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C O L U M B I A U N I V E R S I T Y I N T H E C I T Y O F N E W Y O R K

Samsung and LG: From Also-Rans to Dominance in Consumer Electronics

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Abstract. Today Samsung is the world leader in flat screen TV and cell phone sales. LG is second in TV sales, fifth in cellphones. Samsung fabricated its first LCD screen in 1995, well after such screens already dominated laptop computers, and had shipped its first cell phone only in 1988. LG wasn't even founded until 1958 when it started its development of the first Korean-made radios. By 1982 it shipped its first color TV – made in the USA. In this time frame, not even twenty years ago, TV shipments were dominated by Japanese consumer manufacturers and cell phones were led by Motorola and Nokia. This paper explores possible sources of the secret to the Koreans' success and finds that the usual metrics – in particular patents, R&D investment, and low cost labor – don't explain it. We speculate that "industrial policy" measures of the South Korean government may have been decisive.

Historical Context.

In 1945, World War II ended. Japan was devastated, with most of its cities in ruins and its economy literally a "basket case". Korea was almost as bad, as a former Japanese colony, and about to get worse with the North Korean invasion, followed by the UN "Police Action" and the subsequent Chinese invasion. Ironically, the Korean War was a catalyst for Japan's recovery, as Japan became the pillar of the American war effort. As Japan revived, South Korea was ravaged by war. By the middle fifties, Korea was in no better shape than Japan had been ten years earlier, except it was further troubled by a series of autocratic dictatorships. Japan further benefitted from being viewed by the US as an anticommunist bastion, on which aid and other benefits were lavished². Korea, in contrast, was a footnote in the cold war, mostly characterized by the continued armed confrontation at the 38th parallel. It was a virtual stepchild of American foreign and economic policy.

The advances discussed below are all in the context of recovery from the destruction of these wars. The Korean War did not "end" until 1953, while Japan had surrendered only eight years earlier. With that head start and the US investment during the Korean War the Japanese electronics industry was able to charge into the post-war 20th century with few obstacles. Not only did Korea start later, but the Korean economy was smaller and less advanced than the Japanese – of which it had, of course, been a part until 1945. The European and US electronics makers, being the winners, were not driven by the same necessity to overcome adversity.

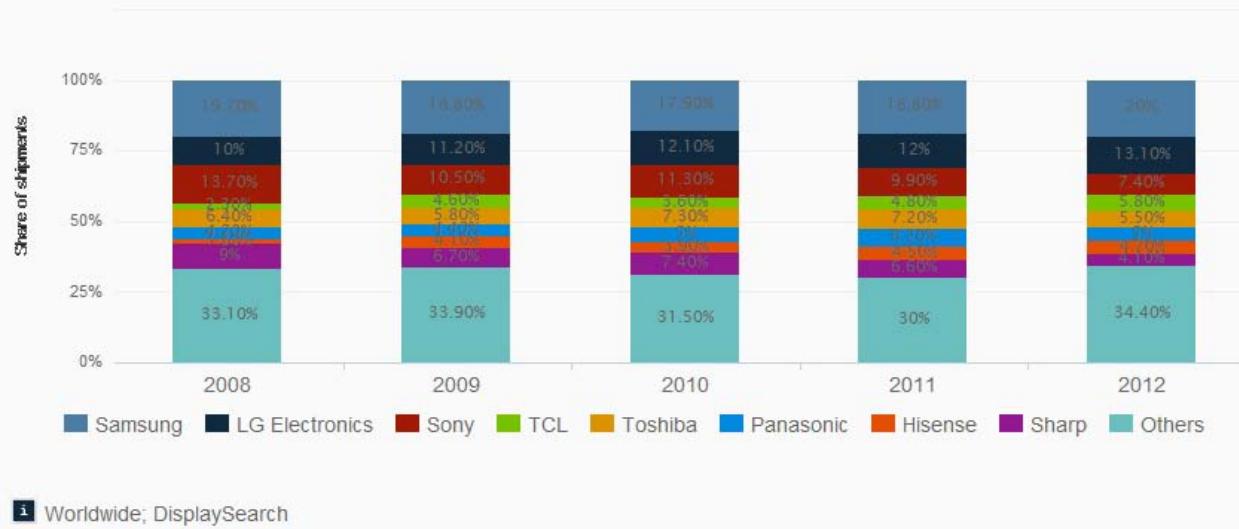
Evolution of the TV Industry

In 2013 sales of TV sets – now, virtually all liquid crystal technology-- are dominated by Samsung and LG, Korean companies who until this century were bit players in the world of consumer electronics.

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² See, for example, <http://www.history.navy.mil/photos/events/kowar/log-sup/log-sup.htm> and <http://www.history.navy.mil/photos/events/kowar/log-sup/japan.htm>

Global market share held by LCD TV manufacturers from 2008 to 2012



Twenty-five years ago one would have been forgiven if they had not noticed these now electronics giants. In those years the leading TV makers – then, of course, using cathode ray tube (CRT) technology – were in Japan, a magnet for “out-sourced manufacturing” thanks to their skill at high volume low cost techniques. Sony, with what we would now recognize as an Apple-like reputation for quality (and prices), Sanyo, Panasonic, Toshiba and Hitachi, conglomerates selling everything from nuclear reactors to washing machines, and Sharp, which was about to bet the farm and its whole business on liquid crystal TV sets. Loitering in the wings were the surviving European makers, Philips, Telefunken, Siemens and others, barely more than brands even then. Perhaps the most striking change was the recent announcement that Samsung will “invest” in Sharp, one of its key suppliers – essentially a bailout. And Sharp is not alone, with some industry experts suggesting that Japan just say “sayonara to TV manufacturing”.³

And the US? Already a hollow giant, with many famous brands like RCA attached to foreign-made boxes thanks to the lower costs promised in the Far East, where “the foothills of the Himalayas” were already a major source of anything with significant labor content. The Americans had evidently gambled that they could survive with their knowledge-based engineering talent, oblivious to the near certainty that there were plenty of smart engineers in China (as there had been in Japan decades earlier) who would, sooner or later, take over the higher value-added parts of the value chain and leave the US to sell and service the machines that the ships from China were busy unloading.

Was this transition inevitable? How, in fact, did it happen? Here are some thoughts, starting with LCD flat panel TV sets.

³ <http://www.eetimes.com/electronics-news/4373507/Will-Japan--Inc--say-Sayonara-to-TV-manufacture->

Evolution of TV Technology

Television itself is, conceptually, at least, 100 years old, with the first US commercial broadcasts (for minimal audiences, of course) transmitted shortly before World War II. However, “The first commercially made electronic television sets with cathode ray tubes were manufactured by Telefunken in Germany in 1934, followed by other makers in France (1936), Britain (1936), and America (1938). The cheapest of the pre-World War II factory-made American sets, a 1938 image-only model with a 3-inch (8 cm) screen, cost \$125, the equivalent of \$1,863 in 2007. The cheapest model with a 12-inch (30 cm) screen was \$445 (\$6,633).”⁴ The war interrupted the growth of commercial TV, but the technology itself was rapidly accelerated by the military need for reliable electronics and (as in radar and sonar) high quality displays. The basics of a CRT TV set are relatively simple for an engineer to master (“not rocket science”) and apart from incremental enhancements a TV set was little more than a commodity, distinguished from its competitors by cost, quality, industrial design, and brand recognition.

Although the military need for advanced technology did not diminish after 1945 – indeed, the cold war provided a continuing source of development money – TV technology was energized in the 1960’s. After RCA had made the then-daring gamble to introduce color TV, teletype-based computer terminals were rapidly replaced by CRT terminals. This was an application which the US TV makers appear to have completely missed. IBM, the industry leader, developed and manufactured its own displays (eventually moving both development and manufacturing to Japan by the 1980’s). This was partly because in those years IBM did everything in-house and partly because TV technology was not mature enough to deliver the needed quality for a computer display, in spite of their superficial similarities. The move to manufacturing in Japan was, again, motivated by the allure of high volume low cost manufacturing.

However, the computer display business had an important side effect. Not being dominated by the traditional consumer electronics brands, any company could dive in and develop a line of “plug-compatible” monitors. Limited by their fragmented computer industry, no Japanese computer company had the volume, much less the vision, to dominate the field. What they did have was cadres of engineers who spent a great deal of energy researching alternatives to CRT-based TV sets. Although liquid crystal displays were slowly emerging, if only in displays more suited to watches and calculators, what initially appeared to be the major technology candidate to replace the CRT was the AC plasma display, originally invented at the University of Illinois in 1964 and seriously commercialized in the early 1970’s by IBM in a banking terminal display.⁵

The plasma display technology had a good run, greatly extended when engineers were able to produce a full color display by adding phosphors to the panel’s cells. Not an easy technology to master, the major protagonist was Panasonic (Matsushita) which appears to be ready to throw in the towel and leave the field in 2014.⁶ Most of the other Japanese TV makers avoided major investments into this new technology, although Samsung and LG did invest, and look like they will be the only survivors for a few

⁴ http://en.wikipedia.org/wiki/History_of_television#Television_sets

⁵ http://en.wikipedia.org/wiki/Plasma_display

⁶ See, for example <http://www.avsforum.com/t/1463886/panasonic-may-end-plasma-production-in-2014> and <http://mashable.com/2012/05/11/panasonic-plasma-tv/>

more years⁷. Other alternatives did not fare nearly as well, although clever engineers regularly showcased the newest technology at the annual “Display Week” show of the Society for Information Display. Faced with the barrier of a potentially huge investment if they were to compete with the LCDs, however, each of these hot technologies soon faded, like a roman candle.

What has become the ubiquitous TV display technology – indeed, virtually the only viable contemporary TV display technology – is the digital liquid crystal display.⁸ LC-based displays first emerged –slowly – in the 1960s when RCA (!), which led the way, demonstrated mini LC displays, using new materials from the German Merck.⁹ The first RCA patent [3,322,485] was filed in 1962 and issued in 1967. By the early 1980’s, virtually every Japanese consumer electronics maker had a group dabbling in the technology. One can speculate that LG did, too – Samsung hadn’t even filed a patent and only released its first (B&W) TV set in 1980. Even IBM kept its hand in. By 1985, prototypes with a diagonal measurement of the order of 10 inches – not competitive for a TV but perfect for a portable (laptop) computer -- were being shown at the SID meetings. By the early 1990’s, the IBM-Toshiba partnership, Display Technologies, Inc., was one of the top three makers of liquid crystal displays.

Even as late as 1993 the first issue of *Information Display*, the Journal of the Society for Information Display (SID) had several articles on advances in CRT technology, along with articles on various LCD competitors such as ferroelectrics in addition to several papers on LCD technology.¹⁰ . The field was open even then, although the articles reporting advances in LC technology strongly indicated where the industry was headed.

The technology involved was intrinsically far more complex than CRTs. The devices were in fact far more like giant integrated circuits than TV sets and the manufacturing skills involved were a challenge to everyone – but well suited to companies that had been making ICs. Making displays at a competitive cost involved processing a large plate of glass (actually anticipated by the glass used at the start of a plasma display line) with the transistors that drive the pixels of the display deposited by expensive tools in a production line that would soon cost billions of dollars. Today’s LCD manufacturing lines process plates of glass the size of a garage door. Few people can afford one of these giant panels, but the key to a competitive cost structure is processing the largest possible sheet of glass, from which smaller panels can be cut. This was long seen as the key to reducing semiconductor cost, in that the larger a wafer being processed, the more chips could be produced in a single process. Recognition of this truism, however, was not enough – management had to take the risk of making multibillion dollar investments. Samsung and LG did.

As challenging as the LCD technology was, it had one virtue in comparison with CRT-based TVs. No one had a head start on building the factory or the displays. The Japanese, of course, had extensive experience in IC manufacturing, greatly facilitated by the government’s catch-up industry policy

⁷ *Information Display*, Mar/Apr 2013, page 3.

⁸ http://en.wikipedia.org/wiki/Liquid_crystal_display

⁹ [See, for example, History Crystallized: A First-Person Account of the Development of Matrix-Addressed LCDs for television at RCA in the 1960s” <http://www.informationdisplay.org/article.cfm?year=2008&issue=01&file=art7.>]

¹⁰ <http://onlinelibrary.wiley.com/doi/10.1002/jsid.1993.1.issue-1/issuetoc>

stimulus¹¹, and all the Japanese computer makers had IC manufacturing capability with large and growing patent portfolios. Sooner or later, they all developed in-house LCD capability, with Sharp making the most aggressive strategic choice in the early 1990's. Samsung was also well positioned to make LCD's, as it was already the world's leading maker of DRAMs.

Samsung and LG

Although founded in 1938, it was not until the late 1960's that the Samsung Group entered into the electronics industry when it formed several electronics-related divisions. Its first TV product was a black-and-white television set. In 1980 Samsung entered the telecommunications hardware industry with telephone switchboards and Samsung Electronics began to invest heavily in research and development, investments that were evidently key in pushing the company to leadership of the global electronics industry. Samsung became the largest producer of memory chips in the world in 1992, and is the world's second-largest chipmaker after Intel.¹² Not until 1995 did it create its first liquid-crystal display screen. The field was already dominated by patented technologies, almost none of which were Samsung's. Ten years later, Samsung had grown to be the world's largest manufacturer of liquid-crystal display panels. Indeed, its current share exceeds that of the three leading Japanese brands combined.

Samsung had earlier made a strategic decision to go into the DRAM business – even then almost a commodity¹³ - and by 1992 Samsung was already the world leader in the manufacture of memory chips¹⁴. This success in the face of even stronger adverse patent positions no doubt encouraged Samsung to challenge other technologies where it would have to make substantial payments for needed patent licenses. Staked by a government eager to catch up with and surpass the Japanese, capital was not a problem and the Korean home market was protected as the Japanese market had been earlier. Even patents were brushed off. When sued for infringement, Samsung just paid – but, meanwhile, making huge R&D investments so that the next time around they would have enough patents of their own to reduce or eliminate royalty payments.

Samsung had followed the DRAM path when it moved into making hard disk drives, again paying for the many needed patent licenses until its internal R&D gave it patent parity. By 2010 it had achieved a 10% global market share but, reflecting a focus on the bottom line, sold the disk business to Seagate for \$1.4B in 2011.¹⁵ The model clearly worked, and it is not hard to see the logic in adopting it to move into LCDs – particularly since the LCD technology in the late 1990s was still emerging, and leadership was still in contention.

The government's deep pockets no doubt made building factories easy – and they didn't have to worry about public investors complaining about return on investment, at least in the US, since Samsung is still not listed on a US exchange. In contrast, IBM and Toshiba abandoned their ambitions to become major

¹¹ http://en.wikipedia.org/wiki/Industrial_policy_of_Japan

¹² [Worldwide Top 20 Semiconductor Market Share Ranking Year by Year](http://en.wikipedia.org/wiki/Worldwide_Top_20_Semiconductor_Market_Share_Ranking_Year_by_Year),
http://en.wikipedia.org/wiki/Worldwide_Top_20_Semiconductor_Market_Share_Ranking_Year_by_Year

¹³ <http://en.wikipedia.org/wiki/Samsung>

¹⁴ http://en.wikipedia.org/wiki/Worldwide_Top_20_Semiconductor_Market_Share_Ranking_Year_by_Year

¹⁵ http://en.wikipedia.org/wiki/Samsung_Electronics

LCD makers circa 1993 when the price tag for the next generation fab approached \$2B¹⁶. Samsung gained the #1 position worldwide in 2007.

By 2012 Samsung led worldwide sales with a dominant 26% share; LG was second with a 14.6% share and Sony third with a 9.5% share. Surprisingly, the sales of “US-based” Vizio¹⁷ virtually equaled Samsung in the US. However, Vizio is hardly a US manufacturer, other than its headquarters and a South Dakota call center: “Vizio's major partner in the consumer electronics arena is AmTran Technology, a Taiwan-based OEM/ODM that manufactures more than half of the televisions sold by Vizio and owns a 23% stake in the company. Vizio also manufactures its products in Mexico and China under agreements with ODM assemblers in those countries.”

LG was originally established in 1958 as GoldStar, producing radios, TVs, refrigerators, washing machines, and air conditioners. In 1999 LG acquired 100% of the bankrupt US Zenith, having purchased a 50% interest in 1995. Zenith at the time had over 900 issued US patents. Although the patents strongly emphasized about-to-be-obsolete analog and CRT-based^{18,19} television and related technologies, it also included valuable patents on vestigial sideband modulation which were essential to emerging digital TV standards. Royalties of \$5 per TV set resulted in total payments of \$25M in 2006 and \$50M in 2007 and still are continuing.²⁰ What the Zenith purchase also provided, in addition to a competent engineering team (even now generating patents for LG), was a brand that still appealed to a US consumer.

I believe that LG saw that Samsung’s “invest, pay royalties, develop internal technology, invest some more” would work and – possibly also backed by the government²¹ or, at least, the chaebols -- saw an opening and moved aggressively. Unlike Samsung, LG Display has been listed on the NYSE since 2004, but well after it had started investing in LCD fabs. Already by 1998, four years after LG’s first CD-ROM drive, LG had achieved worldwide #1 ranking in sales of CD-ROMs – yet another technology dominated by third party patents -- and is now the world's second-largest television manufacturer (after Samsung),^[2] and the world's fifth-largest mobile phone maker by unit sales since the second quarter of 2012.

In comparison with Japanese makers, the Koreans had the advantage of lower labor costs (even if they initially had to buy their manufacturing tools from Japan), lower cost of capital, and little need to conform to Wall Street investment measurements. In retrospect, it is not hard to see the logic of their approach even if they now are close to the bind originally faced by the CRT TV makers. There is industry over-capacity, profit margins are fading, and – as the LCD technology becomes commoditized – lower cost Chinese (and other Asian) newcomers are undercutting the leaders on cost and price. As we see from the technology literature, the reaction is to search for new technologies, like organic light emitting

¹⁶ They (separately) sold their know-how to different Taiwanese display makers.

¹⁷ <http://en.wikipedia.org/wiki/Vizio>

¹⁸ “Zenith was acquired by LG... mostly for its DTV patents.” <http://displaydaily.com/2012/01/30/last-one-out-please-turn-off-the-lights/>

¹⁹ Even their handful of “flat panel” applications covered CRT flat panel displays which still had some attractions to engineers who had been brought up on CRTs.

²⁰ LG Electronics 50-Year History vol. 04, English Edition (1958), p. 48.

²¹ The Korean government announced the electronic industry development plan in 1966 and, in 1969, the 'Electronic industry 8-year development project'. LG Electronics, 50-year History, VOL. 04 2008. English Edition

devices (OLEDs), quantum dots, LED backlights, three-D, ultra-resolution... Only time will tell if any of these initiatives can maintain the industry, or whether some still incipient replacement will come to dominate.

It should not be surprising to note that Samsung and LG have followed the same path into leadership in sales of cell phones and smart phones, so that Samsung – using phones powered by Google’s Android – has become such a force that, in spite of a billion dollar jury damage award to Apple²², they are now the 500 pound gorilla in the smart phone arena, Ranking number one in cell phone and smart phone sales since 2012. Samsung’s mobile initiative started rather late, in 1983, and its first successful handset didn’t ship until 1988. As in LCDs, they surged to a leadership position in spite of having a thin portfolio of relevant wireless patents, almost none of which were “standards essential”. LG has been less successful, but still achieved fifth ranking in worldwide handset unit sales.²³ Now, thanks to their broad and deep patent portfolios, they are in a strong defensive position, even when they choose to enter a new field, as few manufacturers would want to risk infringing a large number of Samsung’s or LG’s many thousands of patents.

Patents and Success

The development of the Samsung and LG portfolios of US patents parallels their technology development. LG first filed its two issued US patents in 1984. Six more issued from applications filed in 1985 and 27 issued from applications filed in 1986. In 1987 LG filed for 95 later-issued US patents while Samsung, just getting started, had two patents issued from 1987 files, 26 filed in 1988 and 189 filed in 1989 (passing LG’s 99). By 1990 both had high triple digit filings that later issued. In short, until 1988-1989, neither LG nor Samsung was a significant patentee in the US (or anywhere else, except possibly in Korea).

Patents and R&D investment are two popular proxy measurements for business success. However, they are hardly decisive. Patents and success are certainly correlated, but causality is not obvious. Microsoft was already a raging success before it earned its first twenty US patents, in 1995; its first (three!) US patent applications were only filed at the end of 1992. And Apple, that paragon of innovation, had received only a total of 61 US patents by 1990, when it had already achieved iconic “innovativeness” status. In contrast, IBM and AT&T had made patenting a key element in their development strategy, and they fed the patent process with leading R&D investments for decades. More recently, IBM has continued to lead in the number of US patents awarded for the last twenty years along with its continuing major R&D investments. Samsung, from a standing start has leapt to the forefront of patent recipients, ironically joining Canon, Sony, Matsushita, Toshiba and other Japanese brands in the top ten. Clearly, there is more to success than accumulating certificates from the US patent office. To borrow a metaphor from criminal law, a good patent attorney can get a patent on a ham sandwich.

Apple offers yet another example of the limited value of using a patent portfolio as a predictor of success. In spite of its huge infringement win over Samsung, the Apple portfolio until very recently has

²² <http://www.foxnews.com/tech/2012/08/24/jury-reaches-verdict-in-apple-vs-samsung-case/>

²³ <http://www.gartner.com/newsroom/id/2335616>

been unimpressive, numbering less than 100 patents per year (in comparison with Samsung's and LG's – and Canon's, Sony's and Toshiba's – thousands). In addition to the royalties it may (but doesn't automatically) generate²⁴, a strong patent portfolio serves to insulate the company's products from infringement suits by providing the currency for cross licenses. However, as we have seen in the above discussion, a company determined to compete can buy its way in if it has enough ready money to pay for licenses and to invest in the R&D needed to generate its own patents. See the Appendix for a table comparing the leading recipients of US patents over the last 20 years.

Nevertheless, it only takes one really good patent to make a company, or a university, or an individual inventor rich. For example, one patent - US3,789,832, *Apparatus and method for detecting cancer in tissue*, issued 2-5-1974, filed 3-17-1972, by Raymond Damadian – underlies the entire MRI imaging industry.

Other Possible Success Factors

R&D investment, while a somewhat better indicator of future success, often fails, as well. Consider the dot-com billionaires whose R&D was carried out in a dorm room. This is consistent with the intuitive feeling, confirmed by data, that patents and R&D are closely correlated, while the number of patents and industrial success are less so.²⁵

Another argument often advanced relates to the availability of low cost labor. Indeed, that was an early rationale for IBM building its presence in Japan in the 1970's and 80's (obviously before the great Japanese bubble). It is still an obvious factor in the dominance of Chinese contract manufacturers such as Foxconn, as well as the US-based Flextronics which does most of its contract assembly in China. Nevertheless, the fields in which Samsung and LG have carved out leadership – DRAMs, hard disks, smart phones and LCDs – are capital intensive industries, with much of the production performed in automated factories, now costing billions of dollars each. These are products where the cost of capital is far more significant than the cost of labor.

As noted earlier, even in the mid-nineties the cost of a competitive TFT-LCD manufacturing facility was approaching several billion USD. Five years ago it was already \$3B²⁶ and is now more than twice that as the size of the glass processed has grown. As J.P. Morgan is said to have replied when questioned about the cost of a yacht, "If you have to ask the price, you can't afford it."²⁷ Since the Korean government controlled access to capital²⁸, much as Japan had done earlier, it is likely that the government copied the successful Japanese industrial policy by enabling access to low cost capital for Samsung and LG,

²⁴ IBM's income from its patent portfolio has been as high as \$1.5B, and still exceeds \$1B.

²⁵ Applied Econometrics and International Development. AEID.Vol. 5 4 (2005), PRODAN, Igor

INFLUENCE OF RESEARCH AND DEVELOPMENT EXPENDITURES ON NUMBER OF PATENT APPLICATIONS: SELECTED CASE STUDIES IN OECD COUNTRIES AND CENTRAL EUROPE, 1981-2001

²⁶ Craig Addison, SEMI Dazzling Display Issues: LCD Market Growth, Glass Size, Fab Cost, and OLEDs, <http://www.semi.org/en/P044084>

²⁷ *Business Education World*, Vol. 42. Gregg Publishing Company. 1961. p. 32.

²⁸ See, for example, Kang-Kook Lee (Ritsumeikan University), *Economic Growth Controlling Capital: focusing on the 1960s' experience in Korea*, www.ritsumei.ac.jp/~leekk/study/lee-ko60cc-ss.doc

providing them with a significant competitive advantage. Moreover, these were not public companies while they were aggressively building up their manufacturing capacity, so they were not troubled by Wall Street's fixation on return on capital. They could afford to focus on the numerator, and ignore the denominator. So, although we must look elsewhere than to labor cost for factors that have led to the success of Samsung and, in a lesser way, LG, the cost and availability of capital are an important factor in their success in comparison with their fading Japanese competitors. And, as a colleague of mine reminded me, we have to look fast before other unknowns rise up and knock today's leaders off their pedestals.

What Happened to the Japanese Makers?

The Japanese consumer electronics giants do not appear to have made egregious errors. After the Plaza Accords bubble burst in the 1990's, they were victims of a high yen and a deflationary economy, limiting their ability to invest and export. In a narrow sense, they also paid a penalty for being too early with innovation: Japan's national broadcasting company NHK led the world with satellite and high definition TV broadcasts into the 1990's. It's possible that this nascent leadership opportunity led the Japanese makers astray by their need to concentrate on analog technology in order to satisfy their domestic market, thus missing the tide favoring digital TV, so astutely exploited by LG in its purchase of Zenith. Another misstep was costly investments in plasma TV, notably by Panasonic (Matsushita) but that didn't seem to have troubled Samsung and LG.

The TV makers continued to invest in R&D and pile up patents and even to invest in bigger and bigger fabs until fairly recently. And, as noted above, they may not have had access to the low cost capital available in Korea, greatly limiting their ability to invest profitably in building new LCD fabs. Finally, no one would argue that Korean engineers were smarter than Japanese engineers but it seems likely that they worked harder and longer in a nationalistic drive to outdo their former colonial masters.

One last possible source of the Japanese loss of leadership would be in the executive suites, where Korean management appears to have been much less risk averse. An exploration of this possibility is beyond the scope of this brief analysis.

The Verdict

Samsung and LG appear to have been the beneficiaries of shrewd industrial policies of the South Korean government and superior senior management choices coupled with the determination of their staff, somewhat enhanced by misjudgments by Japanese TV consumer electronics makers' top management.

Appendix 1 – Some Leading Recipients of US Patents²⁹

	IBM ³⁰	Samsung	LG ³¹	Matsushita	Canon	Sony	Toshiba	Hitachi	Panasonic	Apple	Microsoft	Intel
2012	6478	5081	3101		3174	3032	2447		2769	1303	2613	
2011	6148	4968	2873	2533	2818	2265	2451	1455		825	2309	
2010	5866	4518	2763	2443	2551	2130	2212			741	3086	1652
2009	4887	3592	2014	1759	2200	1656	1669			416	2901	1534
2008	4169	3502	1720	1469	2107	1461	1575			272	2026	1772
2007	3125	2723	1456	1910	1983	1455	1519			166	1637	1864
2006	3621	2451	1364	2229	2366	1771	1672	1732		141		1959
2005	2941	1641	975	1688	1828		1258	1271		104		1549
2004	3248	1604	1012	1934	1805	1305	1310	1514		133		1601
2003	3415	1313	779	1786	1992	1311		1893		108		1592
2002	3288	1328	655	1544	1893	1434		1601		101		
2001	3411	1450	496	1440	1877	1363		1271		117		
2000	2886	1441	579		1890	1385	1232			136		
1999	2756	1545	650		1795	1410	1200			189		
1998	2657	1304	576		1928	1316	1170	1094		268		
1997	1724	731	411		1381	859	862	903		236		
1996		591	323							188		
1995		504	298							138		
1994		486	252							78		
1993		435	175							78		
1992		305	156							56		
1991		205	135							42		
1990		82	126							38		
1989		47	96							12		
1988		15	119							13		
1987		11	111							12		
1986		9	70							10		
1985		3	59							6		
1980-1984			277									

²⁹ Note that not all primary sources agree! http://en.wikipedia.org/wiki/List_of_top_United_States_patent_recipients

³⁰ For 2012 data, see <http://www.lotempiolaw.com/2013/02/articles/patents/top-10-companies-issued-us-patents-in-2012>

³¹ www.delphion.com tabulated by the author