

Can Consumer Price Index be used to accurately predict medical costs? A case study in refractory gastroesophageal reflux disease

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Background

- Gastroesophageal Reflux Disease (GERD) is a condition in which stomach contents flow back upward into esophagus, symptoms include heartburn, chest pain and regurgitation
- Prolonged/untreated GERD can lead to esophagitis and Barrett's esophagus, a precancerous condition
- GERD is commonly treated with proton pump inhibitors (PPIs) and Histamin-2 Receptor Antagonists (H₂RAs or H₂ blockers), however, ~30% of patients do not respond adequately to PPIs and/or H₂RAs and are considered to have refractory GERD (rGERD)
- We performed a study nearly identical to Gerson et al (2011) using more recent data from the same data source
- Consumer Price Index (CPI) is a measure of average price changes expressed as an index for each good and service with weights calculated and reported by Bureau of Labor Statistics (BLS) and is often used in economic studies to normalize prices from different time periods

Objective

- To use results from the previous study and our more recent study to evaluate the reliability of CPI adjustment as a predictive tool for estimating present/future costs of rGERD

Methods

- Our analysis used results from our study using the IBM MarketScan® databases data (from 2011-2017) and the Gerson study (MarketScan data from 2004-2008) both of which quantified the costs of rGERD vs treatment-responsive GERD (TR-Gerd) patients in similar manners
- Total cost and individual line-items of healthcare –inpatient (IP), outpatient (OP), emergency room (ER) and OP Pharmacy – were analyzed and grouped into three categories: All-Cause, GERD-related, and GI-related
- Annual CPI values related to medical care and its sub-indices were extracted from the US Bureau of Labor Statistics website <https://www.bls.gov/bls/news-release/cpi.htm>
- Annual CPIs were used to inflate the older costs using three different adjustment methods: study end to end (2008 → 2017), study middle to middle (2006 → 2014), and the ratio of average annual CPIs for the two study periods
- Total, IP, OP and ER costs were inflated using CPIs for *medical are*, *inpatient hospital services*, *outpatient hospital services* and *hospital services*, respectively
- Beginning in 2010, BLS restructured the sub-items under *Medical Care Commodities*. We, therefore, used CPIs for *Prescription drugs and medical supplies* for 2004-2009 and *prescription drugs* in 2010-2017 (the continuity was preserved) to inflate OP Pharmacy costs
- Each model predicts the new cost of an item i , $c_{i,p}$, at time (year), t_p , to be:

$$c_{i,p} = \frac{CPI(t_p)}{CPI(t_o)} \times c_{i,o}$$

where $CPI(t)$ indicates the annual CPI at time t , and $c_{i,o}$ the cost of the item i at time t_o , where $t_o < t_p$

- Deviations from current data were calculated: $\varepsilon_i = c_{i,p} - c_i$, where $c_{i,p}$ is the predicted current cost c_i the actual current cost of item i
- Mean deviations, mean absolute deviations, standard deviations, and root-mean-square deviations were calculated for each model
 - Mean deviation of a model m :

$$\bar{\varepsilon}_m = \frac{1}{n} \sum_{i=1}^n (c_{i,p} - c_i)$$

where $\varepsilon_{i,m}$ and n are mean deviation of a model m and the number of data points in the model, respectively

- Mean absolute deviation (MAD) was calculated as:

$$\%MAD = \frac{1}{n} \sum_{i=1}^n \frac{|c_{i,p} - c_i|}{c_i}$$

- We also calculated standard absolute deviation (SAD):

$$SAD = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (|\varepsilon_i| - \bar{\varepsilon}_m)^2}$$

- Root-Mean-Square-Deviation (RMSD) of a model m :

$$RMSD = \sqrt{\frac{1}{n} \sum_{i=1}^n (c_{i,p} - c_i)^2}$$

- Each of the three disease categories (all-cause, GERD-related, GI-related) is further divided into GERD (all types of GERD), TR-GERD and rGERD as well as are 5 line-items of cost: total, IP, OP, ER, and OP Pharmacy.
- GI-related OP Pharmacy costs was omitted because many drugs can be used for multiple indications outside of GI.
- All calculations were performed using Microsoft Excel

Results

- The costs were extracted from Gerson et al.'s (old) and our study (current) and compared (Table 1).
- CPI-Adjustment inflation rates, $\frac{CPI(t_p)}{CPI(t_o)}$, of each health care item for each model were calculated (Table 2)
- ER costs and GERD-related and GI-related costs demonstrated higher degree of deviations for all three models (Table 3).
- Middle-to-Middle had the lowest overall MAD and SAD but the highest RMSD (Table 4).
- Note that root-mean-square is always greater than or equal to mean deviation, and because the summed terms are squared, RMSD is more sensitive to outliers.
- Middle-to-Middle was the most accurate model for Outpatient, ER and OP Pharmacy (3 out of 5 items) without much difference in other item (Table 5).
- More detailed comparison among old, current and predicted (Middle-to-Middle) revealed that the model performed especially well in predicting all-cause and outpatient costs (Figure 1a-e).
- Overall, all three models consistently made nearly identical predictions for each item's cost.

Table 1: Annual Average Health Care Costs (USD) of GERD

			Total	Inpatient	Outpatient	ER	OP Pharmacy
All-Cause	Total	Old	13,237	3,149	6,699	298	3,091
		Current	18,077	4,294	10,022	613	3,149
	TR-GERD	Old	11,044	2,442	5,493	219	2,889
		Current	15,285	3,395	8,430	450	3,010
GERD-related	rGERD	Old	18,088	4,711	9,366	473	3,538
		Current	26,057	6,862	14,569	1,078	3,549
	Total	Old	1,437	25	377	20	1,014
		Current	1,381	16	969	60	336
GI-related	TR-GERD	Old	1,172	7	233	7	925
		Current	963	5	633	25	299
	rGERD	Old	2,022	65	696	50	1,212
		Current	2,576	49	1,926	160	\$440
	Total	Old	1,339	290	1,007	42	N/A
		Current	2,287	310	1,874	103	N/A
	TR-GERD	Old	707	119	575	12	N/A
		Current	1,271	127	1,107	37	N/A
	rGERD	Old	2,736	668	1,962	107	N/A
		Current	5,187	833	4,063	291	N/A

Table 2: CPI-Adjustment Inflation Rates of Each Item

Items	2008→2017	2006→2014	Ratio
Medical Care	1.31	1.30	1.30
Medical Care Commodities	1.27	1.20	1.23
Prescription Drugs*	1.32	1.21	1.30
Hospital Services	1.61	1.62	1.61
Inpatient Services	1.64	1.64	1.63
Outpatient Services	1.55	1.59	1.56

Table 3: Prediction Models' Error Percentage Heat Map

(a) End-to-End (2008→2017)	All Cause			GERD related			GI related		
	Total	GERD	rGERD	Total	GERD	rGERD	Total	GERD	rGERD
Inpatient	20.1	17.8	12.5	149	129	117	53.1	53.5	31.4
ER	-21.5	-21.4	-29.2	-46.0	-54.1	-49.6	-34.4	-48.1	-40.8
Outpatient	3.27	0.664	-0.677	-39.9	-43.2	-44.2	-17.0	-19.7	-25.4
OP Pharmacy	25.0	22.3	27.0	285	294	250	N/A	N/A	N/A
Total direct medical cost	-4.39	-5.66	-9.37	35.9	59.0	2.50	-23.6	-27.4	-31.1

(b) Middle-to-Middle (2006→2014)	All Cause			GERD related			GI related		
	Total	GERD	rGERD	Total	GERD	rGERD	Total	GERD	rGERD
Inpatient	20.2	17.9	12.6	150	130	117	53.3	53.6	31.5
ER	-21.2	-21.1	-28.9	-45.8	-53.9	-49.4	-34.1	-47.9	-40.5
Outpatient	6.43	3.74	2.36	-38.1	-41.5	-42.5	-14.4	-17.3	-23.1
OP Pharmacy	17.9	15.3	19.8	263	271	231	N/A	N/A	N/A
Total direct medical cost	-5.19	-6.45	-10.1	34.7	57.6	1.64	-24.2	-28.0	-31.7

(c) Ratio	All Cause			GERD related			GI related		
	Total	GERD	rGERD	Total	GERD	rGERD	Total	GERD	rGERD
Inpatient	19.4	17.1	11.8	148	128	116	52.2	52.6	30.6
ER	-21.9	-21.8	-29.5	-46.3	-54.3	-49.9	-34.7	-48.4	-41.1
Outpatient	4.35	1.72	0.361	-39.3	-42.6	-43.6	-16.1	-18.9	-24.6
OP Pharmacy	20.5	17.8	22.3	271	279	238	N/A	N/A	N/A
Total direct medical cost	-4.96	-6.22	-9.90	35.1	58.0	1.90	-24.0	-27.8	-31.5

Notes: Error percentage of (a) end-to-end, (b) middle-to-middle and (c) Ratio CPI-adjustments when inflated from Gerson et al.'s values and then compared with our data. Red indicates overestimation and blue indicates underestimation.

Table 4: Deviations Summary of Each Model

Model	MAD	SAD	RMSD
2008-2017	53.0%	70.3%	693
2006-2014	50.8%	65.6%	700
Ratio	51.5%	67.1%	693

Table 5: Mean Absolute Deviations (%) of Each Model by Line Items of Healthcare

Model	Total Cost	Inpatient	Outpatient	ER	OP Pharmacy
2008→2017	22.1	64.9	21.6	38.3	151
2006→2014	22.2	65.1	21.0	38.1	136
Ratio	22.2	63.9	21.3	38.7	141

Figure 1: CPI-Adjusted Annual Average Costs of GERD Predicted by Middle-to-Middle Model Compared to Old and Current Data

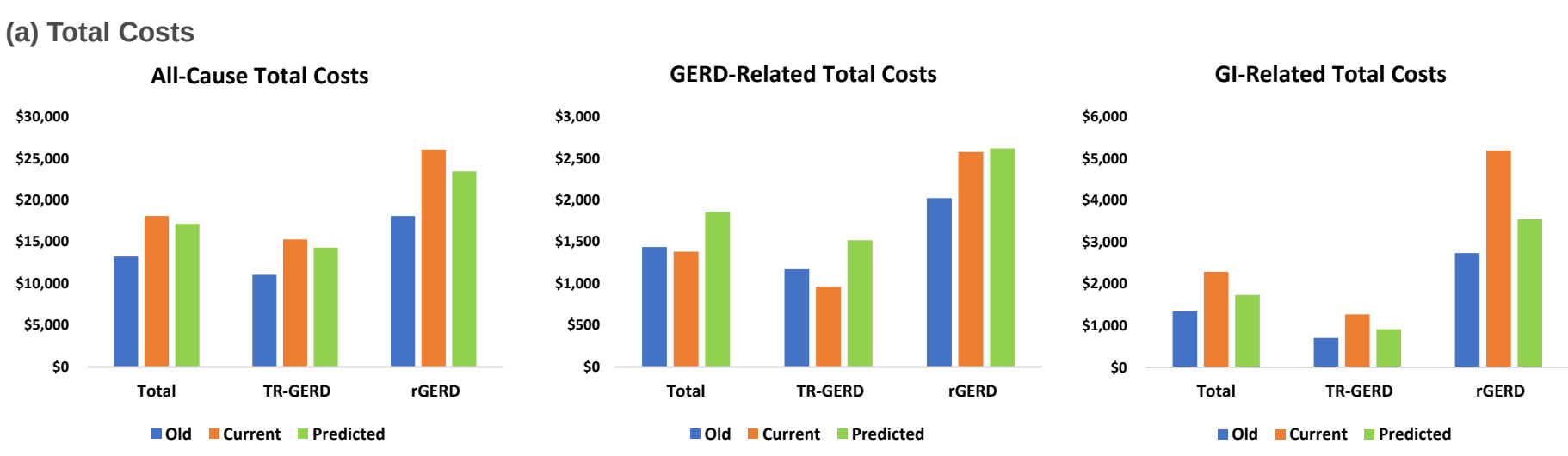
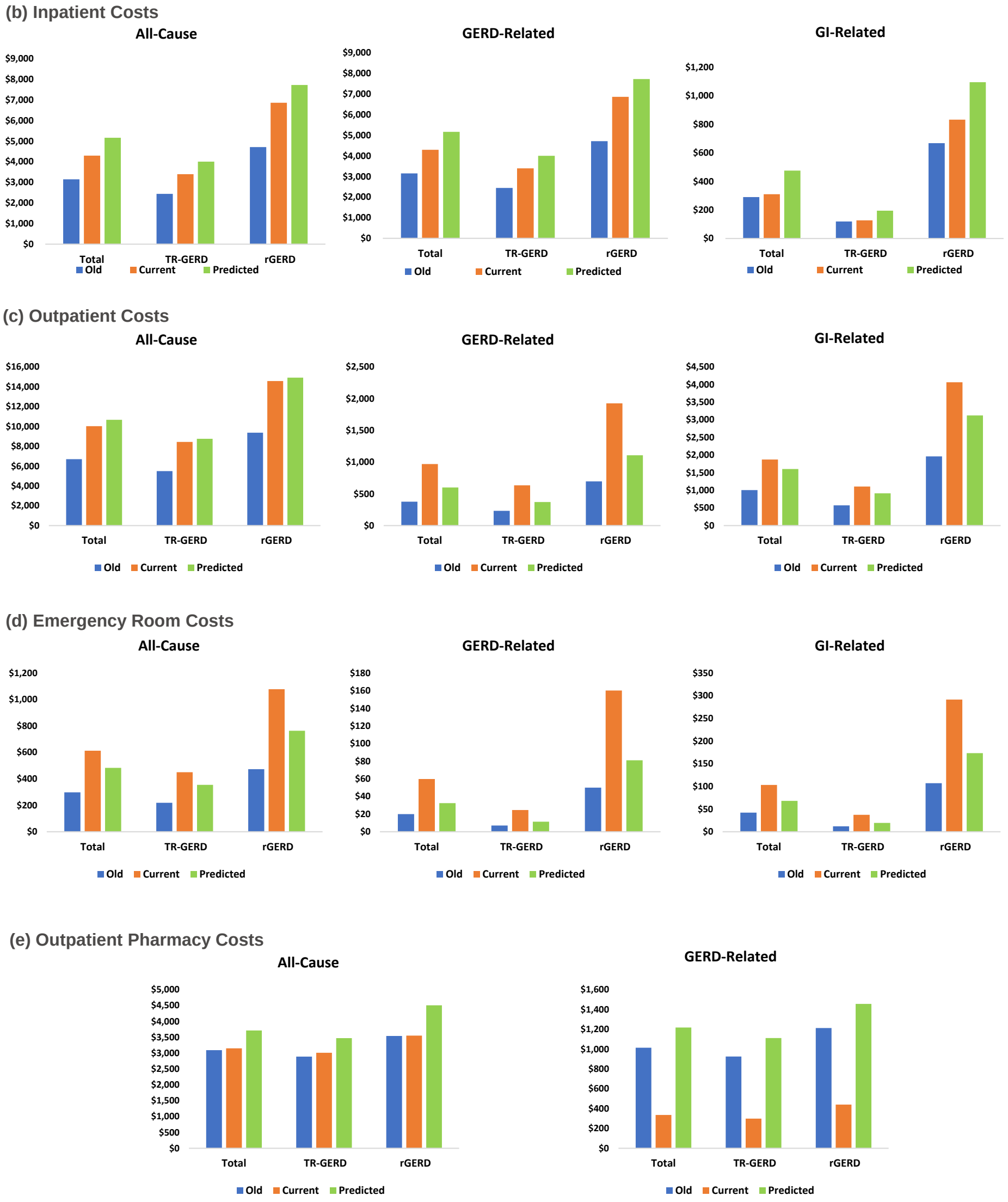


Figure 1 (continued): CPI-Adjusted Annual Average Costs of GERD Predicted by Middle-to-Middle Model Compared to Old and Current Data



Conclusion

- CPI-adjustment inflation models accurately predicted costs of large bundles of items (e.g. all-cause total costs) and/or outpatient costs but became less accurate when the costs of interest were defined more specifically in terms of diagnosis and/or smaller line-items of health care

Limitations

- Claim-based data is intended to be used for reimbursement not research
- There is no "gold standard" treatment algorithm for rGERD – the treatment methods and therefore costs may vary greatly from patient to patient
- CPI is not disease-specific and it only assesses the overall price trend in a given market.