

Mirage of stability: Dissecting China's true growth picture and its implications

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- China's remarkable growth stability, especially when viewed in the context of its highly volatile financial market, has led many to question the validity of official GDP statistics and the extent to which they reflect structural changes in the economy.
- Our research findings show no evidence of consistent under- or overreporting of China's GDP growth. Instead, the alternative growth measures we develop show much higher volatility and more pronounced swings both up and down, suggesting that growth figures are smoothed during both economic upturns and downturns.
- Investors can use our more volatile alternative growth measures and their associated growth factors to form a clearer picture of China's true economic momentum and the associated economic and financial spillovers.
- Specifically, we find that these factors offer additional information in explaining the near-term variation in Chinese equity market returns, suggesting that domestic market participants may have chosen to seek additional information about true economic conditions when making their investment decisions.
- Over the longer term, our analysis shows that growth volatility—a significant driver of earnings volatility—remains an important factor, alongside initial valuations, in explaining equity returns.

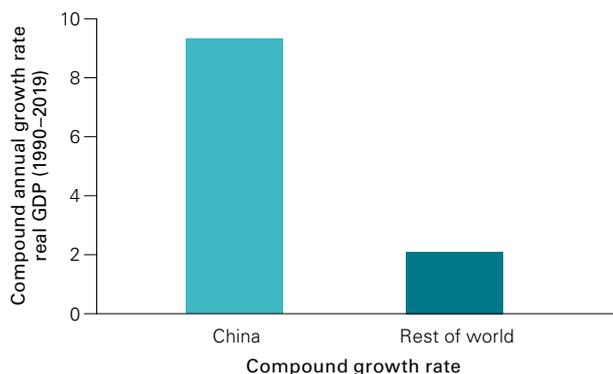
China’s economic growth: Fact or fiction?

China’s official economic statistics are often met with skepticism by the academic and financial communities. The country’s sustained outperformance relative to the rest of the world (see **Figure 1a**) isn’t too surprising considering the catch-up effect and historical push for market-oriented reforms. But its remarkable growth stability (as shown in **Figure 1b**), coupled with a penchant for meeting government growth mandates, has helped fuel suspicion. In addition, a stable growth picture seems at odds with its highly volatile equity market, leaving many investors questioning the extent to which China’s GDP numbers reflect economic reality.

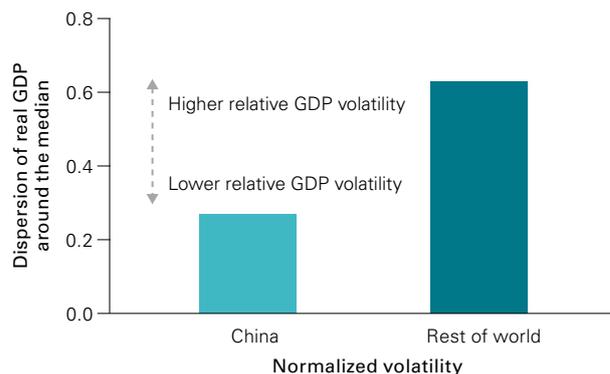
The various issues raised by official GDP statistics fostered our attempts to obtain more reliable estimates of China’s economic activity. Drawing on diverse sources of data and statistical techniques, we constructed three alternate measures of China’s true economic growth trajectory. We ultimately concluded that official GDP numbers are smoothed but not consistently over- or understated. Relative to the smoothed official GDP, we find evidence of a stronger relationship between our alternative measures, global growth, and various asset prices. This suggests that investors could gain a modest informational advantage by using alternative growth statistics.

Figure 1. China’s remarkable economic growth and stability

a. China was one of the fastest-growing economies in recent decades



b. China recorded very stable GDP growth



Source: Vanguard, using data from The World Bank.

Notes on risk

IMPORTANT: The projections and other information generated by the Vanguard Capital Markets Model® (VCMM) regarding the likelihood of various investment outcomes are hypothetical in nature, do not reflect actual investment results, and are not guarantees of future results. Distribution of return outcomes from the VCMM are derived from 10,000 simulations for each modeled asset class. Simulations are as of September 30, 2020.

Results from the model may vary with each use and over time. For more information, see **Appendix 2**.

All investing is subject to risk, including loss of principal. Investments in stocks or bonds issued by non-U.S. companies are subject to risks including country/regional risk and currency risk. These risks are especially high in emerging markets. Past performance is not a guarantee of future results. The performance of an index is not an exact representation of any particular investment, as you cannot invest in an index.

Joining the debate

In recent years, the research community has intensified its efforts to validate China's GDP growth, a phenomenon with a multitude of global economic and policy implications. Conclusions range from claims of outright data falsification to accusations of flawed price deflators. **Figure 2** offers a literature review on the studies of China's macroeconomic data quality.

The debate surrounding the validity of China's GDP growth led us to seek our own, proprietary indicator of the country's economy. We began by measuring growth from several alternative perspectives:

- **"Outside-in" approach.** One way to assess the true growth picture is to imagine the Chinese economy as a black box, about which we only know what business other countries do with China and what materials China trades with the world. International trade data have demonstrated a strong relationship with GDP growth and are highly immune to manipulation because one country's import must net out with another country's export. In this approach, we use provincial trade data as our economic activity proxy and conduct a panel regression on various economic indicators to compute an index of Chinese economic growth.
- **"Bottom-up" approach.** Another perspective on the economy can be gained by "rolling up" data from the sector level using nontraditional microdata sources. This more granular approach has the advantage of providing a more comprehensive view of certain sectors of the economy, such as the private and service sectors, and also addresses concerns about potential reporting biases or data quality in some of the more traditional macroeconomic statistics published by the government. We bucket the various sectors into what we term "old" and "new" economy before aggregating them using regression-weighting.¹
- **"All-in" approach.** As a final perspective, we rely on top-down national tax revenue data to measure the pulse of the industrial sector and use a principal components method to aggregate a select few bottom-up, high-frequency variables to reflect activities in the tertiary, or service, sector. Because of concerns about the deflators used in computing official GDP, we also adjust our price indexes to account for changes in import prices in the industrial sector and a structural shift toward cheaper online goods in the tertiary sector. The final product is a weighted average of the industrial and tertiary sectors using their GDP weights.

Figure 2. Debating China's growth

China's growth has been OVERSTATED . . .	China's growth has been UNDERSTATED . . .
 <p>Rawski (2001): Using electricity consumption statistics as a key alternative indicator, the study claims that historical GDP in China has been exaggerated, with real GDP likely no more than a third of official claims and possibly much smaller.</p>	 <p>Koch-Weser (2013): The author argues that the country's growth does not accurately reflect the activity of small-scale private businesses, which have grown in size over the last decade.</p>
 <p>Chen et al. (2019): Based on the growth rate of VAT tax revenues, the authors find that China's actual GDP growth figure was around 2 percentage points lower than official statistics.</p>	 <p>Rosen and Bao (2015): Official statistics are likely to understate the size of the service sector. According to the authors, the service sector could be about 20% and total GDP 10% larger than shown by official statistics.</p>
 <p>Li and Zhou (2005): This paper argues that China's highly decentralized statistical reporting system and governance incentive structure create opportunities for overstatement of growth.</p>	 <p>Clark et al. (2017): Studying nighttime satellite lights, the authors computed the optimal weights for various components of the Li Keqiang index and found evidence against the hypothesis that the Chinese economy contracted precipitously in late 2015. Instead, the data are consistent with the rate of Chinese growth being considerably higher (about 2 to 3 percentage points) than is reported in the official statistics.</p>

Source: Vanguard.

¹ "Old economy" refers to sectors that require relatively low human capital, are capital intensive, and generally are more state-led. The new economy relies on private enterprise and a highly educated workforce to foster innovation.

Summary of our alternative growth measures

Our three alternative measures, summarized in **Figure 3a**, show that there is no one perfect way to capture growth. Different analytical approaches yield different results, and we have great sympathy for the enormous challenges faced by the statistical authorities in measuring China’s large and complex economy. However, we believe that approaching this task from different angles can help us gain a more reliable picture of the country’s true economic momentum.

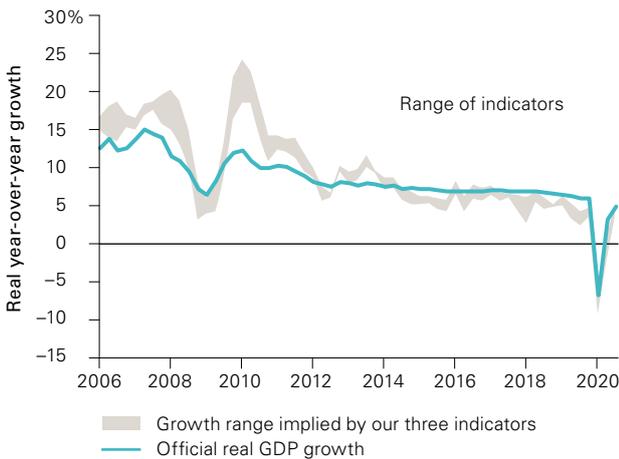
In particular, while our alternative measures suggest that the official data capture the rough pace of economic growth over longer periods as well as the largest turning points in activity, they also imply that the true economic

momentum may have greater volatility than the official data suggest. Consequently, growth may have been a little lower than reported during slowdowns and a little higher during times of rapid prosperity, such as in 2009–2010.

As **Figure 3b** shows, the official GDP may not have the highest or lowest growth reading on average, but it is much less volatile and has fewer extreme data points than the other methods. Such data-smoothing practices will likely continue and may even intensify down the road, especially given the central government’s increasing emphasis on growth stability in recent years.²

Figure 3. Official GDP generally has less volatility than our indicators show

a. Our indicators suggest more volatile growth



b. Official GDP has fewer extreme points

Rank	Standard deviation	Range*
1	"All-in" approach (6.7%)	"Outside-in" approach (37.3%)
2	"Outside-in" approach (6.4%)	"All-in" approach (32.6%)
3	"Bottom-up" approach (4.4%)	"Bottom-up" approach (23.8%)
4	Official GDP (3.2%)	Official GDP (21.2%)

*Range shows the difference between the highest and lowest points in each growth measure.

Source: Vanguard.

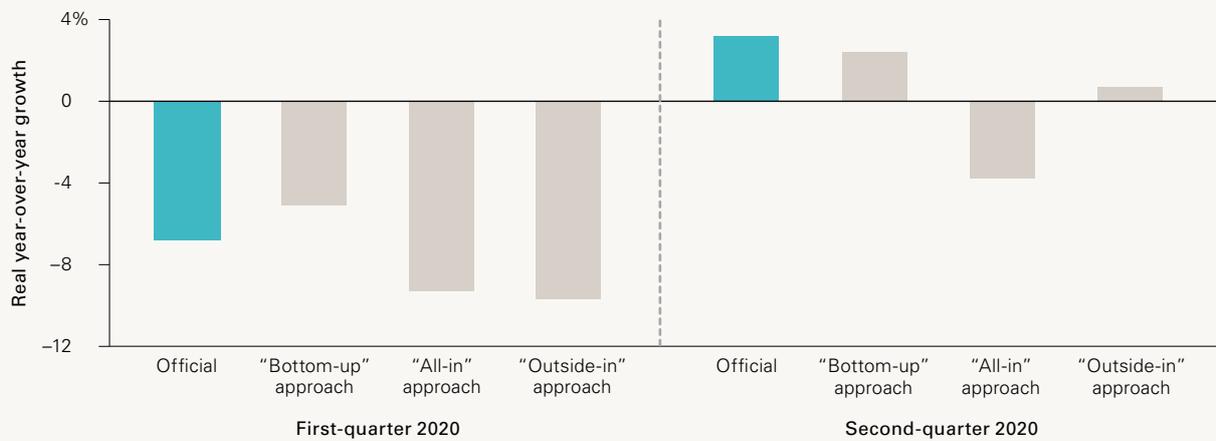
² See China government’s press release “China to Ensure Steady Economic, Social Progress Through Stability in 6 Key Areas,” available at http://english.www.gov.cn/premier/news/202003/03/content_WS5e5e7ae1c6d0c201c2cbd769.html, which repeatedly emphasizes growth and social stability in six areas: employment, finance, foreign trade, foreign investment, domestic investment, and market expectations.

Case study: The 2020 COVID-19 shock

The onset of COVID-19 led to a disruption in China's stellar economic expansion of the last two decades. For the first time in 30 years, the country recorded a -6.8% contraction in first-quarter 2020 as supply and demand shocks reverberated throughout the economy. Although this figure is well below its pre-COVID predecessors, some have argued that it still masks

the magnitude of the actual economic contraction. The exceptionally strong second-quarter rebound of 3.2% served to further increase skepticism about its speed and magnitude. Broadly speaking, our alternative indicators confirm this suspicion (see **Figure 4**).

Figure 4. Our alternative indicators suggest a more severe COVID-19 contraction and a slower recovery



Source: Vanguard.

Does the truth matter?

As the world's second-largest economy, China's true picture has important implications for the rest of the world's economy and asset prices.

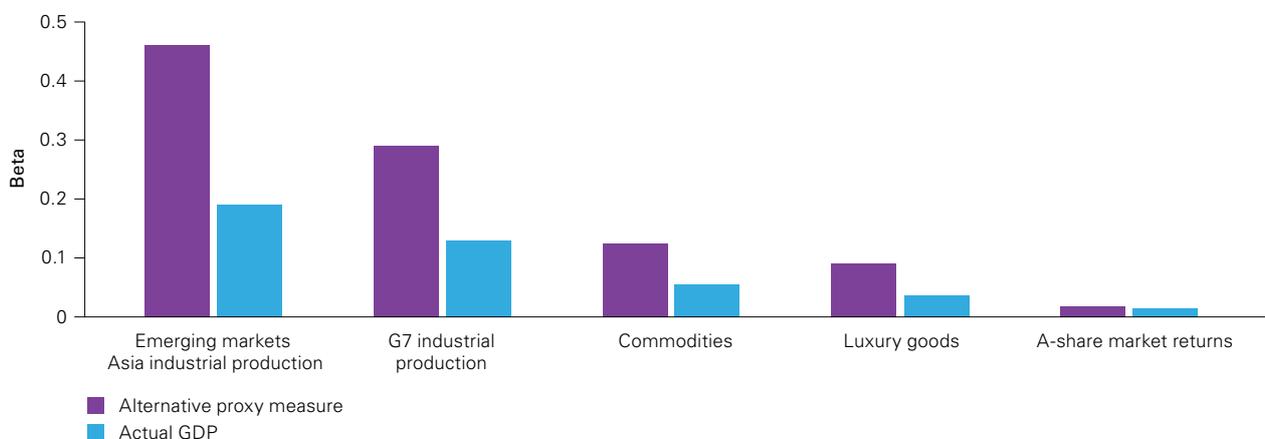
As **Figure 5** illustrates, global growth and the price of commodities and luxury goods appear to be more sensitive to our median alternative growth measure than they are to the official GDP numbers.³ This should not come as a surprise because the presence of smoothing effects in the official numbers obscures critical information about China's business cycle.

By contrast, the informational advantage provided by our alternative growth measure appears to diminish when looking at Chinese equity market returns. These are generally less sensitive to the growth rate, as seen in the lower beta of both alternative and official growth measures relative to other variables. We note that the weak direct relationship between economic growth and

equity returns is not unique to China. The economic growth rate itself proves to be a poor proxy for equity market returns across countries (see the Vanguard research paper *Investing in Emerging Markets: Evaluating the Allure of Rapid Economic Growth*).

This isn't to suggest that the true growth picture is completely irrelevant to stock market investors. In fact, we found China's equity volatility/true growth volatility ratio to be more aligned with the rest of the world, especially emerging markets, when using our alternative growth measure (see **Figure 6**). Because equity volatility reflects investors' view of actual economic volatility alongside country-specific risk factors such as liquidity and regulatory oversight, the difference in the volatility ratio when using official GDP and our alternative growth measure suggests that there may still be valuable information embedded in our growth measure beyond the insights provided by the economic growth rate.

Figure 5. The true growth picture matters for the rest of the world and certain asset classes

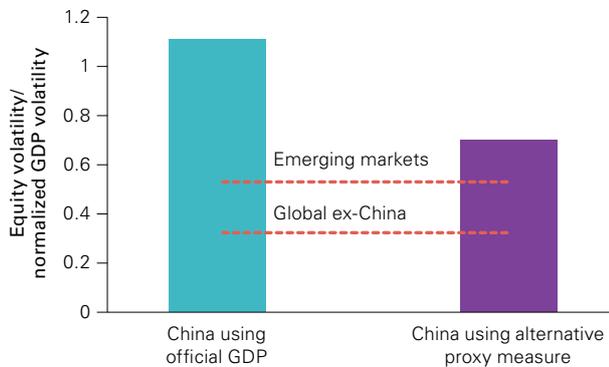


Notes: Emerging markets Asia includes Malaysia, South Korea, Indonesia, and Taiwan. G7 countries are the United Kingdom, Italy, Japan, Germany, France, and Canada. The prices of commodities and luxury goods are proxied by the S&P GSCI Index and the S&P Global Luxury Index.

Source: Vanguard, using data from Bloomberg.

³ This analysis is based on the median of our three approaches. While this may smooth out some volatility in our original data, the variability of the composite median index far surpasses that of the official GDP statistics and therefore still fulfils our objective of comparing a more volatile growth series with the official GDP.

Figure 6. China’s equity volatility is more reasonable in our alternative (unsmoothed) GDP estimate



Notes: Data are from 2000–2019. Equity volatility is the standard deviation of country-level annual equity returns. Normalized GDP volatility is the standard deviation of annual GDP growth divided by average GDP growth.

Source: Vanguard calculations, using data from Thomson Reuters and Global Financial Data.

Economic growth and short-term stock returns: More than meets the eye

Hidden information beyond growth rate

Against this backdrop, we sought to identify the additional information embedded in our alternative growth measure and how it might explain short-term returns in the Chinese

equity market. We explored four growth factors, as shown in **Figure 7**, that are positively correlated with the increased volatility in our alternative growth measure and have been closely watched by market investors.

To test our hypotheses that these growth factors are not only better predictors of short-term equity return than growth rate itself but also superior when used in our alternative growth measure instead of the official GDP, we conducted two separate rounds of regressions. In each round, A-share returns were modeled as a function of the economic growth rate using either our alternative growth measure or official GDP and each one of the four growth factors (again using either our alternative growth measure or official GDP) mentioned above. We also added two control variables—China retail investor sentiment⁴ and China credit growth⁵—to account for returns not explained by macro developments. **Equation 1** shows our model.

Equation 1.

$$CSI\ 300\ annual\ return_{i,t} = \alpha + \beta_1 * Rate\ of\ growth_{i,t-1} + \beta_2 * Growth\ factor_{i,t-1} + \beta_3 * Retail\ sentiment_{t-1} + \beta_4 * Credit\ growth_{t-1} + \epsilon_{i,t}$$

where t = quarter and i = either official GDP or our alternative growth measure.

Figure 7. Potential growth factors that markets may be watching

Factor	Description	Equation
Momentum	6M change in the rate of growth	$Momentum\ factor_{i,t} = Rate\ of\ growth_{i,t} - Rate\ of\ growth_{i,t-2}$
Surprise	Deviation from Bloomberg consensus GDP	$Surprise\ factor_{i,t} = Rate\ of\ growth_{i,t} - Consensus\ GDP_{i,t}$
Discrepancy	Difference between official GDP and our alternative indicator	$Discrepancy\ factor_t = Official\ GDP\ growth_t - Alternative\ growth\ measure_t$
Gap	Difference between level of growth and trend growth	$Gap\ factor_{i,t} = Rate\ of\ growth_{i,t} - Trend\ growth_{i,t}$

Source: Vanguard.

⁴ Retail investor sentiment (first-quarter lagged) is proxied by the annual change in new A-share investor accounts opened in that quarter.

⁵ China credit growth (first-quarter lagged) is proxied by the annual change in the monetary base.

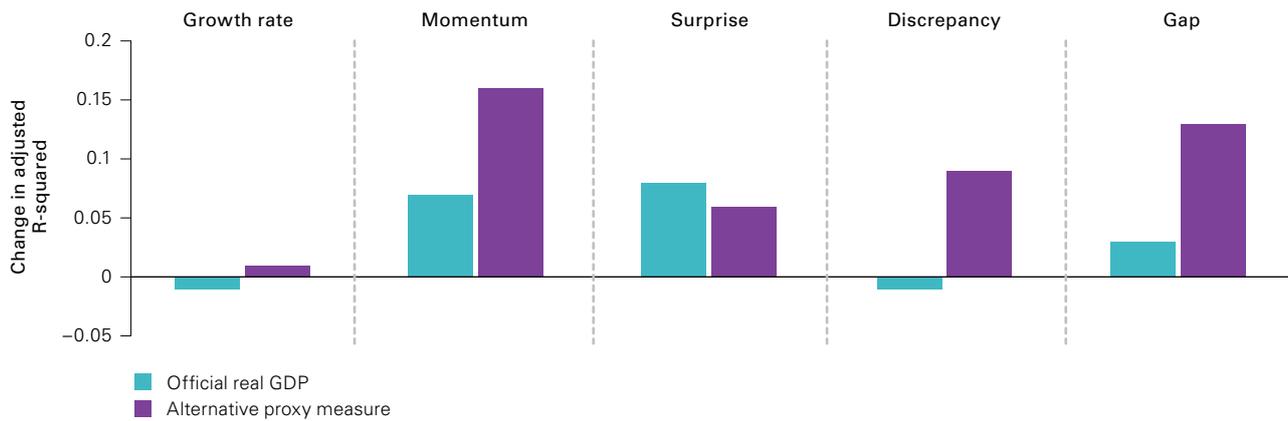
To assess the results, we compared the changes in the adjusted R-squared of each regression with the regression without growth factors (see **Figure 8**, and Appendix **Table A-1** for more details). Our interpretation of the analysis is twofold.

First, while economic growth (both the more volatile alternative rate and the smoothed official rate) has little impact on A-share market returns, other growth factors appear to provide additional insights. The momentum factor, for instance, is a rather meaningful variable in explaining short-term market fluctuations, as evidenced by the positive change in the adjusted R-squared. This underscores that, while the economic growth rate tends to be priced in by market participants, large economic shifts and unexpected macro-events can still contribute to near-term market returns.

Our second conclusion stems from the fact that once we look beyond growth rate, our alternative measure performs better than the official GDP for all factors except the surprise factor. This is to be expected because the markets' reaction to an economic surprise is most often based on the difference between the official real GDP announced and consensus expectation of what will be announced, instead of the true growth.

The other factors, however, generally show a stronger link between our alternative activity indicator and the A-share market returns, suggesting that the true economic picture still matters for equity markets, albeit in a more nuanced way. In particular, we think that domestic market participants may have chosen to seek additional information about the true economic picture to form a better view on fundamentals during the investment process.

Figure 8. In the near term, certain growth factors matter for A-share market investors



Notes: We use adjusted R-squared to adjust for the number of predictors in the model. The adjusted R-squared increases if the new term improves the model more than would be expected by chance and decreases when a predictor improves the model less than expected by chance.

Source: Vanguard.

A- versus H-shares: Sensitivity to growth factors increases in a more sophisticated and open market

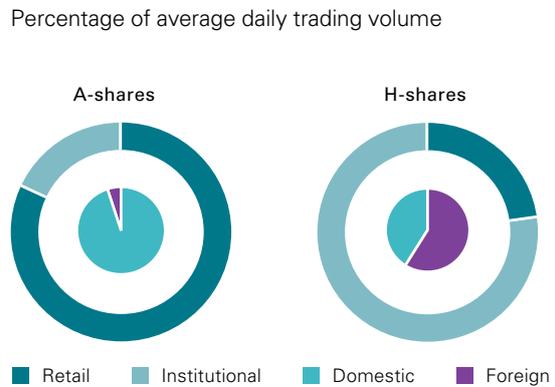
We sought to validate our hypothesis in an equity market other than the A-share to see if our conclusions still held true with a different investor base. Because A-share market retail investors are known for being more micro-driven, we wanted to test whether the true economic picture would matter more in an institutional-driven, open market such as the H-share (Figure 9), which consists of mainland Chinese companies listed on the Hong Kong Exchange. The free flow of capital in this market could increase sensitivity to macro-fundamentals because it implies that, unlike domestic investors under strict restrictions on overseas investment, H-share investors may have greater flexibility and more options to redirect their equity investments overseas and reduce China exposure should the true macro outlook deteriorate significantly.

Equation 2 specifies our model for the H-share market. The only differences from the previous A-share regression are the dependent variable (we replaced China Stock Index 300 with Hang Seng China Enterprises Index returns) and the addition of global control factors.⁶

Equation 2.

$$HSCEI \text{ annual return}_{i,t} = \alpha + \beta_1 * \text{Rate of growth}_{i,t-1} + \beta_2 * \text{Growth factor}_{i,t-1} + \beta_3 * \text{Retail sentiment}_{t-1} + \beta_4 * \text{Credit growth}_{t-1} + \beta_5 * \Delta US_3M \text{ yield}_{t-1} + \beta_6 * \Delta VIX_{t-1} + \varepsilon_{i,t}$$

Figure 9. Different investor bases shape the reaction function of markets

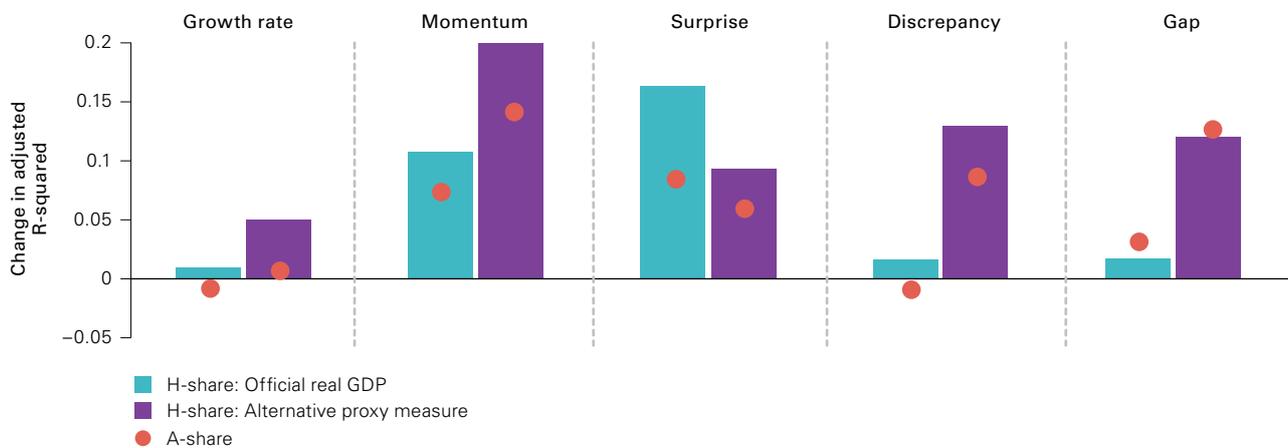


Note: Data are as of 2017.
Source: Vanguard, using data from WIND.

where t = quarter and i = either official GDP or our median alternative proxy.

As shown in Figure 10, we find compelling evidence that institutional investors with two-way access to global markets, as proxied by the H-share market, are indeed more sensitive to the true macroeconomic picture. The explanatory power of our growth factors using the alternative growth measure generally proves to be not only higher than that of the growth factors using official GDP, but also much higher than in the A-share regressions.

Figure 10. H-share market investors are more sensitive to macro-developments



Source: Vanguard.

⁶ The absence of capital controls in this market creates more sensitivity to global control factors such as U.S. monetary policy and equity volatility, which were previously found to be rather insignificant variables in explaining A-share market returns.

Overall, the results from the H-share market imply that as China's onshore (A-share) equity market becomes more mature and symmetrically open to the rest of the world—in both inflows and outflows—it could trend more toward the direction of the offshore H-share market in experiencing greater sensitivity to economic fundamentals and, in particular, the true growth picture.

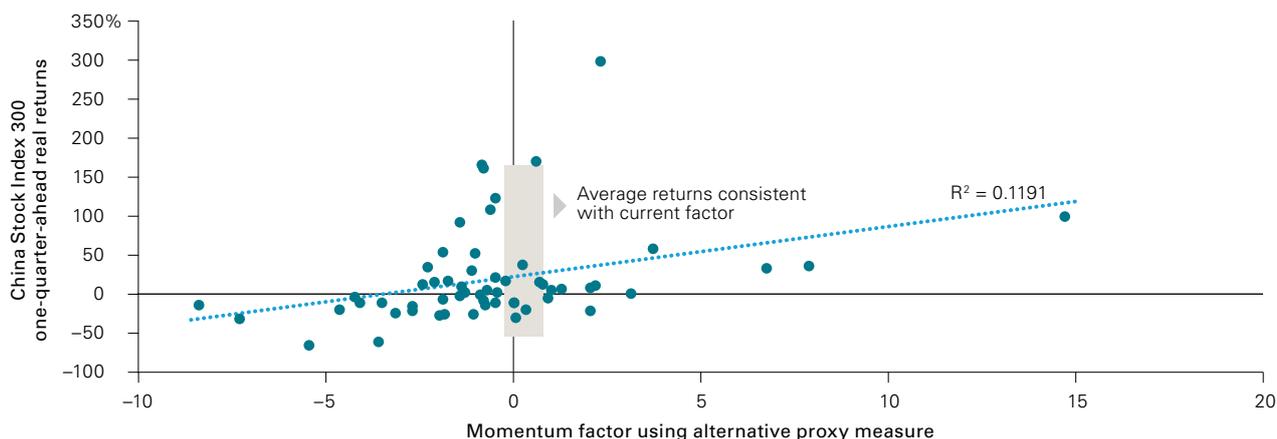
Putting it into practice: Timing the market may still prove challenging using these growth factors alone

The analyses above suggest that Chinese equity movements have greater sensitivity to the more volatile true economic momentum once growth factors are taken into account. However, the average investor should

refrain from attempts to time the market solely based on these factors, as they leave more than 80% of the historical variation in stock returns unexplained.

The imperfect relationship between our macro factors and stock returns is illustrated in **Figure 11**. The average significant relationship between the momentum factor, which appeared to have the highest explanatory power among the various growth factors, and Chinese stock returns is evident from the positive sloping line, but so is the dispersion in actual returns around that line. For instance, the latest reading as of fourth-quarter 2019 for the momentum factor showed future A-share market returns ranging from roughly -40% to 175% (the shaded region of Figure 11).

Figure 11. What a realistic return forecast looks like when more than 80% is unexplained



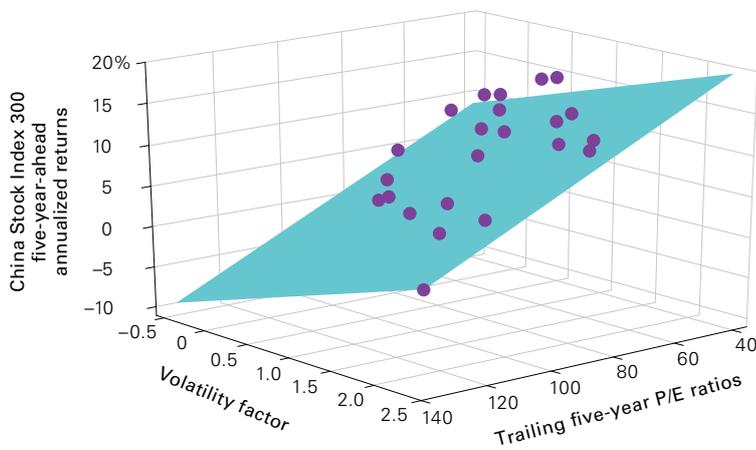
Note: Figure plots CSI 300 one-quarter-ahead returns against the momentum factor for the period Q1 2008 to Q4 2019.
Source: Vanguard.

Growth volatility remains a key driver of longer-term returns

Over longer time horizons, we find the true growth volatility picture as measured by the volatility in our alternative growth measure to be a significant positive variable in explaining five-year-ahead returns once we control for initial valuations. In our view, this relationship reflects the compensation investors require over time for undertaking growth and hence earnings risk.

Figure 12 illustrates this point by showing that the highest long-term returns in the A-share market historically have been a function of both high volatility and low valuations. This is consistent with the view that emerging markets in general command a higher expected return than their developed peers do because of the uncertainty associated with the local macro environment and other country-specific risk factors.

Figure 12. Growth volatility and valuations matter for the long-term



Source: Vanguard.

The outlook for China's equity market

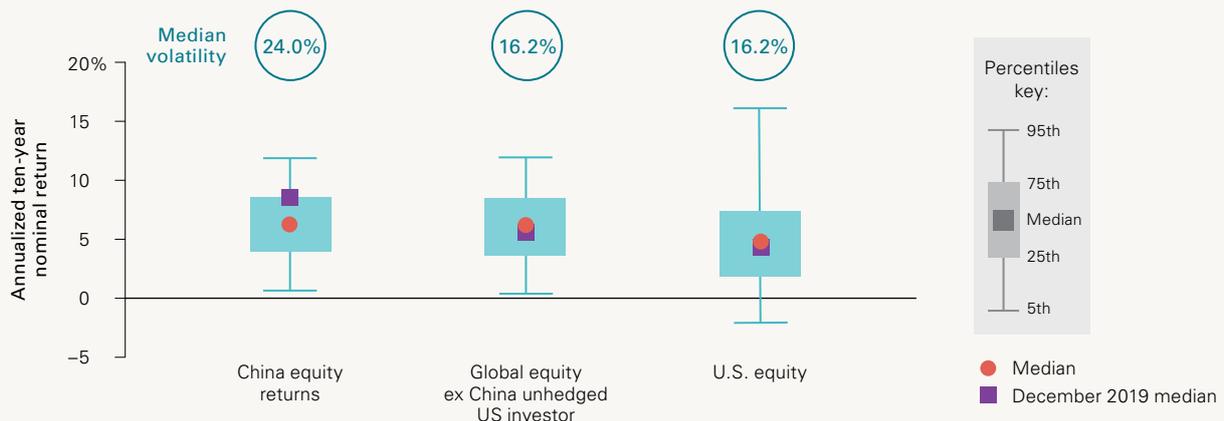
China has had significant gains in its equity market and outperformed the rest of the world because of its first-in-first-out experience with the COVID-19 pandemic and much-stronger-than-expected rebound in economic activity. As of August 2020, valuations in the China Stock Index 300 were about 18% higher than at year-end 2019, versus 3% average year-to-date returns for the MSCI AC World index.

The rise in valuations suggests that returns will be more muted going forward, as seen in the negative relationship between valuations and future returns in Figure 11. In fact, China is one of the few regions in which our ten-year nominal equity return forecast,

derived from Vanguard's Capital Market Model (VCMM),⁷ has declined relative to 2019 (Figure 13), in large part because of its remarkable 2020 equity returns and resulting increase in valuations.

The upshot: Because of the increase in initial valuations and compressed risk premium, our ten-year China equity return forecast is now only slightly higher than developed markets, even as expected volatility—partly driven by the high degree of uncertainty surrounding growth and, hence, fluctuations in earnings—is considerably higher.

Figure 13: A modest reduction in our China equity return forecast



Notes: This forecast corresponds to a distribution of 10,000 VCMM simulations for ten-year annualized nominal returns as of September 30, 2020. Median volatility is the 50th percentile of an asset class's distribution of annual standardized deviation of returns.

Source: Vanguard.

Conclusion

Interest regarding the validity of China's growth has intensified in recent years as the country's rise has become a defining global economic megatrend of our era. Previous research efforts have often pointed toward consistent over- or underreporting, affecting perceptions about the long-term pace of China's rise toward global economic leadership.

In constructing three alternative indexes, we conclude that China's post-2005 growth is factual but smoothed, distorting the true magnitude of cyclical slowdowns and accelerations. While the central government has started to deemphasize the importance of the GDP growth target and its use in performance evaluation of local officials in recent years, the increasing focus on growth stability suggests that data-smoothing practices may continue into the foreseeable future.

Against this backdrop, investors may derive greater value by relying on alternative growth measures and their associated growth factors to form a clearer picture of China's true economic momentum and the magnitude of spillover effects on global growth and various asset prices. This informational advantage becomes particularly evident when examining the near-term variation in Chinese equity returns.

That said, with more than 80% of the variation in near-term equity market returns left unexplained, we would caution the average investor against timing the market solely based on these macro factors. The tails of the resulting distribution could be very wide. Over the longer term, we find that the true magnitude of economic volatility, a significant driver of earnings volatility, remains a significant factor, alongside initial valuations, in explaining equity returns.

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Appendix 1

Table A-1. Regression results of Equation 1

	Level factor		Surprise factor		Momentum factor	
	Official	Alternative	Official	Alternative	Official	Alternative
α	-3.326	-7.732	20.071	-31.852**	25.446*	7.209
<i>Retail sentiment</i> _{t-1}	0.153***	0.160***	0.155***	0.162***	0.144***	0.158***
<i>Credit growth</i> _{t-1}	2.374**	2.253**	1.244	0.401	1.674*	-0.408
<i>Rate of growth</i> _{t-1}	0.711	1.006	-3.411*	4.808**	-2.483	-0.257
<i>Growth factor</i> _{t-1}	—	—	31.166***	-6.182**	6.031***	4.985***
<i>Adjusted R</i> ²	0.384	0.399	0.475	0.455	0.465	0.552

	Discrepancy factor		Gap factor	
	Official	Alternative	Official	Alternative
α	-24.789	-33.829***	16.434	13.235
<i>Retail sentiment</i> _{t-1}	0.150***	0.161***	0.151***	0.157***
<i>Credit growth</i> _{t-1}	1.808	-0.134	2.872***	2.675***
<i>Rate of growth</i> _{t-1}	3.835	5.019***	-1.729	-1.064
<i>Growth factor</i> _{t-1}	-2.410	-7.362**	5.310**	5.170***
<i>Adjusted R</i> ²	0.383	0.487	0.423	0.519

***, **, and * reflect significance at 10%, 5%, and 1%.

Note: Data are for the period Q1 2008 to Q1 2020.

Source: Vanguard.

Table A-2. Regression results of Equation 2

	Level factor		Surprise factor		Momentum factor	
	Official	Alternative	Official	Alternative	Official	Alternative
α	-21.668	-13.931**	18.542	-23.755**	-4.445	-3.851
Retail sentiment _{t-1}	0.036*	0.042**	0.035*	0.043**	0.032	0.043**
Credit growth _{t-1}	1.315*	1.149	0.267	0.377	0.438	-0.591
Change in VIX _{t-1}	-0.838***	-0.736**	-0.796***	-0.718**	-0.453	-0.528*
Change in 3-month Treasury bill _{t-1}	7.454**	7.424***	6.916***	6.791**	2.038	4.047
Rate of growth _{t-1}	2.769*	1.522**	-3.247	3.043**	0.827	0.562
Growth factor _{t-1}	—	—	28.110***	-2.529	7.500***	3.232***
Adjusted R ²	0.382	0.426	0.518	0.440	0.462	0.541

	Discrepancy factor		Gap factor	
	Official	Alternative	Official	Alternative
α	-29.042	-26.290***	-18.572	2.436
Retail sentiment _{t-1}	0.036*	0.043**	0.0371*	0.044**
Credit growth _{t-1}	1.142	0.018	1.416*	1.260*
Change in VIX _{t-1}	-0.842***	-0.703**	-0.819***	-0.639*
Change in 3-month Treasury bill _{t-1}	7.646**	6.821**	6.543*	1.400
Rate of growth _{t-1}	3.837	3.389***	2.345	-0.272
Growth factor _{t-1}	-0.771	-3.474**	1.390	3.573**
Adjusted R ²	0.371	0.468	0.371	0.473

***, **, and * reflect significance at 10%, 5%, and 1%.

Note: Data are for the period Q1 2008 to Q1 2020.

Source: Vanguard.

Appendix 2. About the Vanguard Capital Markets Model

IMPORTANT: The projections and other information generated by the Vanguard Capital Markets Model regarding the likelihood of various investment outcomes are hypothetical in nature, do not reflect actual investment results, and are not guarantees of future results. VCMM results will vary with each use and over time.

The VCMM projections are based on a statistical analysis of historical data. Future returns may behave differently from the historical patterns captured in the VCMM. More important, the VCMM may be underestimating extreme negative scenarios unobserved in the historical period on which the model estimation is based.

The VCMM is a proprietary financial simulation tool developed and maintained by Vanguard's Investment Strategy Group. The model forecasts distributions of future returns for a wide array of broad asset classes. Those asset classes include U.S. and international equity markets, several maturities of the U.S. Treasury and corporate fixed income markets, international fixed income markets, U.S. money markets, commodities, and certain alternative investment strategies. The theoretical and empirical foundation for the Vanguard Capital Markets Model is that the returns of various asset classes reflect the compensation investors

require for bearing different types of systematic risk (beta). At the core of the model are estimates of the dynamic statistical relationship between risk factors and asset returns, obtained from statistical analysis based on available monthly financial and economic data. Using a system of estimated equations, the model then applies a Monte Carlo simulation method to project the estimated interrelationships among risk factors and asset classes as well as uncertainty and randomness over time. The model generates a large set of simulated outcomes for each asset class over several time horizons. Forecasts are obtained by computing measures of central tendency in these simulations. Results produced by the tool will vary with each use and over time.

The primary value of the VCMM is in its application to analyzing potential client portfolios. VCMM asset-class forecasts—comprising distributions of expected returns, volatilities, and correlations—are key to the evaluation of potential downside risks, various risk–return trade-offs, and the diversification benefits of various asset classes. Although central tendencies are generated in any return distribution, Vanguard stresses that focusing on the full range of potential outcomes for the assets considered is the most effective way to use VCMM output.

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