is calculated once per night after each day's sales have been approved. The mathematical representation of this formula is below.

$$Index\ Value_{basic\ methodology} = \frac{(Sum\ of\ the\ \text{Last Sold}\ Value\ of\ Every\ Card\ of\ Player\ X)}{(Number\ of\ Cards\ of\ Player\ X)}$$

- *Example:* Suppose Kobe Bryant has 500 cards in Card Ladder's database. Each card is multiplied by its "last sold" value. The resulting sum is $5,000,000. This sum is divided by 500 (the number of Kobe cards in the index) to produce an index value of $10,000.

Each night, a new index value is created, and a new data point is added to the player's index.

(B) Exclusions

A card must have at least 2 sales in the last year, and at least one in the last 6 months, in order to be included in a player index.

(C) Retroactivity

Because Card Ladder houses the all-time online sales histories for every card in its database, player indexes are retroactively calculated going as far back in time as the very first online sale of any card of a player.

Furthermore, any time a new card is added to Card Ladder's database, the index is retroactively updated to include that card's all-time sales history.

II.   Divisor Adjustments in Player Indexes

(A) Problem with Player Index Methodology

A problem facing player indexes is that most cards have recorded their first sale on a different date. This means that the index value will jump each time a card in the index records its first sale, effectively rendering index values from the period prior to that sale irrelevant for the purposes of understanding fluctuations in the player's market over time.

- *Example:* Suppose that a Kobe Bryant 1/1 card in Card Ladder's database recorded its first sale – for $1,000,000 – on April 1st, 2021. Suppose further that Kobe's index value was $10,000 on March 31st, and then, because of the $1,000,000 sale, jumped to $15,000 on April 1st, while the prices of the other cards in Kobe's index remained constant. The index thus registered a 50% increase in value although none of the cards in Kobe's index changed in value. This portrays a non-representative fluctuation in Kobe's market, thus defeating the purpose of the Kobe index.

(B) Solution: Divisor Adjustments

Stock market indexes face a similar problem that player indexes face. From time to time, stocks are added to or removed from an index. To prevent an index's value from changing when stocks are added or removed, a "divisor" is used. (Read more about the methodology of stock market index construction at this link:
https://www.spglobal.com/spdji/en/documents/methodologies/methodology-index-math.pdf)

A divisor is a number used to divide the value of an index. Card Ladder's player indexes use a divisor.

- *Example:* Suppose that Kobe's index value is $10,000. A divisor of 10 is then applied. The new index value is $1,000.

The formula, including divisor, for calculating player index values is:

$$Index\ Value = \frac{(Sum\ of\ the\ \text{Last Sold}\ Value\ of\ Every\ Card\ of\ Player\ X)}{(Number\ of\ Cards\ of\ Player\ X) * (Divisor)}$$

A divisor is useful in player indexes because it can be adjusted to offset fluctuations that are caused by a card selling for the first time. When a card in a player index records its first sale, then (1) the net change in the index's value due to that card's first sale is determined and (2) this is used to create a new divisor.

The formula for adjusting the divisor follows:

$$Divisor_{new} = Divisor_{old} * \frac{Index\ Value_{new}}{Index\ Value_{old}}$$

For the purposes of the following illustration, assume that each player index in Card Ladder begins with a divisor value of "1." When the second card in the index records its first sale, the

divisor is adjusted. The same happens when the third card in the index records its first sale, and the fourth, and so on.

Example:

- Suppose that the first Kobe card in Card Ladder's database to record a public online sale is the 1996 Topps Chrome #138 Base PSA 10. Its first sale is $455 on January 11th, 2004. Kobe's index's value on January 11th, 2004, is $455.

Example: Index Value Calculation

$$Index\ Value = \frac{\$455}{1 * 1} = \$455$$

- Suppose that the second card in Kobe's index to record its first public online sale is the 1996 Flair Showcase #31 PSA 10 for $126 on May 9th, 2004. No other Kobe cards have sold, except for the $455 sale of the 1996 Topps Chrome #138 PSA 10. Because a card in the index has recorded its first sale, this triggers a divisor adjustment.

Example: Divisor Adjustment Calculation

$$Index\ Value_{old} = \frac{\$455}{1 * 1} = \$455$$

$$Index\ Value_{new} = \frac{\$455 + \$126}{2 * 1} = \$290.50$$

$$Divisor_{new} = 1 * \frac{\$290.50}{\$455} = 0.6384615384615385$$

$$Index\ Value_{new\ divisor} = \frac{\$455 + \$126}{2 * 0.6384615384615385} = \$455$$

Example: Index Value Comparison With and Without Divisor Adjustment

***Without* Divisor Adjustment:**

Date	Index Value
January 11th, 2004	$455
January 12th, 2004	$455
…	
May 8th, 2004	$455
May 9th, 2004	$290.50

***With* Divisor Adjustment:**

Date	Index Value
January 11th, 2004	$455
January 12th, 2004	$455
…	
May 8th, 2004	$455
May 9th, 2004	$455

Thus, the divisor adjustment preserves the index's $455 value as a new card records its first sale. The index does not experience a value fluctuation merely because one of its constituent cards sold for the first time.

Example: Index Fluctuations

Going forward, of course, if the value of the constituent cards fluctuates, the index will, too. For example, the 1996 Flair Showcase #31 PSA 10 sold for $177.50 on May 17th, 2004, marking an increase in value of the card from its $126 sale on May 9th, 2004. The index will adjust as follows:

$$Index\ Value_{May\ 17th,2004} = \frac{\$455 + \$177.50}{2 * 0.6384615384615385} = \$495.33$$

Date	Index Value
May 9th, 2004	$455
…	
May 16th, 2004	$455
May 17th, 2004	$495.33

The index increases in value to reflect the fact that the one of its constituent cards increased in value while the other remained constant in value. Thus, the divisor-adjusted index has captured a market fluctuation in Kobe's index.

(C) Methodology for Calculating "Old" and "New" Index Values

For the purposes of adjusting the divisor, the definitions of the "old" and "new" index values are important. The event that the divisor adjustment seeks to offset is the first sale of a card in a player index. In an index with hundreds of cards, for example, some of them can experience value fluctuations on the same day that a different card in the index sells for the first time. Those fluctuation should show up in the index.

To ensure that only the first sale is offset, the following order of processes is followed:

1. A card that records its first sale on Date Z is temporarily set aside.
2. All sales of cards in the index that are not first sales that occur on Date Z are used to calculate Date Z's index value. This is the "old" Index Value.
3. Then, any first sales on Date Z are included into the Index Value calculation. This is the "new" Index Value.

(D) Normalization

Each player index is normalized so that its initial value is $1,000. This is accomplished by modifying the divisor's initial value in relation to the index's unnormalized value on its first day.

$$Divisor_{Initial\ Value} = \frac{Index\ Value_{Day\ 1-Unnormalized}}{\$1,000}$$

Once the initial divisor is derived, it is then applied to the index's unnormalized value on its first day, resulting in an index value of $1,000.

$$Index\ Value_{Normalized} = \frac{Index\ Value_{Day\ 1-Unnormalized}}{Divisor_{Initial\ Value}} = \$1,000$$

Example

- Suppose that Kobe's player index's value on its first day is $455. The following calculation is performed to generate an initial divisor.

$$Divisor_{Initial\ Value} = \frac{\$455}{\$1,000} = 0.455$$

- The initial divisor is then applied to the index's unnormalized value on its first day in order to normalize its value to $1,000.

$$Index\ Value_{Normalized} = \frac{\$455}{0.455} = \$1,000$$

III.   Index-Suggested Price Modeling

Beyond the insights that can be gleaned from observing total market player indexes for players in Card Ladder's database, these indexes present a unique opportunity for price modeling.

(A) Ratios

A numerical relationship exists between the price history of a player index and the price history of each of its constituent cards. Any time a card records a sale, that sale can be understood as one side of a ratio. The other side of the ratio is the value of the player index to which the card belongs on that date.

$$Ratio = \frac{Card\ Value\ on\ Date\ Z}{Index\ Value\ on\ Date\ Z}$$

- *Example:* Suppose the Kobe index is worth $10,000 on March 31st, 2021. On that date, the "last sold" value of the 1996 Metal #181 Kobe Bryant PSA 10 was $3,333. Thus, the card's value in relation to the index's value is $3,333/$10,000, or 0.33.

Because Card Ladder's player indexes are retroactively calculated going back to the first sale of any card in that index, every sale of every card in a player index can be understood in relation to the price of the index on the date of that sale.

(B) Price Modeling

Assuming that there is predictive value in the historical relationship of these ratios – or, put differently, assuming that there is reason to believe that the price ratio between a card and its player index will remain constant going into the future – the fact that player indexes log a new data point every day, whereas certain cards can go for weeks, months, or even years without recording a new sale, provides the opportunity to use these historical ratios to project current card values.

$$Index\ Suggested\ Price = Ratio * Index\ Value$$

- *Example:* Suppose that the ratio between the 1996 Metal #181 Kobe Bryant PSA 10 and its player index is 0.33. Suppose further that the index values for the first 5 days of the month of April, 2021, are $10,250, $11,100, $10,300, $9,400, and $10,200. This produces the following index-suggested values for the card.

Date	Ratio	Index Value	Index-Suggested Price
April 1	0.33	$10,250	$3,382.50
April 2	0.33	$11,100	$3,663
April 3	0.33	$10,300	$3,399
April 4	0.33	$9,400	$3,102
April 5	0.33	$10,200	$3,366

A card and its respective player index could have dozens, hundreds, or even thousands of historical ratios, depending upon how frequently the card sells. By the same token, an exceedingly rare card might have only one or two sales in its sales history, and thus will have only one or two historical ratios.

Card Ladder's index-suggested pricing model uses a card's "last sold" price to generate the ratio. As noted above, "last sold" means the average value for which the card sold on the most recent day that it sold. Practically speaking, this means that the ratio will update every time a new sale is recorded.

(C) Confidence Levels

Because the relationship between a card and its player index can change over time, index-suggested prices that are based on *recent* ratios probably hold more predictive power than index-suggested prices based on *older* ratios.

To underscore the existence of this spectrum of uncertainty, Card Ladder displays a confidence level next to each index-suggested price.

There are 5 confidence levels:

- Level 5: the "last sold" date occurred within the last 2 weeks.
- Level 4: the "last sold" date occurred more than 2 weeks but less than 1 month ago.
- Level 3: the "last sold" date occurred more than 1 month but less than 3 months ago.
- Level 2: the "last sold" date occurred more than 3 months but less than 6 months ago.
- Level 1: the "last sold" date occurred more than 6 months ago.

(D) Price Modeling for Cards Not Yet in Card Ladder's Database

For cards not yet included in Card Ladder's database, members can add the card to their collections and utilize the index-suggested pricing model themselves. Once the member enters the date and price of their purchase of their card, Card Ladder's software automatically syncs these data points with the appropriate player index, which allows a ratio to be generated. That ratio will then be used going forward to create a new index-suggested price for the card every day.

IV.   Final Thoughts

Total market player indexes offer an analytical lens through which to study the sports card market. The limitations of this approach are worth noting.

From a practical point of view, player indexes are limited in scope by the number of cards that comprise them. Some indexes will have thousands of cards while others will have a few dozen.

Second, by their nature, player indexes create generalizations about a market that run the risk of overlooking unique trends that might be happening in different segments of that market.

Third, player indexes are calculated based on the "last sold" value of every card in the index, subject to the above-mentioned limitations that if the card has not sold at least twice in the last year, as well as at least once in the last 6 months, then it is temporarily excluded until it meets those criteria. It is conceivable that a player's market can shift during a period in which their cards are not transacted frequently, which means the index may not track the true market trend.

These three plausible shortcomings of player indexes are not exhaustive; it is wise to contemplate all conceivable shortcomings when utilizing a player index to perform analysis.

The limitations on player indexes extend to Card Ladder's index-suggested pricing model as well. In short, any pricing model – even one that is based purely on "comps" – should be conceived of as a theoretical tool for performing analysis, rather than a definitive determination of value.