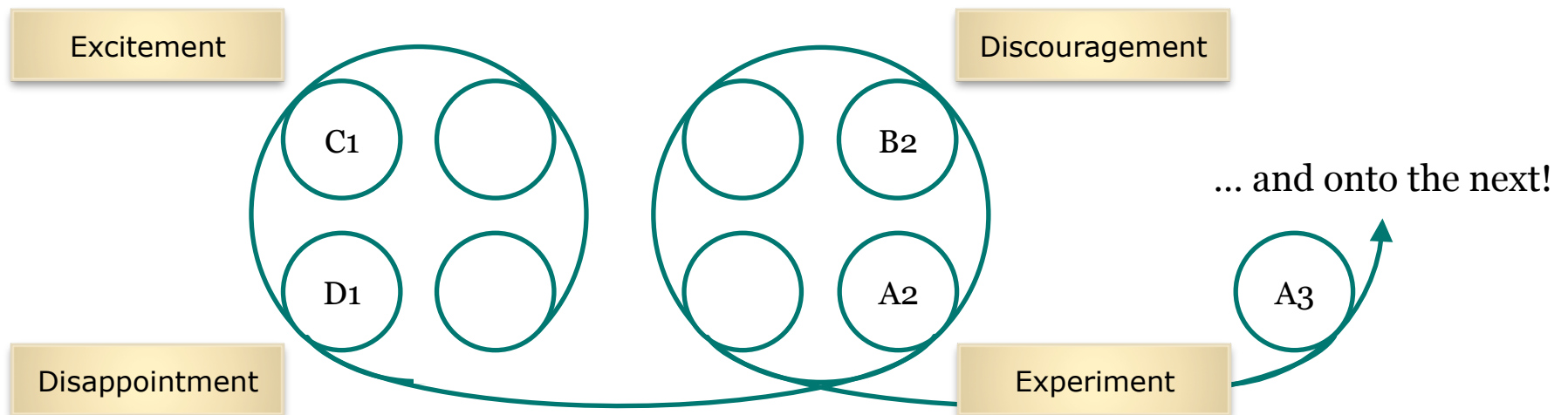


Slinking into the Future

Looking back on two decades of displays

—David Barnes, May 2015

Slinky Business—loops within loops



The FPD industry and its markets loop from cycle to cycle as producers loop from product to product in a cycle of experiment–discouragement–excitement–disappointment... then another experiment.

Slinky Business—some prior loops

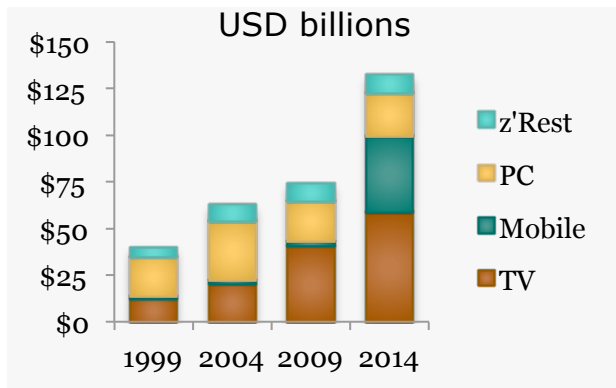
| | Experiment | Discouragement | Excitement | Disappointment |
|---------------|-----------------------|----------------------|--------------------|--------------------|
| Display—PDP | 1992: color PDP | 1996: Plasmaco sale | 2000: NHK HD | 2008: exits begin |
| Nation—Taiwan | 1990: Unipac, et alli | 1998: ITRI stymied | 2004: Securities! | 2010: China policy |
| Product—DPF | 2000: novelty | 2005: usage model? | 2007: \$388 m peak | 2012: bargain bins |
| Feature—s3D | 1997: FLC shutter | 2002: Picvue et alli | 2010: Blue-ray 3D | 2013: content? |
| Process—IJCF | 2001: Toppan et. al. | 2005: PI app only | 2009: Sharp Sakai | 2012: restructure |

Prior to 2008, next-gen fabs or PC upgrades drove major loops in nominal three-year cycles.

Since then, product-market development such as iPhone have been necessary for substantial cycles. Novel value propositions such as 3D have generated short-cycle loops.

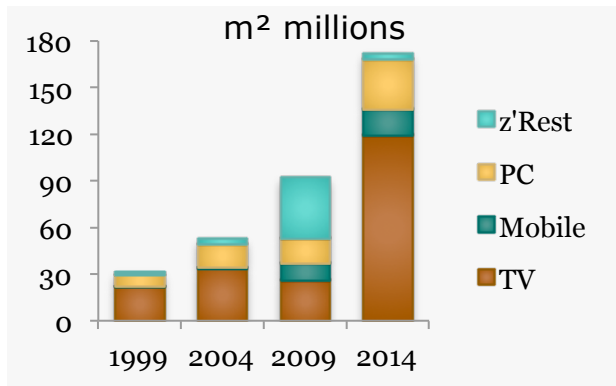
The omnipresent opportunity for “hi-rez” panels is a classic example of endless spirals.

Display Industry Review—flat TV and mobile displays



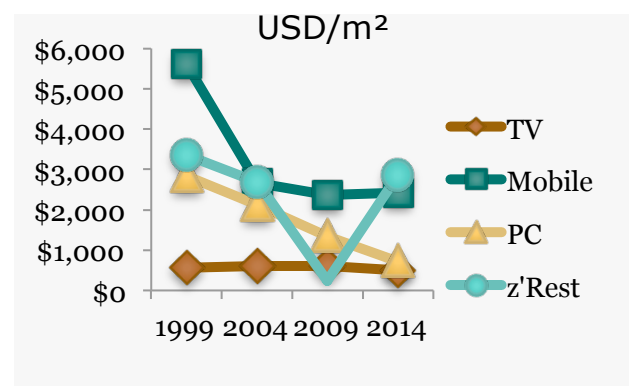
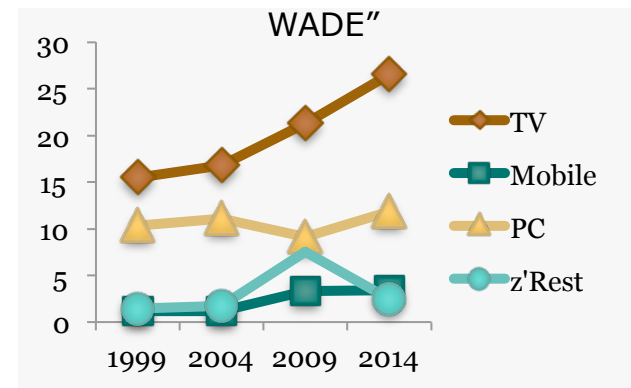
Thanks to IHS, we have three decades of great data to study.

TV screen area surged after 2004 with ever larger panels and smaller prices. In 2014, TV screens comprised 45% of display sales and 70% of area.



Without the mobile revolution sales would have grown 6% a year instead of 8% (with a surge since 2007).

Increasing diversity has kept total price decay to 3% a year.



Display Technology Review—AMLCD predominates

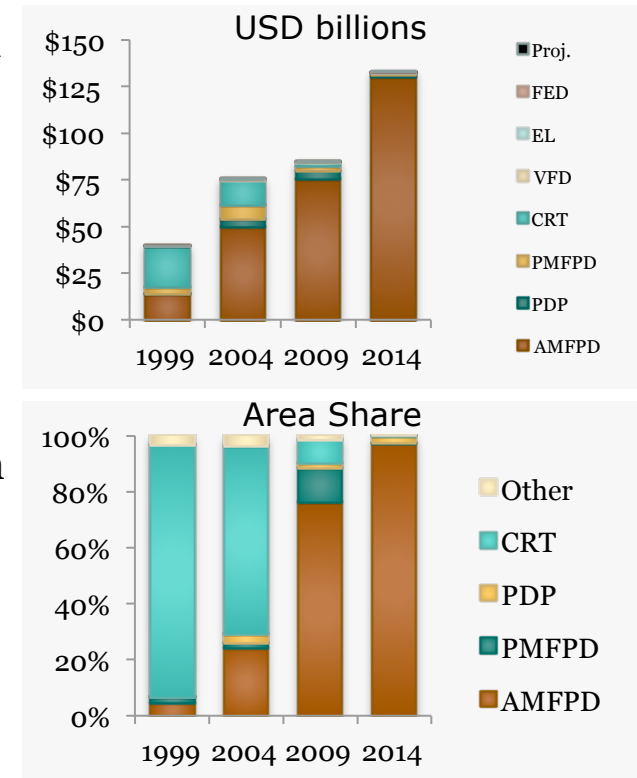
CRT captured 54% of display sales and delivered 90% of screen area in 1999. By 2014 those figures were near zero.

Many challengers came and went. Remember FED, TFEL, PDP, EPD and electrowetting technologies?

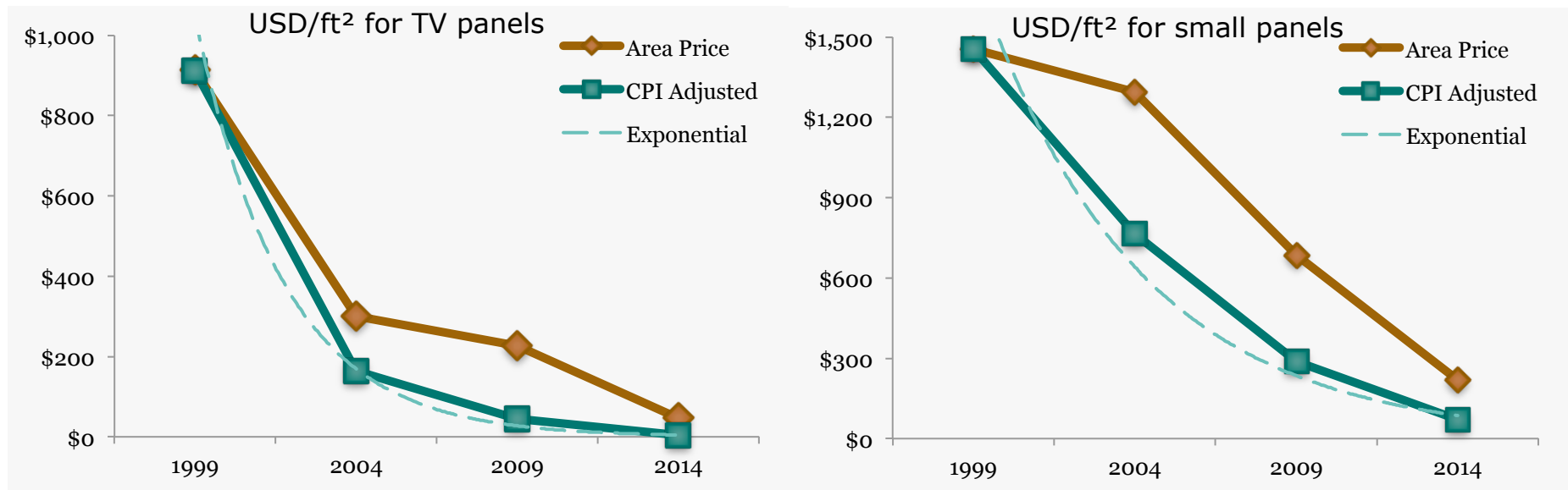
Aggressive investment in a capacity race made AMLCD the predominate display technology and even a close variant, AMOLED, remains a distant challenger this decade.

Capacity leadership has shifted from Japan to Korea, to Taiwan and now to China as nations supported champions. Panel makers have acted as non-profit contributors to national infrastructure and have realized returns only after restructure.

So, will China be the last national entrant? Will AMLCD slink into maturity or will it march towards rejuvenation?

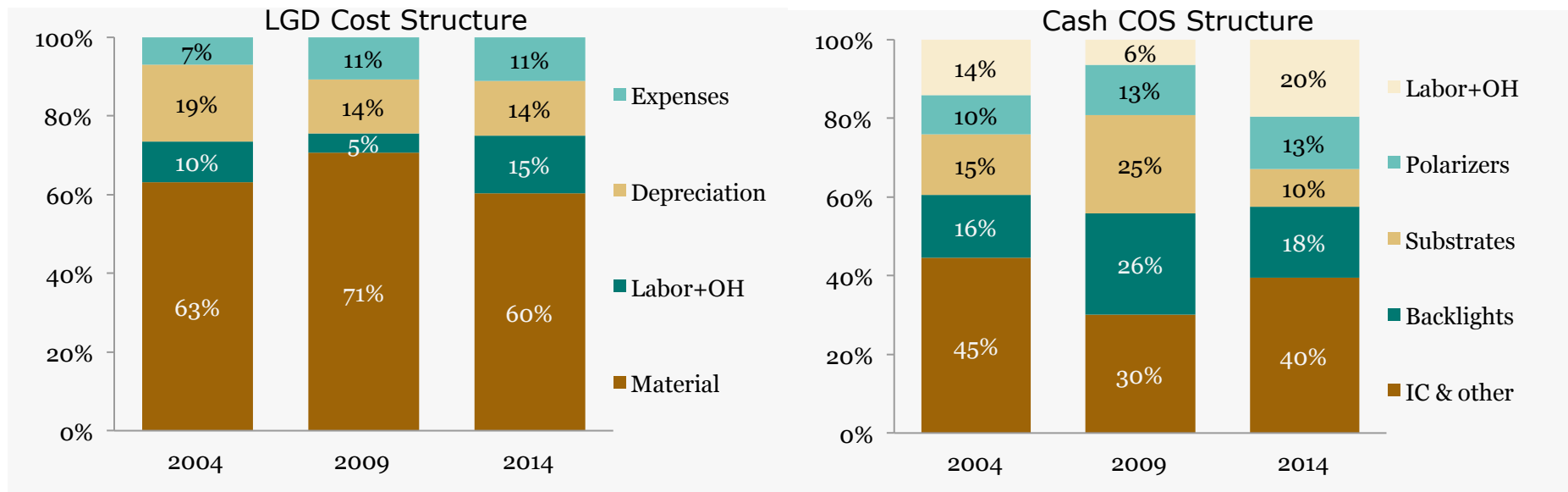


AMLCD Review—value flows to consumers



Adjusting panel area prices for the US CPI* shows real TV panel prices fell 31% a year for a half-price time of 22 months. Unadjusted price erosion matched the historical trend of 18% per year. Small panel prices fell slower: 18% a year adjusted for CPI and 12% unadjusted.

AMLCD Review—value flows to suppliers

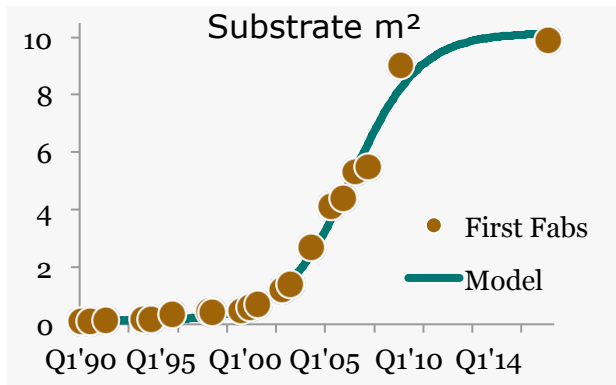


Even leading AMLCD makers see 75% of their cost as variable, material cost primarily.

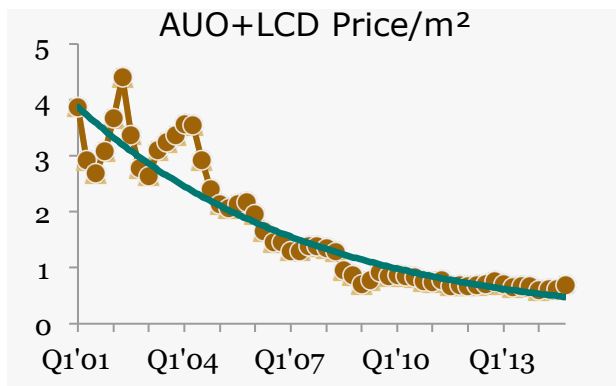
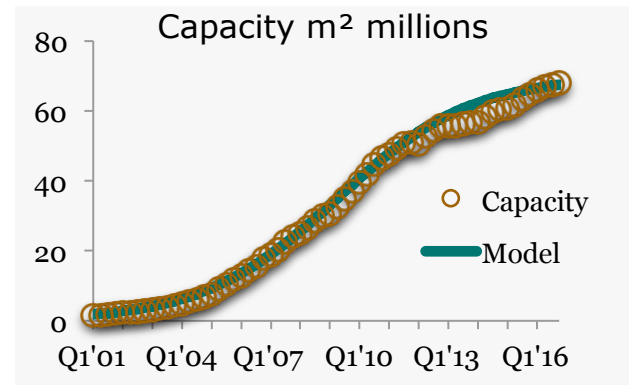
For LGD, we see effects of new technology projects on labor and affiliated sourcing of glass.

Notice also the normalization of backlight cost as LED suppliers became efficient.

AMLCD Review—capacity expansion peaked in 2009



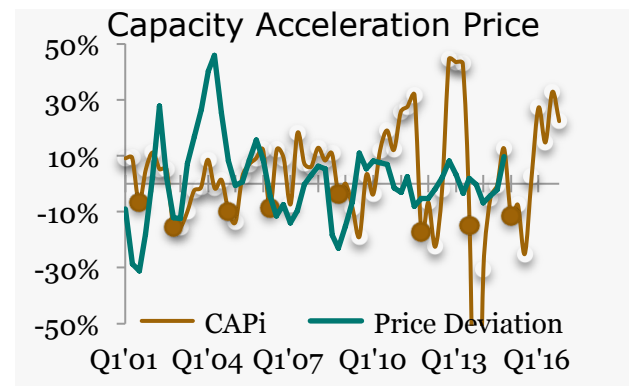
We saw a frenzy of new glass sizes come on-line until 2006. Since 3Q06, substrate size has decelerated and BOE's Gen-10 may be the limit.



Meanwhile, areal prices keep falling exponentially, even for leading panel makers.

Maturity and equity constrain expansion to 3%–6% a year...

Which makes CAPI more volatile and less useful as an indicator, perhaps.



AMLCD Review—the rise of wireless diversity

| SM panels | 1999 | 2004 | 2009 | 2014 |
|------------|-------|-------|-------|-------|
| Types | 18 | 45 | 96 | 158 |
| nIHI* | 13 | 9 | 30 | 28 |
| Avg Sales | \$111 | \$306 | \$171 | \$233 |
| Avg Area** | 7 | 22 | 389 | 99 |
| Avg Mpi*** | 4 | 14 | 34 | 210 |

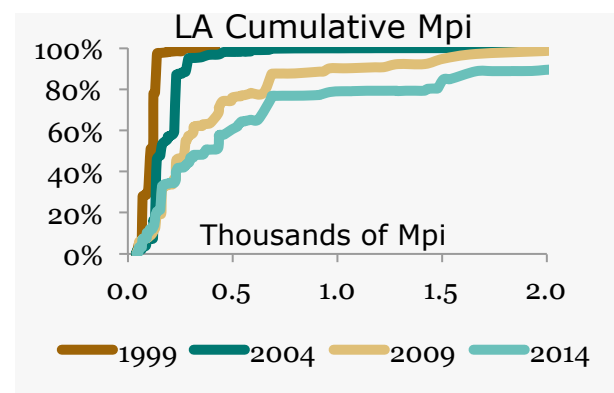
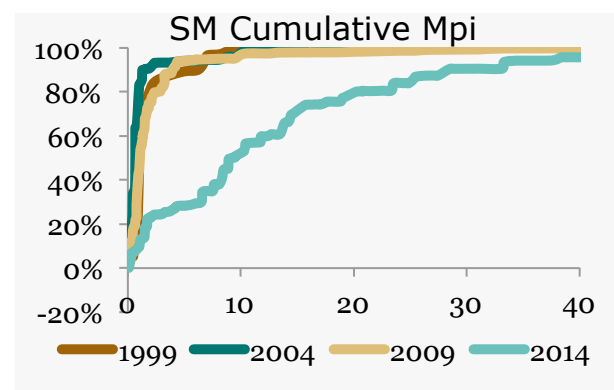
| LA panels | 1999 | 2004 | 2009 | 2014 |
|------------|-------|-------|-------|-------|
| Types | 29 | 83 | 119 | 152 |
| nIHI* | 5 | 7 | 20 | 27 |
| Avg Sales | \$394 | \$424 | \$486 | \$555 |
| Avg Area** | 45 | 140 | 284 | 985 |
| Avg Mpi*** | 86 | 322 | 1,793 | 3,422 |

Panel makers are making ever more types of panels.

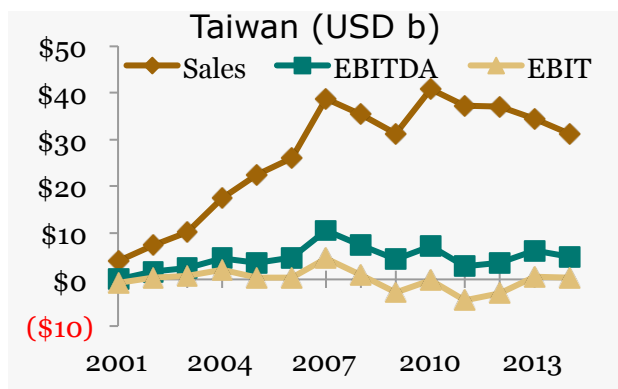
Small panel diversity surged as smartphones emerged. Pixels drove contribution margins and attracted makers.

Large panel diversity rose with larger demand by type and rising pixel counts.

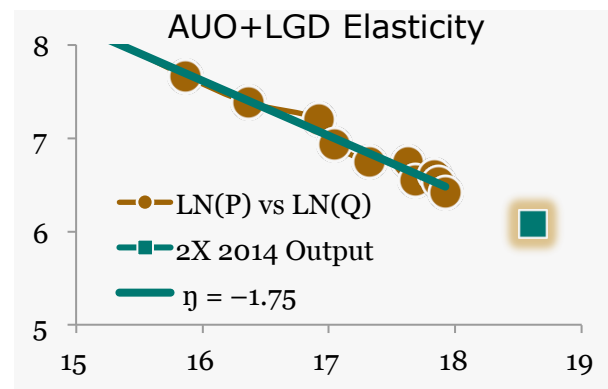
Panel makers may continue competing on product mix, which keeps value flowing downstream unless touch integration increases.



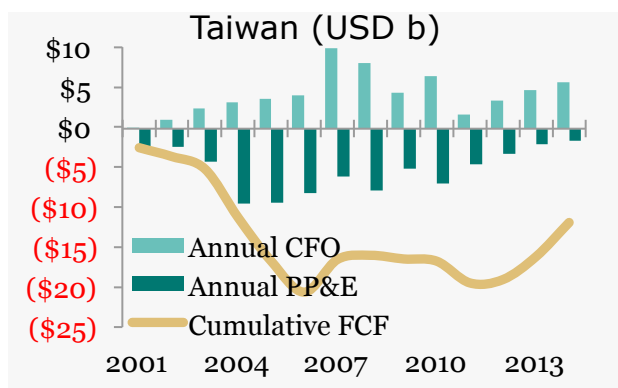
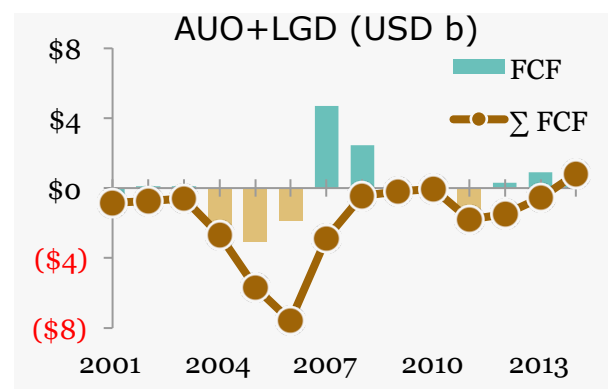
AMLCD Review—the fall of Taiwan



Left— Taiwan's panel makers remain unprofitable and have generated negative free cash flow of \$11.7 billion. It would look worse if AUO had not stopped investing so much.

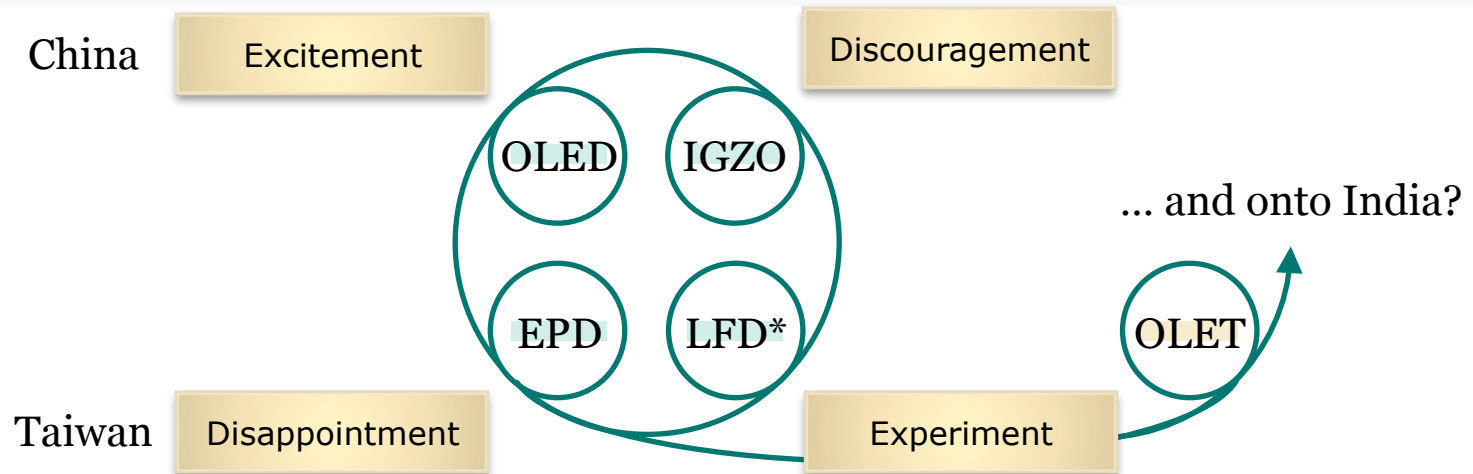


Right—AUO+LGD enjoy elastic demand. Average area price should decline 30% if industry doubles but these leaders became Σ FCF positive after 15 years... hoorah!



So there is some hope for leaders who expand slowly.

Slinky Business—future loops depend on funding



Who will fund more capacity after China digs several more money pits?

Will we see project funding (JV, etc.), supply funding (e.g. Apple) or creative vertical integration (perhaps state sponsored)?

... or will we see FPD slink into a CRT-like future of cash management?

Our services...

Growth

- Market entry
- Business structure
- Phase gates, R&D

Performance

- Price position
- Cost reduction
- Portfolio balance

CapEx

- Factory plans
- Tool selections
- Plant conversions

Sourcing

- Make/buy
- Value chains
- Supplier selection

Technologies

- Market sensing
- Market & IP value
- Consortia synergy

Alliances

- M&A candidates
- Partnerships, JVs
- Integration plans

Plans

- Strategic audits
- Investor insights
- Business valuation

Materials

- Pricing policies
- Market strategies
- Licenses, royalties