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BME aluminium market case study:
using mathematical models to sharpen thinking and de-personalise debate on metal prices

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Mathematical modelling was a very useful tool that got forgotten whilst prices "flat-lined" in the 1980s

- For those old enough to remember, there always used to be two strands to market analysis: (1) in depth knowledge of supply, demand and stocks and (2) mathematical modelling of prices.
- In the 1980s, prices were moribund for a decade, the mathematical modellers all moved to the Forex markets, and the supply-demand-stock experts felt no urge really to understand prices: what was there to understand about a flat price?
- The surviving supply-demand-stock experts (including BME at first) then dumbed down analysis just to a price to stock curve.
- That over-simplification made prices much harder to understand once they stopped being just a flat line.

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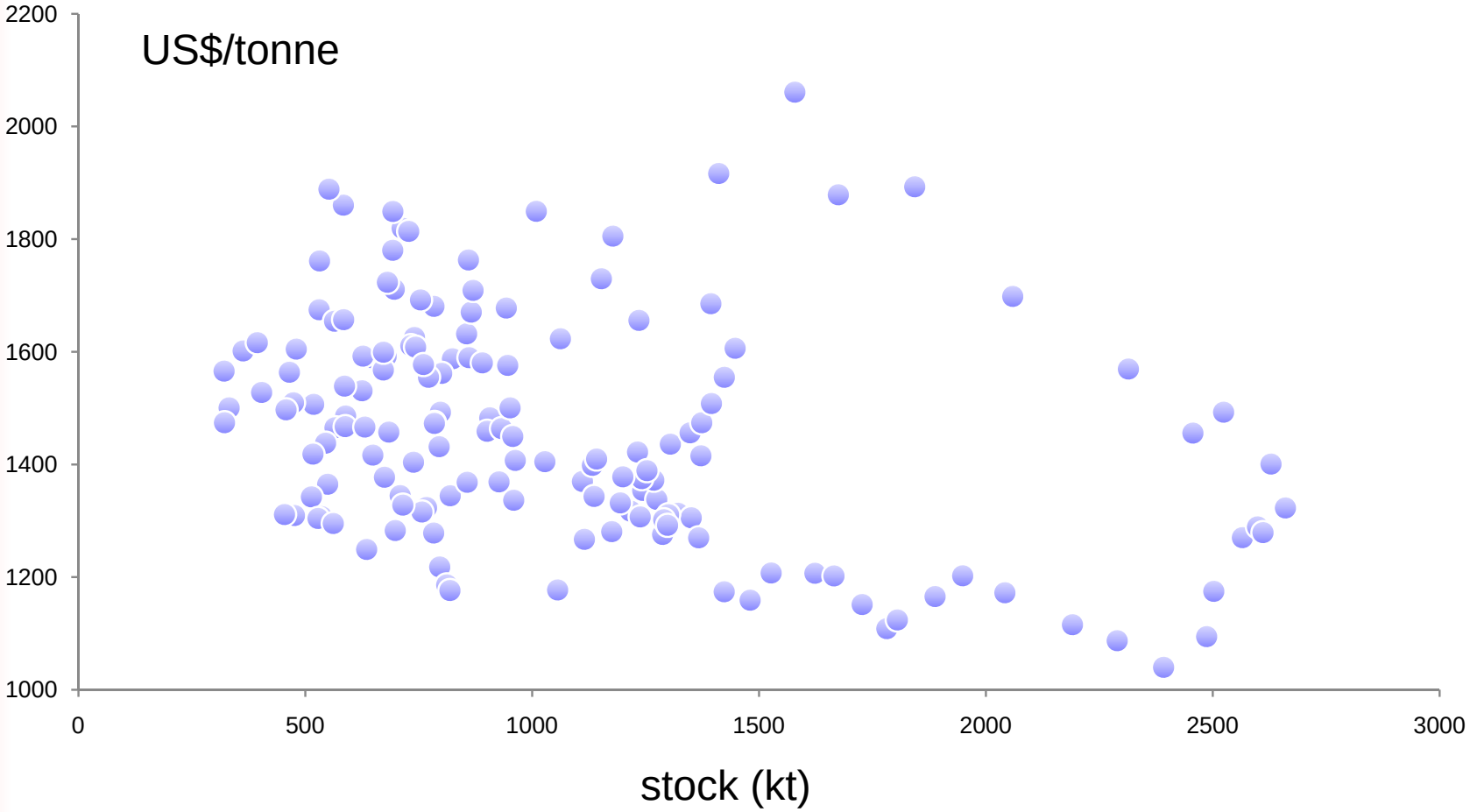
LME price to stock relationship for aluminium, 1990-2004

This chart shows the former price to stock relationship. Note how poor the fit was. Prices of $1400 equated to stock levels from ~350 kt to ~2650 kt. Conversely, stocks of 1650 kt corresponded to prices from $1100 to $2100.



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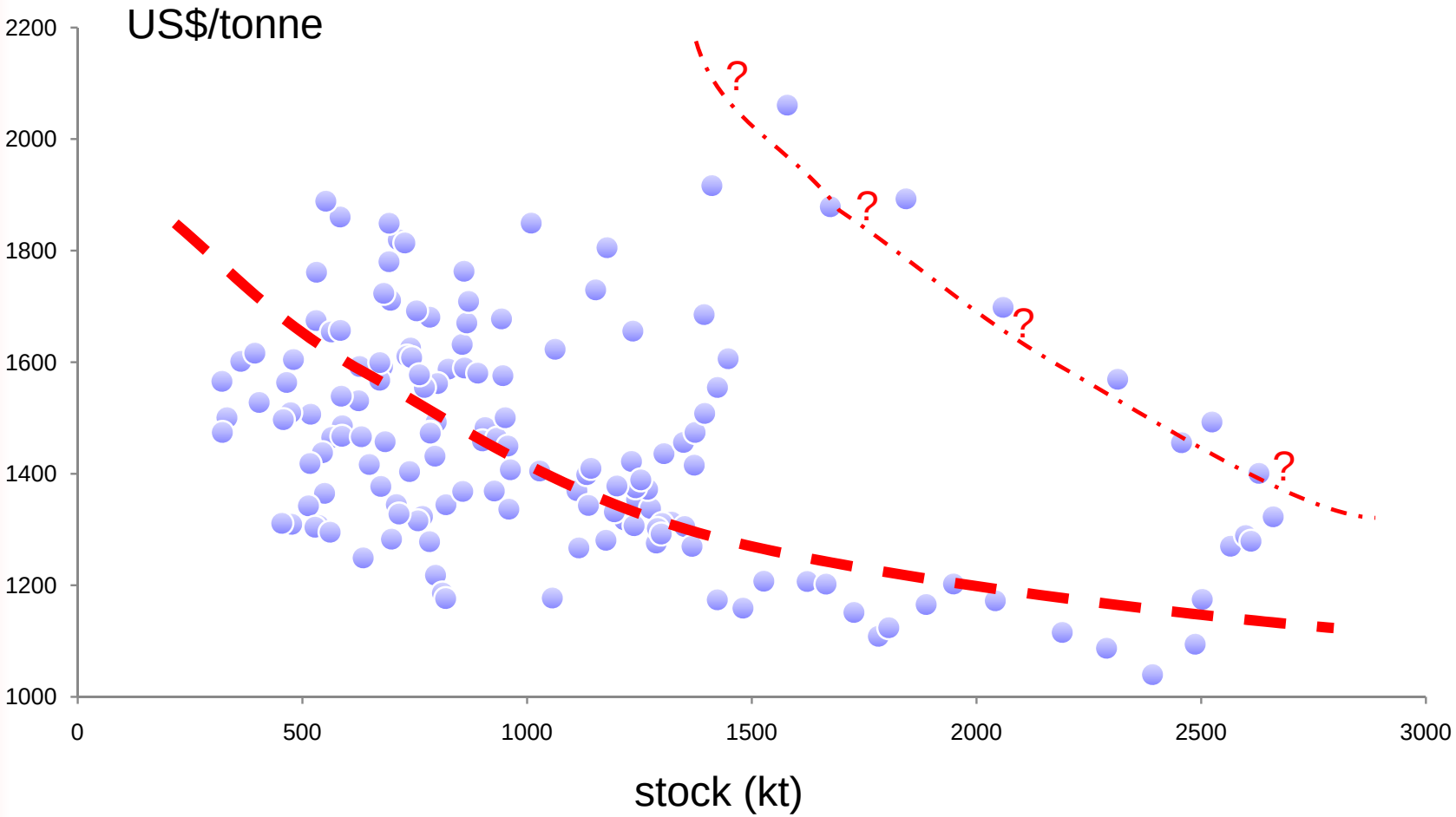
Non-modellers adapted the price to stock curve to <u>appear</u> to be useful by drawing a trend line through this broad scatter

Unfortunately, that only made any sense if the variation around trend was random, which it very definitely wasn't (see next two slides for proof…).



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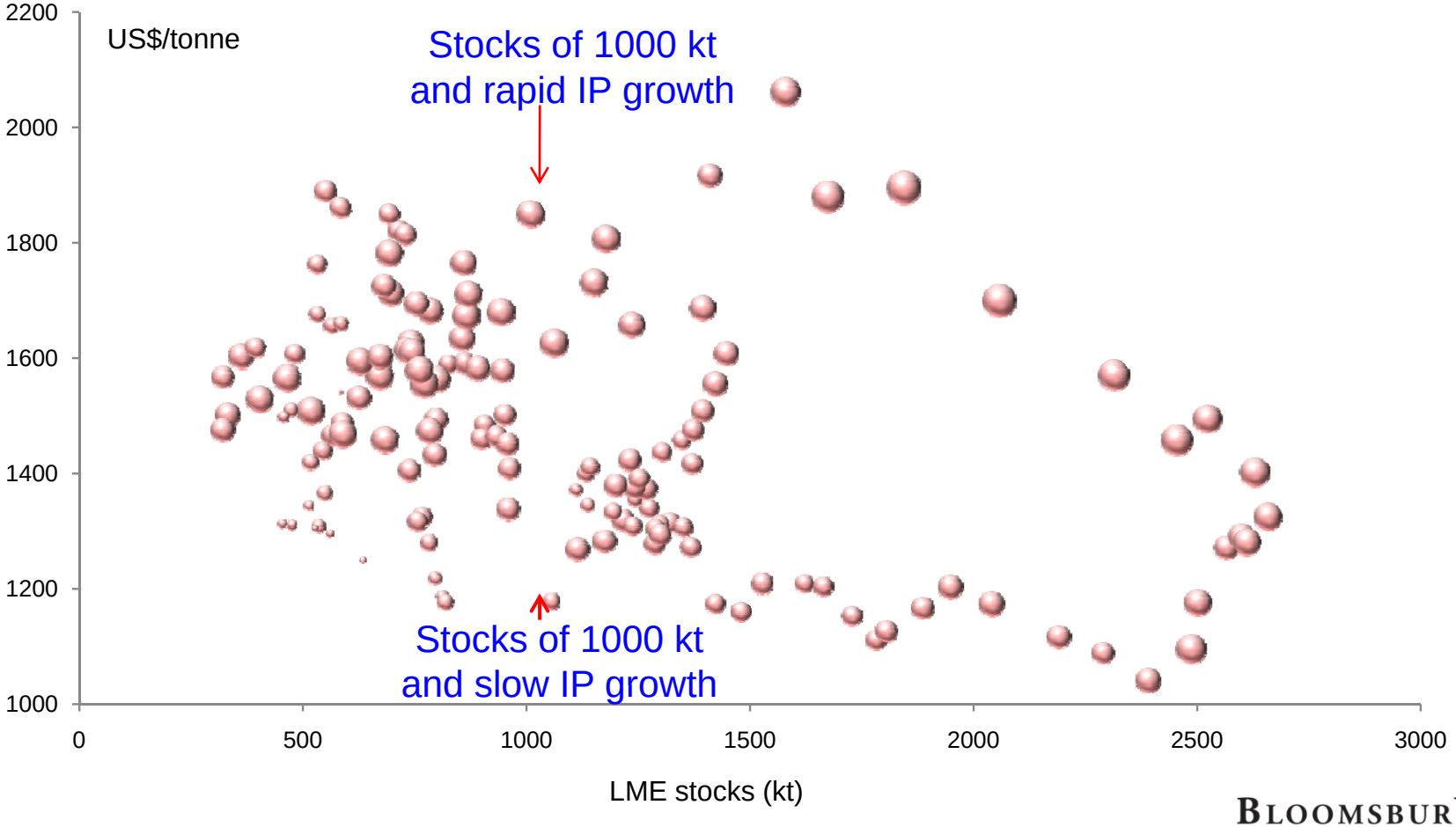
Variation around the price to stock trend was systematic

The rate of demand growth (or IP growth, a useful proxy) was one systematic cause of the scatter. Note that shifting attention away from the variation towards the trend eliminated most of the useful information.



Weak IP Growth → Strong IP Growth

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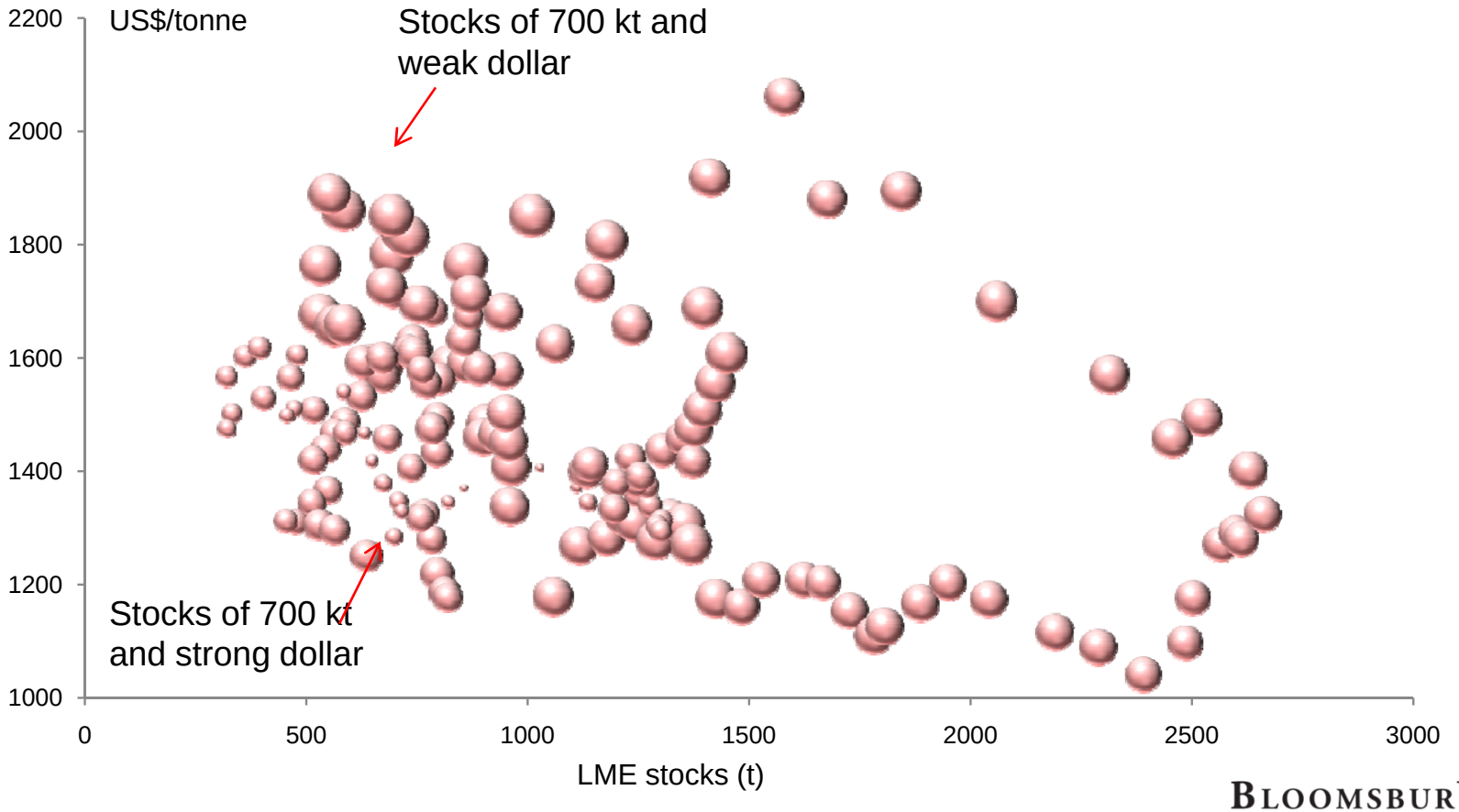
Exchange rates were the other key cause of variation around the trend.

With a price to stock trend and two main systematic causes of variation around the trend, a model was the easy way to proceed.



Strong US$ → Weak US$

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What people understood until 1980s, when mathematical modellers left metal analysis for the Forex markets

That the inverse relationship to stocks was very poor for aluminium (and nickel), unlike copper and the inverse relationship to dollar strength was profoundly and anomalously low: an almost disfunctional market! Degrees of fit (R^2) 1990-2004 in fact were:

	LME stocks	Y-O-Y IP Growth	US$ Index	The three combined in a BME model
Nickel	0.21	0.12	0.21	0.84
Copper	0.62	0.11	0.59	0.82
Aluminium	0.13	0.14	0.09	0.69

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The purposes and benefits of fundamentals-based price models

- Constructing a model forces the modeller to think rigorously about mechanisms in the market.
- A model allows the effects of many forces to be combined; more than can be handled in 2-D charts.
- A model allows you to quantify links between market circumstances and price.
- A model tells you quickly when relationships have changed. Models can be at their most useful when they go wrong - you know a new force has arrived - especially if five models go wrong simultaneously.
- A model facilitates rigorous scenario analysis.

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Limitations and risks of fundamentals-based price models

- They are only relevant over the medium- and long-term periods when fundamentals drive prices (for the short-term use BME technical analysis expert systems).
- They do not involve a mechanism for wholly new forces to be anticipated before they happen.
- When quantitative relationships first change, a model user may be over-confident that this is a temporary deviation, and may trade the wrong way.
- Over-emphasis on modelling can cause non-quantitative price drivers to be neglected.

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How BME constructs a price model

- Commonly used methods to forecast time series are based on multivariate linear regression.
- BME uses a refinement: **multivariate regression splines.**
- This method estimates different linear slopes for different ranges of the independent variables.
- This type of regression is useful in our case where we have change of relationships between prices and drivers at certain crucial thresholds, floors or ceilings.
- For example, we can detect “pinch-points” in stock levels associated with a sharp change in price behaviour.

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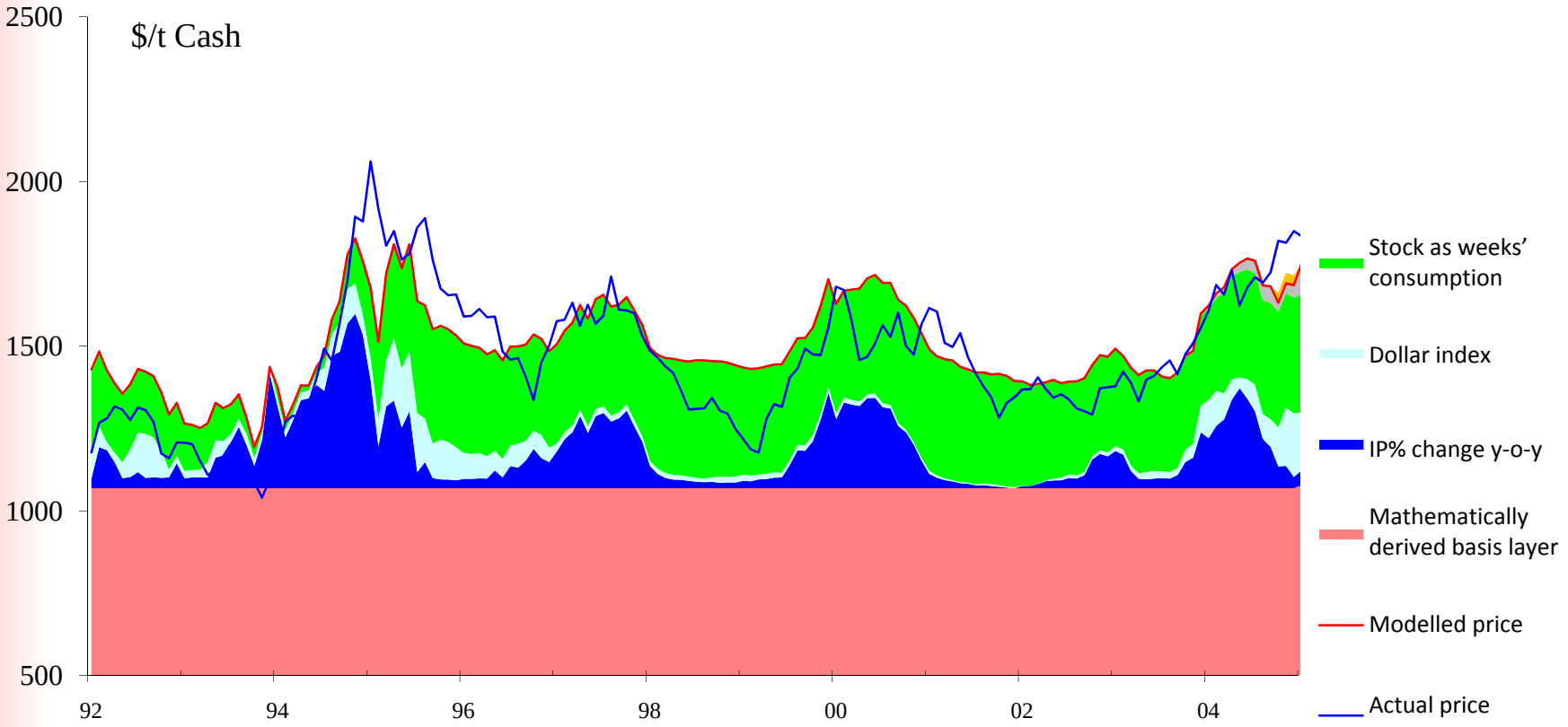
BME price model for aluminium in the period 1997-2004

Easily combines three price drivers on one chart (or four in those models where production cost data readily substitute for the mathematically derived basis layer, e.g. copper, gold)



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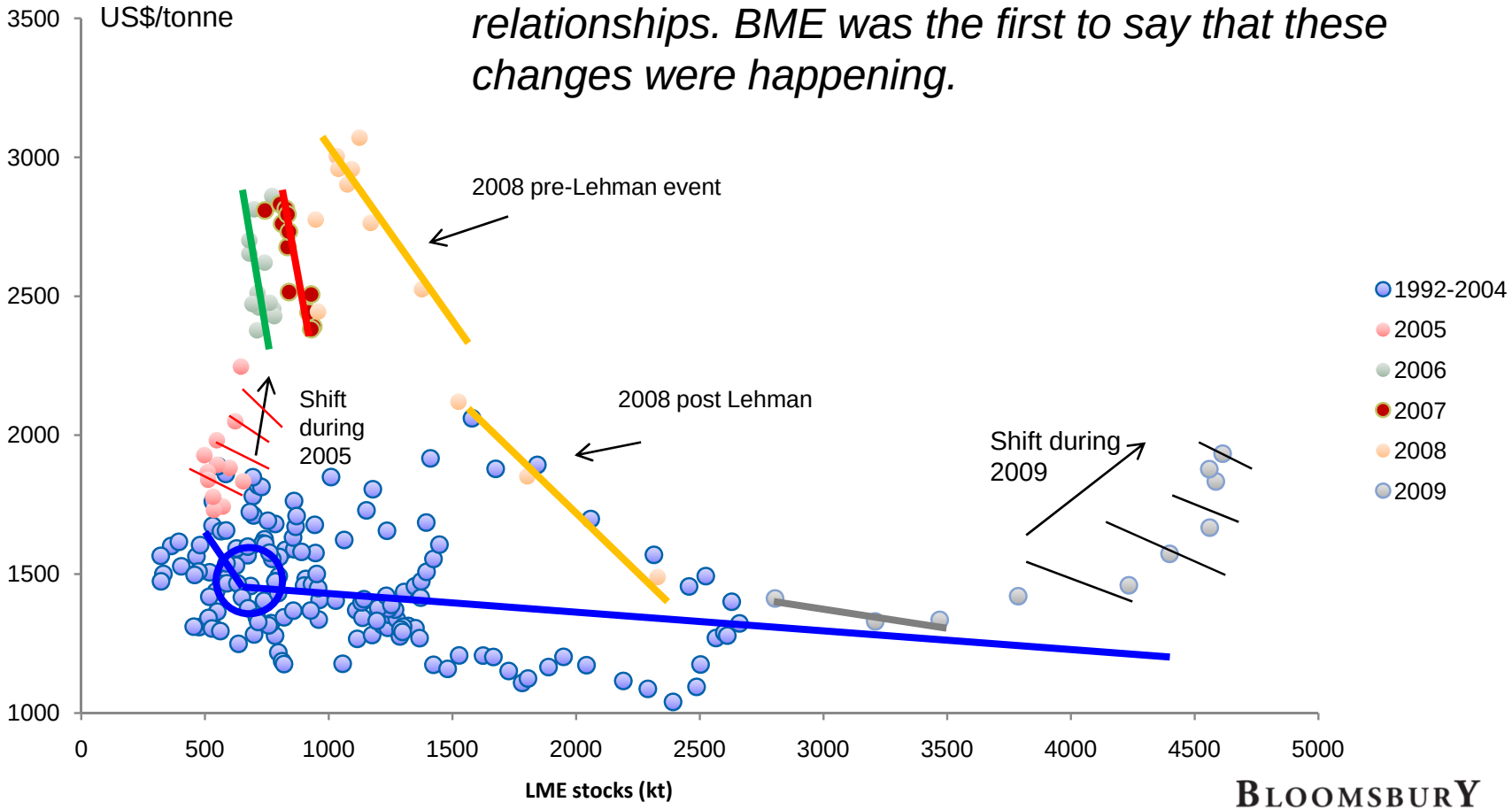
How LME aluminium price to stock relationships changed after 2004

A price modeller is alert to changes in quantitative relationships. BME was the first to say that these changes were happening.



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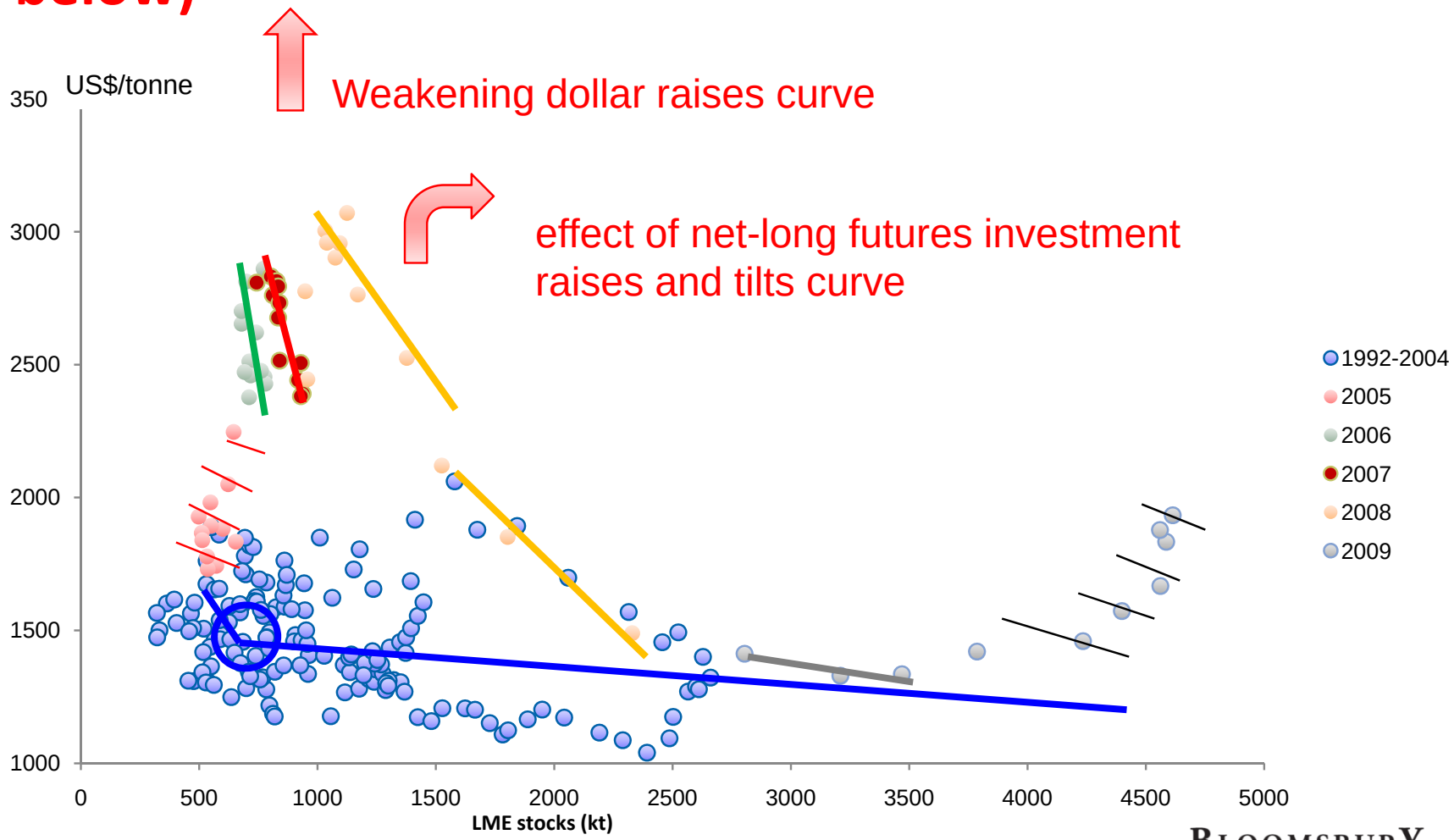
LME aluminium price to stock relationships through time: a modeller seeks causes (in red below)



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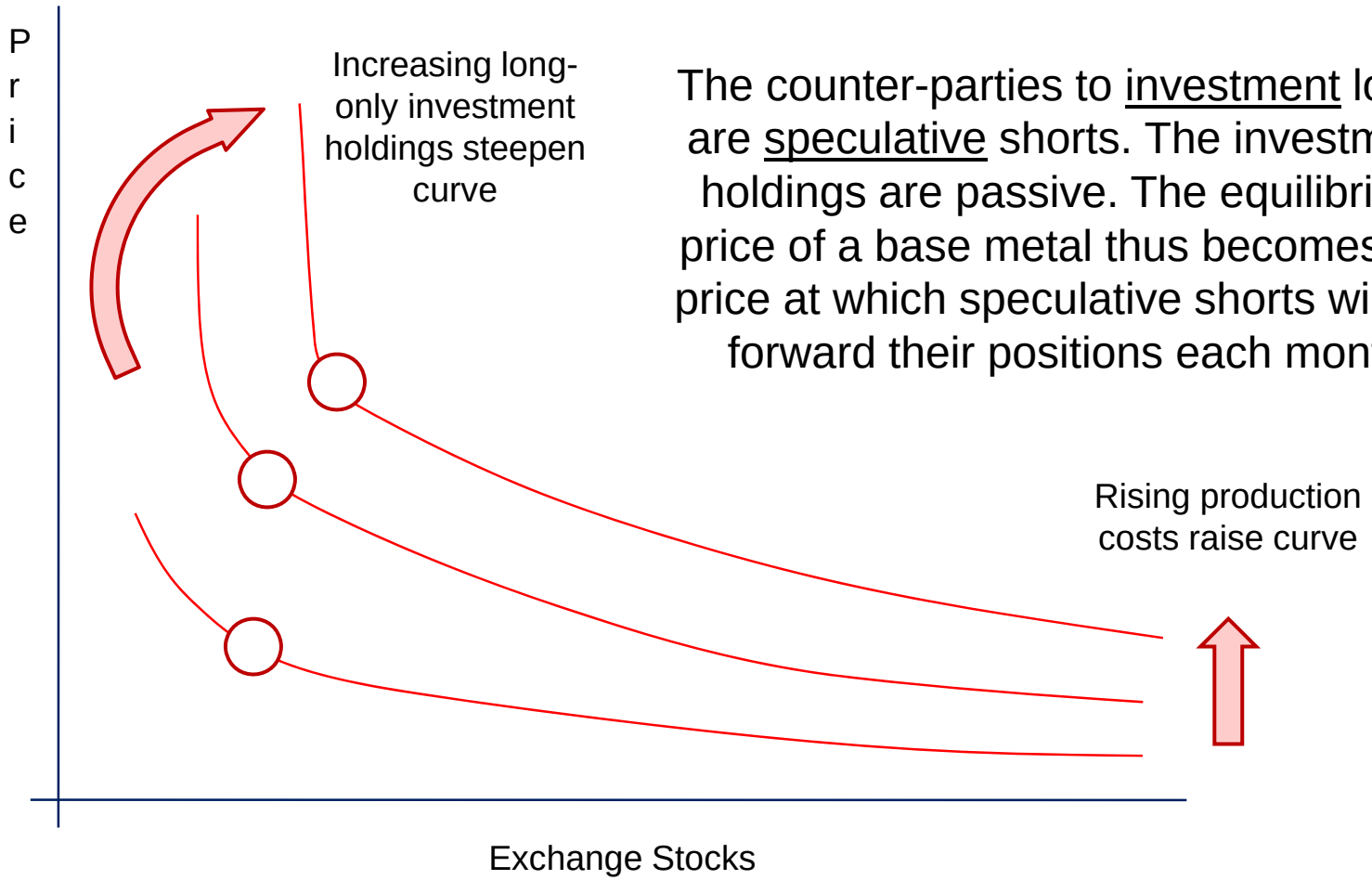
The BME hypothesis on what has been happening to price to stock relationships over 2005-2009



The counter-parties to investment longs are speculative shorts. The investment holdings are passive. The equilibrium price of a base metal thus becomes the price at which speculative shorts will roll forward their positions each month

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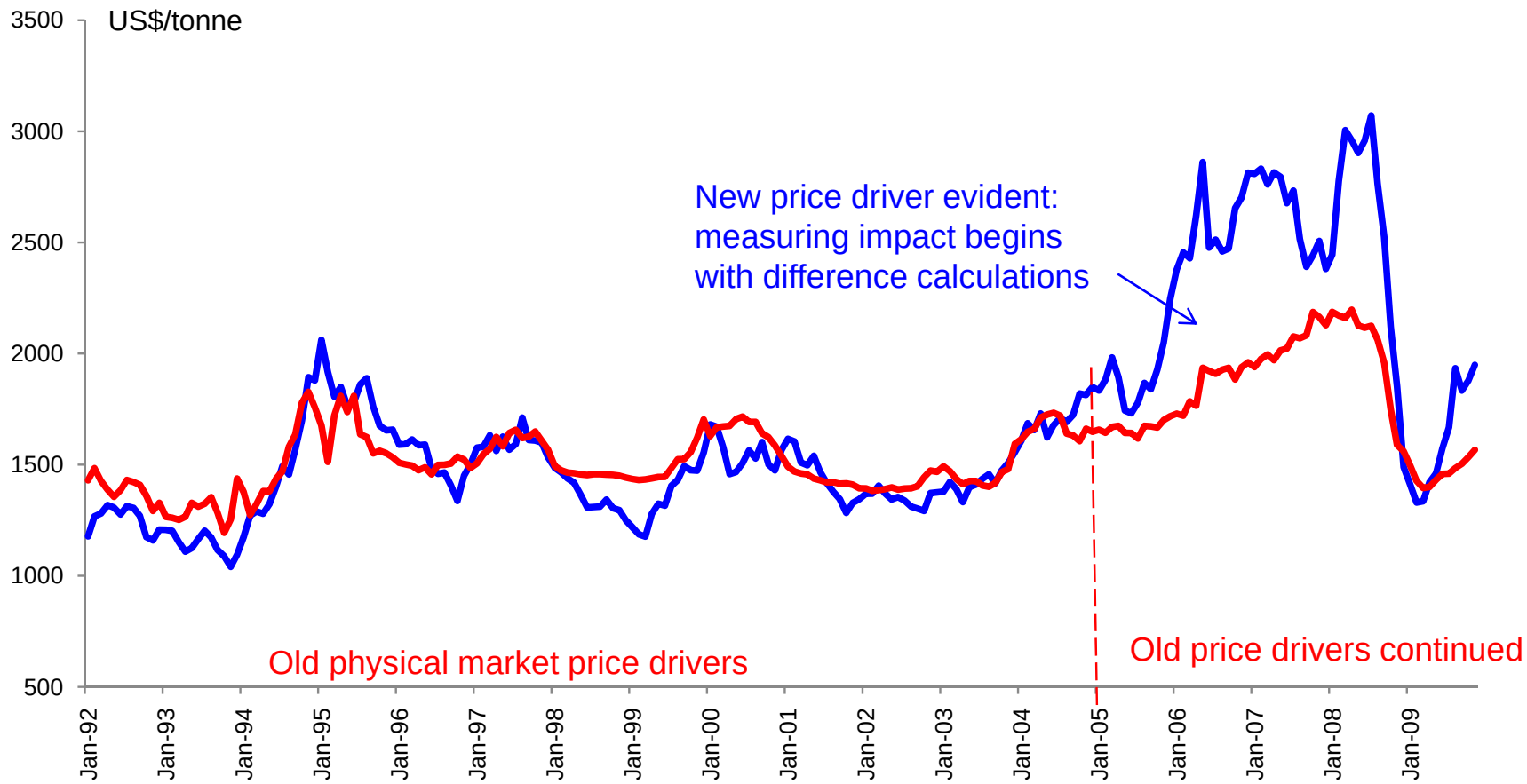
Splitting the *traditional* physical market price drivers from the *new* net-long-investment price driver



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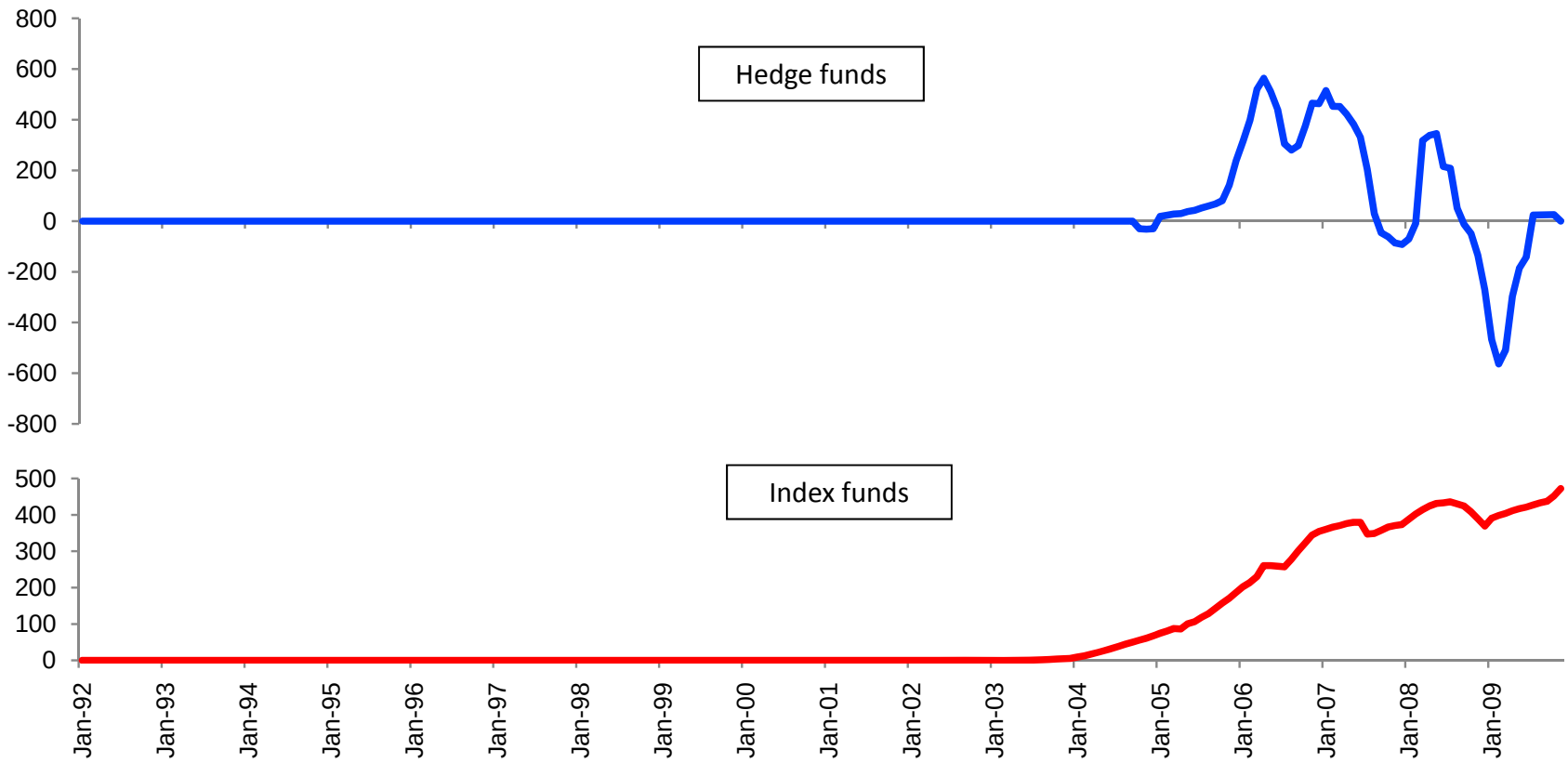
Splitting net-long-investment price driver into quite smoothly growing positive only index funds and much more volatile long/short hedge funds



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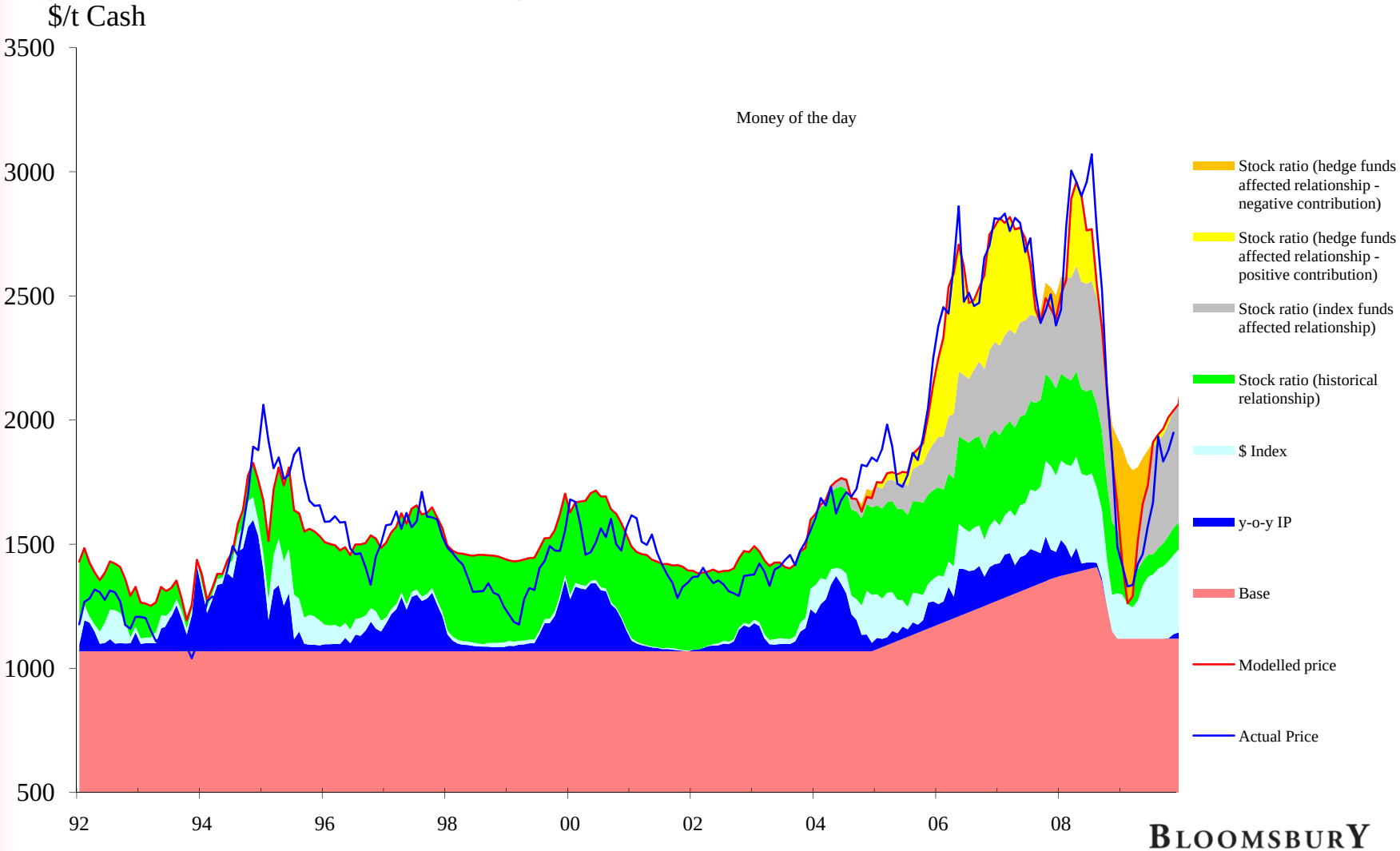
BME aluminium price model output as a layer diagram (1997-November 2009) – historical



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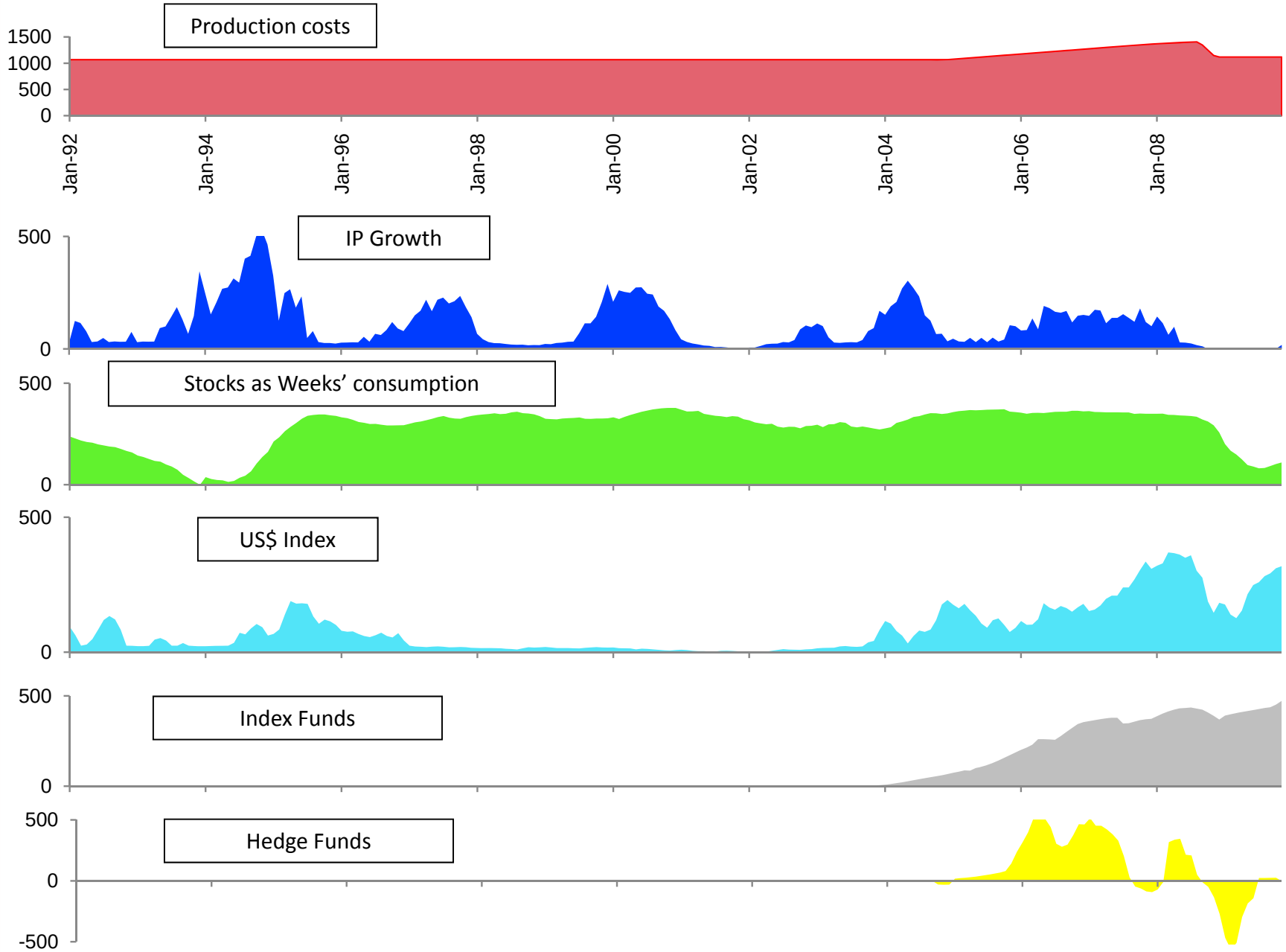
Contributions to price



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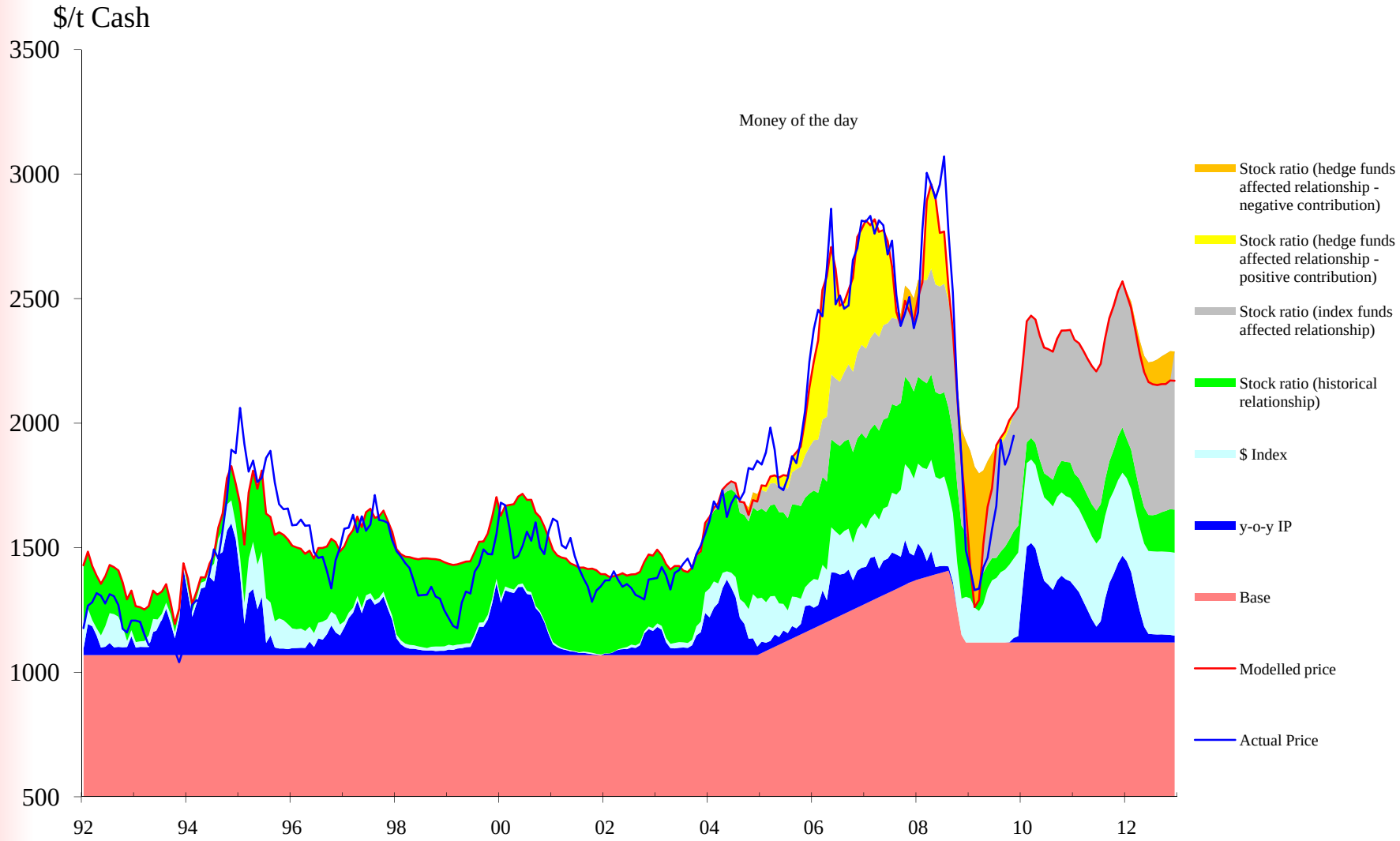
BME aluminium model



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How do our existing users take advantage of the aluminium price model?

- They use it to convince their colleagues and bosses that the aluminium price is (mostly!) understandable and not just the plaything of one or two major players.
- They use it to de-personalize discussions on price.
- They use it to explore different future scenarios.
- They use it in discussions on hedging.
- If they do feel obliged to forecast (to rank competing investments, to value assets or projects for instance), the model allows them at least to explore rigorously their assumptions on <u>all</u> of the main price drivers. But, it is <u>not</u> magic. Forecasting remains a difficult business that one does (as best one can) only if one must.

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A brief comment on long-net price prospects and modelling as BME extends its models to 2030

- Most companies which need to work with long-term prices assume a simple, smooth reversion from today's very high investment/speculation boosted prices to much lower production cost related prices.
- Mathematical modellers on the contrary would analyse the anticipated legacy of excess stocks and structural over-capacity that will result from any continuation of excess (investment/speculation driven) prices.
- Modellers would then attempt to assess when and for how long prices would be below assumed cost-related levels, before reverting to presumed long-term equilibrium.
- The two views of assets' capital values can be very different.

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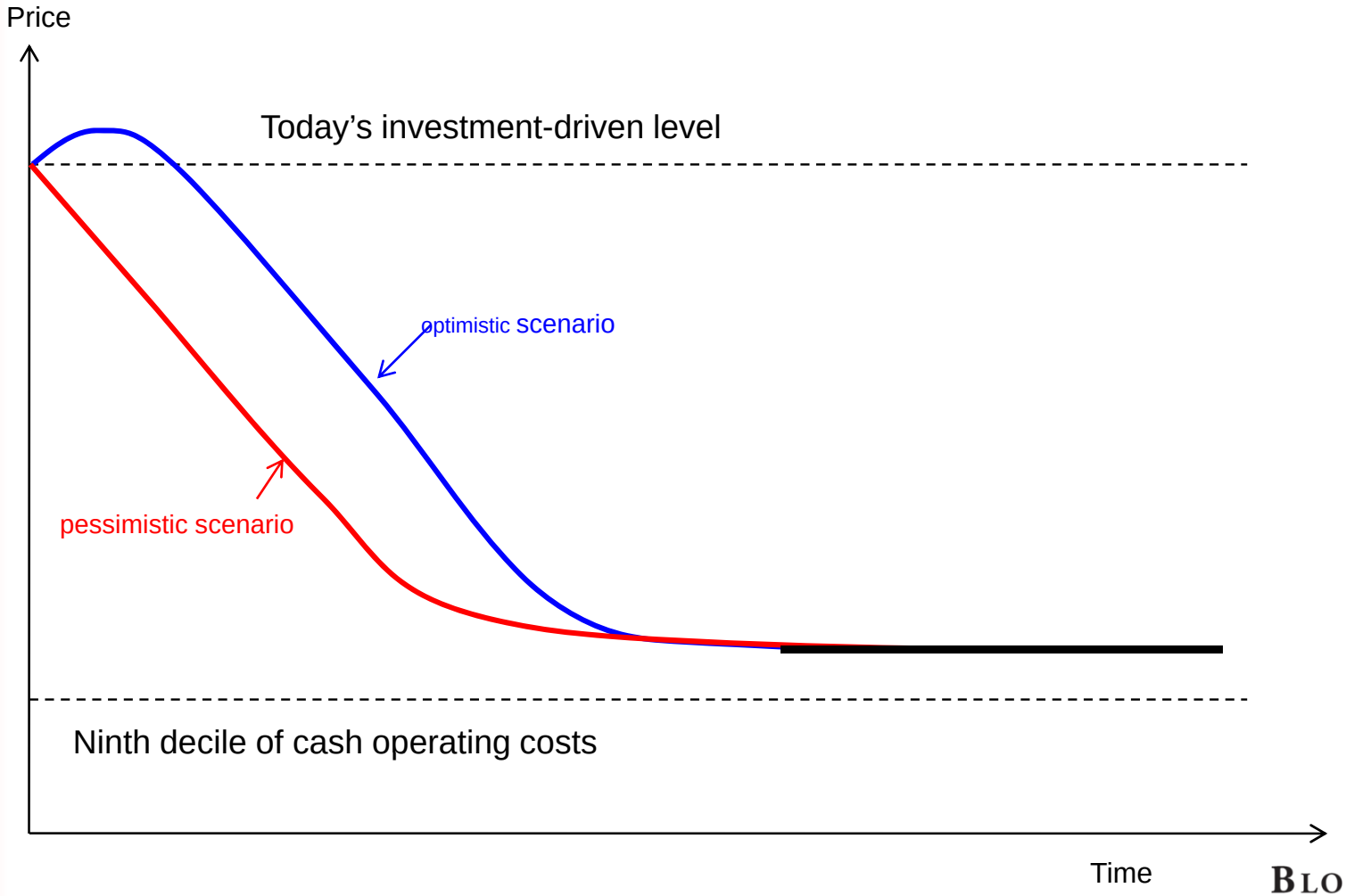
A typical long-term price scenario analysis of a non-mathematical price modeller



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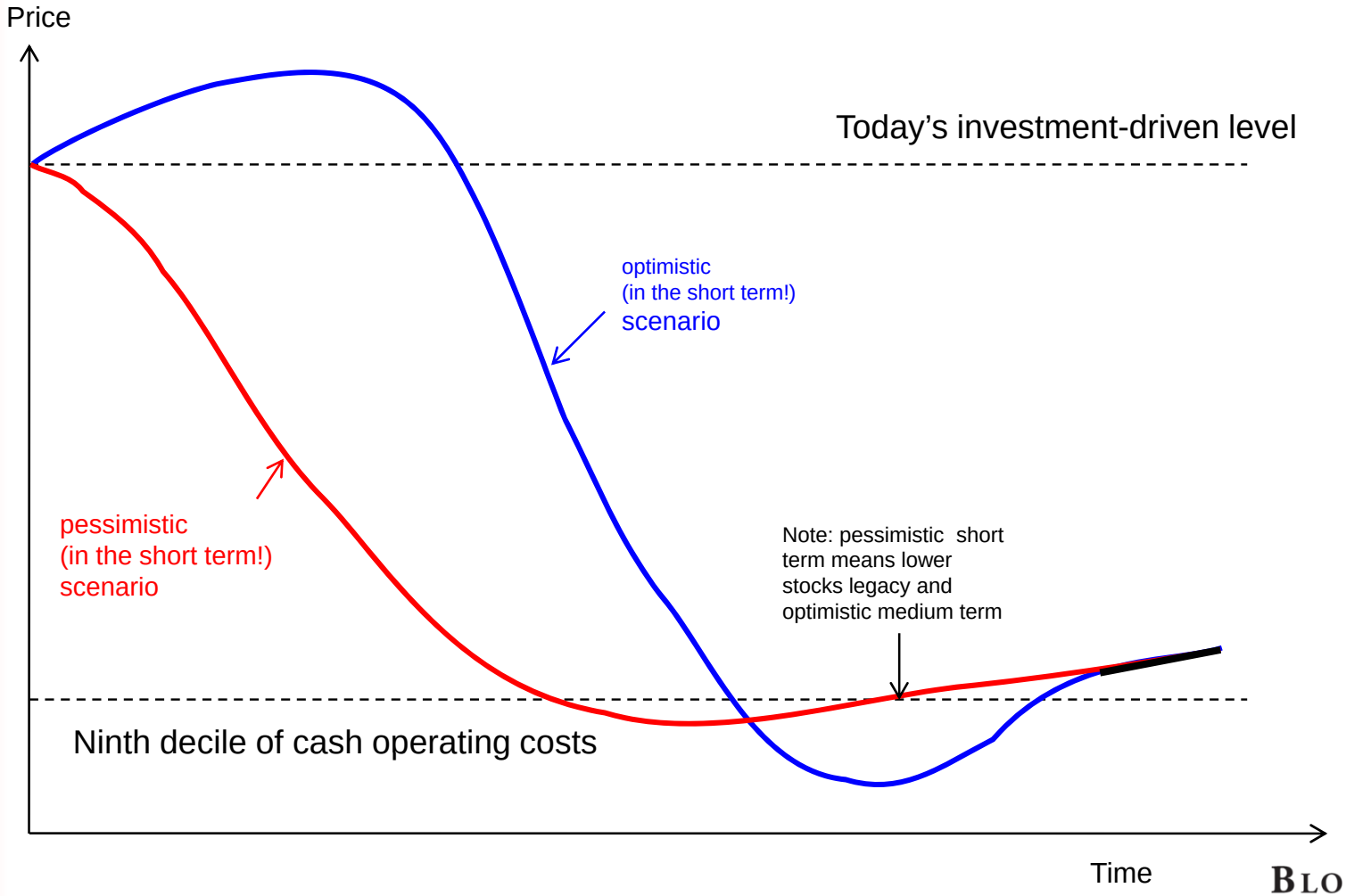
A possible mathematical price modeller's rather different long-term price scenario analysis



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Understanding commodities prices: a moving target

- **Analysis of simple industrial raw material markets**

  BME was the 'thought leader' over 2002 - 2005
  - Stock ratios
  - Rate of demand growth
  - Strength / weakness of the dollar
- **Analysis of hybrid raw material / investment vehicle market**

  BME the first to incorporate investment effects from late 2005
  - Add effect of commodity index fund longs
  - Add / subtract effect of hedge fund longs / shorts
- **Next stage is to model better the level of investments in commodities**

  BME will again be leading the way in 2010
  - Feedback loop from investment boosted prices to market balance
  - Investor sector rotation: equities, bonds, commodities

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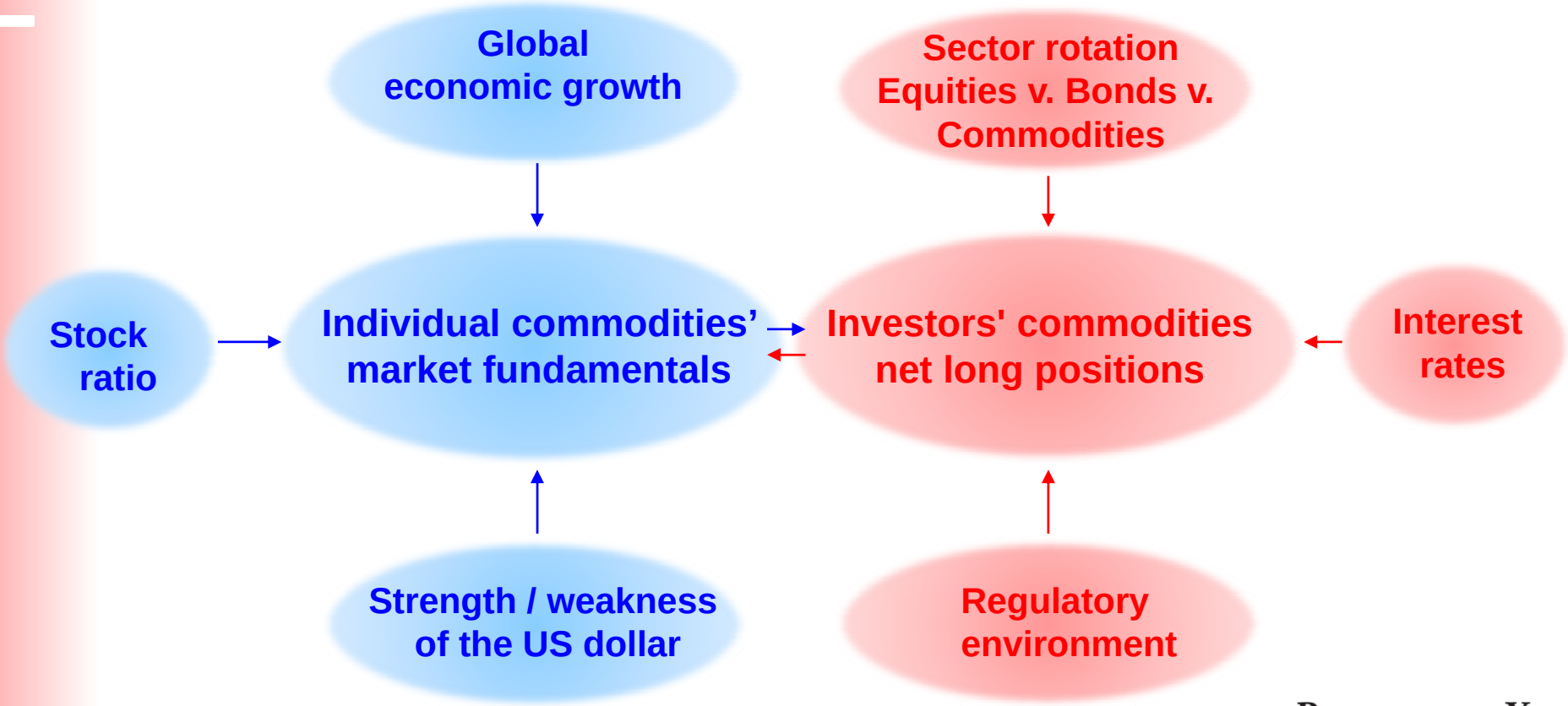
Understanding commodities prices: a moving target

The old world shown in **blue**; the new world of commodities added in **red**



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The next step: gaining access to standard or customised BME models

- BME's current models run with monthly data through 2012; they are updated and circulated to clients monthly.
- The models are being extended to 2030 to allow users to explore in full future legacies of excess stock; eventual disinvestment; short-, medium- and long-term price prospects.
- There are five standard models: aluminium, copper, nickel, zinc and lead. Annual licenses cost £10,000 for one metal, £16,000 for two, £20,000 for three, £23,000 for four, £25,000 for five.
- BME can work with clients to customise these models or create new ones.

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Further information on these models or on technical analysis expert systems from Robert Goldstein: rbg@bloomsburyminerals.com

See also our website: www.bloomsburyminerals.com

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